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Improving Scientific Literacy through Reading Strategies: An Action Research Study

by

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Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Education in

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DEDICATION

This dissertation and all of my academic achievements are dedicated to the memory of my mother, Beverly S. Dailey. She was a beautiful courageous soul who faced her death too early. Her faith and strength through her most difficult times is what continues to inspire me today. Being an educator herself, she taught me the love of learning and instilled in me a desire to help others. To my mother: May I continue to grow so that I may be a true reflection of you.

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This dissertation was possible due to the encouragement and support of several individuals I would like to thank. First, to Dr. Susan Schramm-Patte, thank you for your continued guidance, belief in me, and your efforts to talk me off the ledge from my frustrations. Without your help, I would not be where I am today. To my committee, I am extremely grateful for your assistance and suggestions for improvement. I am especially thankful for Dr. Lussier whose course work and teaching style has challenged me to be a more critical thinker and understand the importance of dialoging across difference. I am also thankful for Mrs. Brown, her willingness and desire to be a part of my action research study, and our shared love and passion for science education. Last, but not least, to my husband Patrick Finneran, thank you for your love, patience, and support over the last three years. Without you, I could not have achieved this success.

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ABSTRACT

The purpose of this quantitative action research study is to examine a Scientific Reading Intervention Model (SRIM) with students enrolled in Honors Chemistry at a private high school in South Carolina. Students were given a pre-test prior to the intervention. The research took place over a six-week period in the spring of 2017. A teacher-participant worked with the researcher-participant to implement the intervention that consisted of three reading activities—pre-reading, during-reading, and post-reading. These three activities were designed to enable the low-level science readers to better comprehend their chemistry texts by activating prior knowledge with an anticipation guide, identifying key concepts through coding and connecting facts to comprehend a big picture by constructing concept maps. Students were given a post-test at the end of the unit and a simple t-test was used to analyze the pre-test and post-test data. Other data collection included semi-structured interviews with the teacher-participant and the student-participants as well as classroom observations during the implementation of the unit. Findings include reading strategies for chemistry students. An action plan includes teacher in-service for science faculty that focuses on the need and importance of implementing scientific reading strategies to improve comprehension. *Keywords*: constructivism, disciplinary literacy, multimodal text, scientific literacy

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CHAPTER 1. INTRODUCTION

Scientific literacy involves more than reading a scientific text. For a student to be literate in science means that they cannot only identify the words of the reading, but they can also interpret the meaning of the text and apply it to the everyday world around them. According to the National Research Council (NRC), scientific literacy is the ability to "use evidence and data to evaluate the quality of science information and arguments put forth by scientists and in the media" (NRC, 1996, p. 22). Literacy, according to Norris and Phillips (2003), requires the ability to both read and write scientific texts in richly constructed ways. Driver, Newton, and Osborne (2000) continue that a scientifically literate person can also understand and apply the fundamental elements of scientific argumentation, including claim, evidence, and warrants.

Literacy has been and continues to be a popular topic among educators. However, much of the research is focused on the elementary and middle grades. During this time, students are taught general reading strategies such as previewing and summarizing. However, these strategies are not sufficient for reading more complex informational text. There are different degrees of literacy with the more complex level involving one being able to utilize the language of a secondary discourse for critique (Gee, 1998). Preparing students to move beyond the basics of literacy means higher level literacy strategies are needed.

Basic reading strategies are generally taught at an early age utilizing narrative and chronological text. Therefore, students often struggle when they are presented with a text

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that is not of the same design. Shanahan and Shanahan (2008) examined adolescent literacy in three disciplines: chemistry, history, and mathematics. They explained that scientific text often has a high degree of lexical density or percent of content words related to total number of words. To ensure a deep understanding of the material, students must develop an understanding of the vocabulary. Lemke (2004) also described scientific text as multi-modal. In other words, the text is often presented in written format and through the use of visuals. While other contents, such as history, may incorporate visuals, they are often seen as supportive to the written text (Shanahan & Shanahan). Due to these differences, it is imperative that students use more content specific reading strategies to assist their comprehension. "Students' text comprehension, we believe, benefits when students learn to approach different texts with different lenses" (p. 44).

Being literate in science means more than just being a proficient reader. It means students are capable of reading information text, decoding it, and processing it for application. Armbruster (1993) describes some of these skills such as engaging prior knowledge, evaluating understanding, determining relative importance, making inferences, and generalizing. Students must decode and organize the information in a manner that allows them to generate a comprehensive understanding. From reading to problem-solving practices, disciplinary literacy in science encompasses what it means to be a scientist" (Cliger, 2014, p. 5). Reading science text and textbooks requires the same critical thinking, analysis, and active engagement as performing hands-on science activities. Science and reading have many process skills in common (Barton & Jordan, 2001). Additional literature review is provided in chapter two.

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Problem of Practice

The problem of practice for this study is that high school students enrolled in 10th grade chemistry courses do not show evidence of comprehension after reading their text. Prior to the study, the researcher identified that students were unable to successfully answer questions pertaining to the content after reading passages of their textbook and/or scientific articles. The researcher-participant struggled to get her students to comprehend scientific reading material. She held class discussions with the students regarding why they thought they could not answer questions or discuss the content post-reading. Students overwhelmingly responded that the information was difficult to understand, there were too many terms and too much information. The students indicated that they were trying to read the text line by line and in the same way they would read a story or newspaper. They stated that they were overwhelmed by the details. This was preventing them from being able to develop a comprehensive understanding of the big ideas and concepts. The students indicated they had not been taught how to read complex material like their science book. This lack of instruction on how to break down the information, organize the details, and construct an understanding prohibits students from being able to develop conceptual understanding of the material. Therefore, not equipped with strategies to independently process scientific information, students tend to rely on the teacher's instruction and assistance for learning. This teacher dependence and lack of skill for independent learning is not adequately preparing students for their educational future or career (O'Brien, Stewart, & Moje, 1995).

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Research Question

Developed by the researcher-participant in collaboration with the teacher-participant, this study utilized the Scientific Reading Intervention Model (SRIM) which consisted of pre, during, and post-reading strategies aimed to improve student comprehension. The research question for this study is, what is the impact of the SRIM on students enrolled in Honors Chemistry at a private school in South Carolina? The researcher-participant hypothesized that the addition of reading strategies will aid students in their reading of scientific text and therefore improve their level of comprehension.

Statement of Purpose

The purpose of this study was to investigate the impact of the SRIM on student's ability to read and comprehend scientific text, specifically their Chemistry textbook. The aim of the SRIM is to equip students with advanced reading strategies that may enable them to process expository text. Additionally, the study aims to contribute to the existing research on scientific literacy and provide data on the effectiveness of the three chosen strategies for science specific content.

Scholarly Literature

Passively transferring information from the teacher to the student is no longer an effective method for preparing students for their future (Bar-Yam, 2002). As educators, we are no longer preparing students for specified jobs. Instead, our job is to prepare our students for a future that is constantly changing. During the past generation, the expansion of information-based technology, the internationalization of labor markets, and

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the changing of workplace demands have increased the importance of literacy as an ingredient of economic and social participation (Carnevale, 1991).

Shanahan and Shanahan (2008) state that the implementation of new literacy programs and initiatives at the state and federal level have been successful. National reading scores for young children have increased since 1992. However, they continue even today to state, "The idea that early literacy improvement would automatically lead to consequent later growth in literacy has not panned out" (p. 43). There is a clear need to expand literacy instruction upward through the middle and high school grade levels to better support the reading of older students (Shanahan & Shanahan).

Most current research has a focus on elementary and middle level grades. As literacy is expanded to include the secondary level, it is important to determine the best strategies to use for improvement. Current research focuses on the need for content specific strategies and the standards that have been set (DeBoer, 2000). However, there is little research on specific strategies and their effectiveness that have been used for science content. Researchers have yet to agree upon a single set of measurable skills critical for scientific literacy, beyond unanimously agreeing that these skills must include conceptual understanding, as well as views about science and society, per Bauer et al. (2007; as cited in Gormally, Brickman, & Lutz, 2012). As students transition from a history reading, to a mathematical problem, to a chemistry equation, it is essential that students can read all forms of information and determine the practical significance of each. By identifying strategies that can be utilized for all types of reading, and teaching students' new ways to use strategies for a specific content, students may improve not only their scientific literacy, but may become more versed in all fields as well.

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Science textbooks are especially difficult for high school students to independently read and comprehend due to the multi-modal presentation of information. To comprehend the material, student's must read complex writing that is laden with technical and abstract vocabulary terms (Shanahan & Shanahan, 2008). Additionally, students must utilize other factors such as figures, tables and charts to interpret a full understanding of the concepts being presented. McCrudden (2010) explained that text structures, prior knowledge and the organization of knowledge have a significant impact on the student's ability to comprehend scientific material, and therefore achievement.

Jacobs (1989) describes the importance of teaching the skills that students need to acquire knowledge and develop the capacity to think and learn independently. Skill teaching is prominent for the primary grades but loses momentum in the secondary grades. For secondary subject teachers, content curriculum dominates and teachers are often unwilling to sacrifice class time for teaching skills sets they believe they should have already obtained (Jacobs, 1989). Teaching and reinforcing the skills, such as reading, help students to acquire the curriculum and become more independent learners so that they may be able to handle the large amounts of information they will encounter in their educational future and career.

The framework guiding this study was action research. Action research is defined as any systematic inquiry conducted by teachers, administrators, counselors, or others with a vested interest in the teaching and learning process or environment for the purpose of gathering information about how their particular schools operate, how they teach, and how their students learn (Mills, 2001). The purpose of action research is to provide insight for improvement to achieve more successful educational outcomes.

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While several models of action research are available, they all involve some form of observing, monitoring, collecting and analyzing data, then taking action to make a change. According to Stringer (2007), the primary purpose of action research is to provide means of inquiry and evaluation. However, the findings may not be generalizable to large populations. Results from action research are designed to provide insight to specific and local situations (Stringer).

Stringer describes a model of action research that consists of three phases: "look, think, and act." During the "look" phase, the researcher observes and gathers information about the current situation. The "think" phase occurs when the researcher develops a research plan, collects data, and interprets meaning. The final phase is the "act" phase. In this phase, the research develops an action plan and puts the plan into place. Often, the "look, think, act" model will continue in a cyclical pattern as new findings are discovered (Stringer).

This action research was also guided by the framework of the BSCS 5E Instructional Model (Bybee et al., 2006). This instructional model has been used by Biological Sciences Curriculum Study (BSCS) since the late 1980s in the development of new science curriculum materials. The model was developed based on previous models accompanied with new additions from more recent research. The model uses work from Johann Herbart (1901) who proposed two foundations for teaching: interest and conceptual understanding (Bybee et al., 2006). Herbart (1901) believed students should use their current knowledge to discover new information from experiences and relationships. The role of the teacher, according to Herbart (1901), is to question, guide and suggest through indirect methods (Bybee et al., 2006). The work of John Dewey

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played an important role in many instructional models during the 1950s. In *Democracy and Education* (1916), Dewey described the importance between thinking processes and student experience. His ideas helped teachers realize the connection between hands-on activities and reflective thinking. The 5E Model suggests that students engage, explore, explain, elaborate, and evaluate science material as they learn. This action research study utilized three readings strategies together to comprise the participant-researcher developed scientific reading intervention model (SRIM). These strategies included an anticipatory guide to activate prior knowledge before reading, a coding strategy to organize content during reading and a post-reading construction of a concept map. Additionally, students evaluated their own understand through peer-group and teacher-led class discussions following the implementation of the strategies.

This study utilized the foundation ideas of the BSCS to challenge students to become aware of their current knowledge, be receptive to new ideas, and develop methods to assist with the integration of the two. In addition, based on the work of Piaget (1950), Vygotsky (1978), and Bruner (1961), students, not the teacher, will be responsible for the actual construction of knowledge. The instructor served to lead and design the learning environments.

In conclusion, this study utilized pre, during, and post reading strategies in conjunction with the framework set by Stringer (2007) for action research design, as guides to assess how the incorporation of learning strategies may improve secondary student's comprehension of scientific text.

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Participant and Site Selection

With permission granted by the superintendent and the high school principal, participants for this study included eighteen 10th grade students enrolled in honors chemistry. Each participant in the study signed and returned the parent consent and child assent form prior to the start of the study. Names of the students and teacher-participant were not recorded in the documentation of this study. It was also made clear to all participants that the pre-test and post-test scores would not be reflected in the student's overall chemistry grade.

A teacher-participant, Mrs. Brown (pseudonym) facilitated the treatment, with assistance and guidance from the researcher-participant, to her students in her classroom at the school. She signed and returned a participant consent form as well. The researcher-participant established and maintained reciprocity and constant communication with the teacher-participant throughout the study. The researcher-participant made formal observations of the classroom and setting seven times throughout the study to gain insight into the climate of the classroom and interactions between Mrs. Brown and the students.

Research Setting

The research took place in the 10th grade honors chemistry classroom located in a private school. The private school is situated in a suburban area of southeast South Carolina. The research was conducted during the spring of 2017 during normal school day hours in the science classroom of the teacher-participant located at the school.

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Sources of Data Collection

Both quantitative and qualitative data was analyzed for this study. Quantitative data was collected from a pre-test/post-test design. Both tests were created with two ACT science reading passages with five questions following each passage. The questions are designed by the College Board to assess the student's ability to successfully comprehend science related text and answer the corresponding questions. The reading passages for both assessments contained scientific information that students have not yet been exposed to in their science classes. The reason for this is to gauge student's ability to comprehend the materials and prohibits students from answering questions based on prior knowledge. The pre-test and post-test scores were analyzed and compared to determine the impact of the SRIM on the student's ability to comprehend scientific text.

Qualitative data was also collected throughout the study and analyzed in conjunction with the quantitative data. The researcher-participant observed Mrs. Brown's classroom and documented the observations on field note sheets for review. The observations were reviewed and analyzed with the teacher-participant. Semi-structured interviews were also conducted with each student-participant to determine their perceived effectiveness of the study, suggestions they may have for future action, and their post high-school science related plans.

Assumptions

Based on the research about content literacy the assumptions I have for this study are:

1. Decoding of the scientific text is the prominent disadvantage students face when it comes to demonstrating understanding of scientific material.

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2. Students have not previously been taught content-specific reading strategies or strategies to comprehend informational text.
3. The three strategies chosen are, based on research, most effective for science related material.

Delimitations

The limitations that were under control of the researcher include the selection of the participants for this study. The student-participants were tenth graders from a private school who were enrolled in honors chemistry class. The students enrolled in this class may not be the top achievers simply based on their enrollment status. In addition, utilizing only an honors level for the study eliminates the review of effectiveness for students enrolled in general chemistry courses who may share similar struggles when it comes to reading comprehension. By only utilizing chemistry, which utilizes more mathematical concepts than other science contents such as Biology, this study is limited by application of content. The results of this study are not intended to be applied to all student enrolled in science courses, but rather are unique to the selected student-participants enrolled in honors chemistry at the designated private school in South Carolina.

Limitations

This study does not take into consideration other factors such as student motivation or prior math and science background knowledge. These factors could contribute to the overall success of the individual students. The honors section of chemistry was utilized for this study in attempts to establish a population of student-participants that are of similar academic level. However, diversity of academic abilities

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still exists and each student brings with them a different level of motivation and prior knowledge that may enhance or prohibit their success in this treatment.

Scope

Science reading comprehension is a broad category. This study narrowed in on how tenth grade students may improve their ability to read and comprehend scientific information. The purpose of this study was to determine the impact of the SRIM on the student's ability to comprehend scientific text.

Significance of the Study

The present study is an examination of how reading strategies part of the SRIM impact student comprehension. Being a fluent reader can significantly improve a student's level of success. Providing skill sets that may be applied to improve student reading comprehension could better prepare students for their next science course and/or science courses at the college level, which require extensive amounts of reading from content rich text books. Reading comprehension of scientific information is critical for science achievement, and the ability to comprehend, analyze and evaluate information is an important skill set for scientists (Otero, Leon, & Graesser, 2002). As Dewey (1966) claimed in *Democracy in Education*, the aim is not only the target, but hitting the target as well. It is more important to teach students how to learn rather than how to memorize the concepts. In order to prepare students for their dynamic future, educators must empower students to take an active role in their own learning. This study focuses on improving student's ability to read and comprehend scientific material in hopes of creating more independent and higher achieving students.

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Professional Application

This study enabled myself and Mrs. Brown, the teacher-participant, to understand how to utilize strategies that may help students be more successful when it comes to reading and comprehending scientific material. The addition of these strategies, in addition to others, helped us improve the chemistry curriculum and address the needs of the students. In addition, being the curriculum director for the district, this study provided me with insight regarding the need and importance of content literacy strategies. The study provided me with a first-hand experience as to what teachers face on a daily basis when it comes to teaching skills sets in addition to their curriculum. It enabled me to develop an action plan that may assist science teachers when it comes to teaching reading in the content of science. Knowing the strategies is not enough, teachers also need to be aware of the importance of reading comprehension and they need training on what strategies work best for the multi-modal scientific text.

Conclusion

Chapter one of this dissertation provides an overview of the study and the need for examining ways to improve student comprehension with science text. This chapter points out how students struggle with textbook reading and how this impacts their overall success in their science courses. To increase student achievement, as well as self-confidence, students must be equipped with skill sets that enable them to independently comprehend provided scientific information whether it is a textbook, journal article, or lab report. By incorporating reading strategies in science instruction, students may be better prepared for their educational future and career.

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Chapter Two summarizes the themes and ideas associated with the problem of practice as well as literature reviewed related to methodologies. Chapter Three reviews the methods used for the study. Chapter Four describes the collection strategies used, the analysis used, and reflections. Chapter Five describes the key questions that emerged from the study along with the development of the action plan and how it is targeted to the findings of this study.

Glossary

Action research. This term refers to research initiated to solve an immediate problem or a reflective process of progression problem solving led by individuals working with others in teams or as a community in practice (Mertler, 2014).

Comprehension. This is a common term referring to the ability to understand (Snow, 2002).

Comprehension monitoring. Such monitoring is the ability of a reader to be aware, while reading, whether a text is making sense (Snow, 2002).

Constructivism. Constructivism is a theory based on observation about how people learn. It concludes that people construct their own knowledge of the world through experience and reflection on that experience (Brill et al., 2004).

Disciplinary literacy. McConachie (2010) defines this term as the confluence of content knowledge, experience, and skills merged with ability to read, write, listen, speak, think critically, and perform in a way that is meaningful within the context of a given field.

Metacognition. This is an awareness and understanding of one's own thought processes (Holliday, Yore & Alvermann, 1994).

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Multimodal. This adjective characterizes several different modes of activity or occurrence (Fang & Schleppegrell, 2010).

Nominalization. This linguistic term refers to the use of a word that is not a noun as a noun (Halliday & Martin, 1993).

Pre-test data. Data collected prior to the treatment in a research paradigm is often identified as pre-test data. (Mertler, 2014)

Prior knowledge. This locution refers to the existing skills, beliefs, and attitudes that influence how people attend to, interpret, and organize new information (Holliday et al., 1994).

Post-test data. Data collected after the treatment in a research paradigm is often identified as post-test data (Mertler, 2014)

Reading comprehension. Comely et al. (2010) define reading comprehension as the ability to read a text, process it, and understand its meaning.

Schema. A schema is a representation of a plan or theory in the form of an outline or model (Cromely et al., 2010).

Scientific literacy. This term refers to knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civil and cultural affairs, and economic productivity (Lemke, 2004).

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CHAPTER 2. LITERATURE REVIEW

Introduction

While hardcopy textbooks are becoming more obsolete with the advancements in technology, the ability to read and comprehend text is a skill set that is necessary for college success, especially in the STEM related fields. According to Woodward and Elliott (1990), more than two-thirds of the world's instruction is structured by textbooks. College students are often required to read and understand large amounts of information from written material. Most students purchase their textbooks, skim the pages, and immediately feel a sense of panic. The question is how we ensure our students not only learn the content material, but the skill set of analyzing and interpreting information when it is presented in different formats.

Thumbing through a science textbook can cause a student to feel overwhelmed and defeated. The written text is dense with information, the chapters are long, and amount of specialized vocabulary is generally larger than that of a foreign language text. In addition, most science text books utilize figures, charts, and tables to further expand the written ideas. Focusing on either the written or non-written text individually will not allow the student to encompass a full understanding of the topic at hand.

Students are taught general reading strategies early in their education career. However, these general strategies are not sufficient for these more complicated texts.

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According to Perele et al., (2005), these reading strategies do not automatically develop into complex reading skills. These more advanced skills must also be taught. However, many secondary content teachers are content specialists and are not trained to teach reading strategies (Parris & Block, 2007). Therefore, students are often moving on to college unprepared and without ever having learned skills needed for independent reading and comprehension. Due to the design and readability of the text, the reading strategies being used by the students, and the lack of preparedness of the teacher to teach the strategies needed, it is understandable as to why students are struggling with their independent reading in college. "As the knowledge that students have to learn becomes more specialized and complex in secondary schools, the language that constructs such knowledge also becomes more technical, dense, abstract and complex" (Fang & Schelppegrell, 2010, p. 587). Adolescents need to develop content-specific reading skills and strategies to be successful.

The purpose of this study was to evaluate how the addition of higher level reading strategies may help secondary science students improve their comprehension of scientific text. Scientific literacy involves more than simply reading word for word and regurgitating information. The ability to comprehend what one reads is essential to developing disciplinary literacy (Lemke, 2004; Tenopir & King, 2004). McConachie (2010) stated, "Disciplinary literacy involves the use of reading, reasoning, investigating, speaking, and writing required to learn and form complex content knowledge appropriate to a particular discipline" (p. 16). The discipline studied for this research project was chemistry. This study utilized the SRIM, developed by the researcher-participant and the teacher-participant, with aim of improving student comprehension for scientific materials

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such as student textbooks, journals and lab reports. Three reading strategies were selected for the model based on their perceived effectiveness for science related materials. Specifically, this study examined how the use of these reading strategies may affect students' ability to comprehend scientific material. The following research question helped guide the study: What is the impact of the SRIM on the abilities of the student-participants to comprehend scientific text?

Importance of the Literature Review

The goal of this review is to examine the body of literature related to scientific literacy and the strategies utilized by high school students with reading comprehension. This literature review will attempt to narrow the research question regarding scientific literacy. It will describe previous studies and their findings that are relevant to literacy, content literacy and the more narrowed, scientific literacy. The following literature review will attempt to show how the research on scientific literacy and reading comprehension is missing some valid research regarding what strategies are best for implementation within specific content areas. Specifically, this study will review the strategies for scientific comprehension. Studies for this review were selected based on their relevance to high school science literacy. However, to provide a more comprehensive background on the topic, other studies were utilized that involved middle level grades, basic reading strategies, literacy research, and scientific processes.

The research studies utilized were selected from electronic database searches, journals, and cross-referencing applicable bibliographies. Keywords such as: scientific literacy, literacy, disciplinary literacy, content-area literacy, scientific text, and reading strategies, were used as search criteria.

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Action Research

The purpose of action research is to provide tools to enable people to deal with problems they may confront as they perform their work (Stringer, 2007). Action research, among research typically used for educational research, is the most practical design (Creswell, 2008). Action research utilizes a design in which participants are either designing or in direct control of the research (Herr & Anderson, 2005). It provides a practical way to conduct research in schools and provide information for data based decisions. As opposed to other methodologies of research, action research focuses on the quality standards rather than the external validity (Herr & Anderson, 2005). The cycling of phases is most often involved in action research. These phases consist of observing and reflecting, organizing and analyzing, and creating and implementing action plans (Herr & Anderson, 2005; Stringer, 2007).

This study will attempt to utilize the *look, think, act* (Stringer, 2007) model of action research to examine how reading strategies, will impact the level of scientific comprehension. Stringer (2007) states, "Action research is based on the proposition that generalized solutions may not fit particular contexts or groups of people and that the purpose of the inquiry is to find an appropriate solution for the particular dynamics at work in a local situation" (p. 5). This topic, scientific literacy, will be explored in a high school honors chemistry classroom with a set group of students. While the topic may be of importance for many educators, the study is designed to provide results based on the specific setting. According to Stringer's model, action researchers should first *look* at the settings and gain insight. There is a high importance on observations, interviews, surveys and other tools that would help examine the purpose of the action research. The look

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phase means the researcher should “build a picture” of the surroundings and the problem (Stringer, 2007, p. 84).

After examination, the researcher should use the gained information to “produce meaningful descriptions and interpretations of social processes” (Stringer, 2007, p. 96). This is the *think* phase of the model. During this phase the researcher should evaluate, analyze, and interpret the information for meaning. It is important for the researcher to notice any deficiencies or misrepresentations of the problem.

The final phase, the *act* phase, occurs when the researcher implements action in response to the problem and gained information. In evaluating, the researcher “judges the worth, effectiveness, appropriateness, and the outcomes of the activities” (Stringer, 2007, p. 132). According to this model, it is important that researchers’ cycle through the phases until the research is complete.

Through the look, think, act model, this study examined the use of the SRIM and its impact on student’s ability to read and comprehend scientific text. During the look phase of this action research, the researcher-participant worked with the teacher-participant to examine the quantitative and qualitative data. The pre-test and post-test scores were examined, compared and analyzed for meaning. Additionally, the qualitative data, such as classroom observations and student survey responses were reviewed and analyzed for trends and patterns. All data was carefully analyzed individually and collectively as a whole to determine the impact of the model on student comprehension.

The think phase consisted of exploring and analyzing the data to interpret and explain the issues related to scientific literacy (Stringer, 2007). The collected data provided insight regarding the impact of the SRIM. In addition, the review of data

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allowed both the researcher-participant and teacher-participant to reflect on the chosen strategies of the SRIM and determine what actions should be taken for future improvement and implementation of the SRIM.

The act phase includes planning, implementing, evaluating and reporting (Stringer, 2007). During the act phase of this study, the treatment was planned according to the data and reflections. The implementation of the action plan will occur in the fall of the 2017-2018 school year in the same private high school science class. The plan involves constant evaluation by both the teacher-participant as well as the science department. The results collected from the action will be presented in the Spring semester of 2018 to all science teachers as well as the academic dean and principal.

Constructivism

This action research design, as well as the reading strategy selection, was based on the learning theory of constructivism. Learning theories provide educators with "verified strategies and techniques for facilitating learning as well as a foundation for intelligent strategy selection," according to Ertmer and Newby (1993, p. 44). Based on the philosophical viewpoints of Piaget, Bruner, and Goodman, constructivist believe that learning is an active process where students construct meaningful representations of objective reality based on their personal experiences. Constructivism also stresses that learning is not a transfer of knowledge from one person to another; rather, learners build their knowledge by linking their prior knowledge to new knowledge through personal experiences. The "transfer of knowledge is facilitated by involvement in authentic tasks anchored in meaningful context" (p. 56). Constructivism theory suggests a shift from the traditional teacher led classroom to a student-centered learning environment.

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This action research study incorporated strategies that promote the constructivism ideology. With a focus on enabling students to take control of their own learning and become more independent readers, the SRIM was designed to facilitate change in classroom instructional strategies. The reading strategies that make up the SRIM were chosen based on their effectiveness in assisting students to take an active role in their processing of information. The teacher's role is still important in this shift to a student-centered classroom. However, instead of transferring knowledge directly to the student, the teacher's responsibility is to instruct students on how to construct their own meanings from context. Additionally, say Ertmer and Newby (1993), the teacher should provide students with skills on how to "effectively monitor, evaluate and update those constructions" (p. 59). The teacher is also responsible for the alignment and design of the experiences for the students. These experiences need to be authentic and relevant for learning to occur. The role of the teacher for the SRIM was to implement reading strategies and provide feedback that would help students improve their skill of reading and comprehending scientific text. Instead of teaching the material directly and spoon feeding the students with information, the teacher's role for this study was to equip students with the skills needed to process and comprehend the information independently with assistance from the teacher when needed.

History

The textbook has been a foundational unit for primary, secondary, and post-secondary schools for years. The student's inability to efficiently and accurately understand the material presented in these textbooks is not a new struggle that teachers are facing (Herber, 1970). Many teachers and students recognize this struggle; however,

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they are often at a loss as to how to fix it (O'Brien, Stewart, & Moje, 1995). Students are taught basic reading comprehension strategies throughout the primary grades that are designed to fit all contents. The problem is that these strategies continually prove to be inefficient when students are presented with higher-level text in different formats and contexts. Topping and McManus (2002) concluded that while many strategies are being used, they are not helpful to student comprehension due to the fact they are not founded on research. More recent studies have shown the relevance of including reading comprehension strategies within content areas for secondary students (Shanahan & Shanahan, 2008). These studies are utilizing content specific strategies across the curriculum to help students improve their reading comprehension in all content areas (Roe, Stoodt, & Burns, 1995). Based on their research, Brown and Ryoo (1998) concluded that these practices taught in content allow students to not only understand the content, but also allow them to make connections between the content and the strategies needed for comprehension, therefore improving their ability to be self-directed learners.

Based on the limited number of studies, there is a clear need for more research based studies to help determine which strategies are most beneficial within each content area. This research study will attempt to analyze how the SRIM could be employed to improve reading comprehension of scientific text.

Disciplinary Literacy

The Common Core State Standards require that literacy be supported in every classroom. However, according to Ness (2006), the average amount of classroom time spent on literacy development in high school content courses is less than three percent. Literacy organizations and researchers are asking schools to provide greater support for

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students in their contents as they interact with their various forms of text (Fang, 2005). Basic literacy skills acquired in the primary grades are not sufficient for the more complex reading students encounter as they progress in their educational career. Additionally, reading comprehension is strongly associated with academic achievement. Therefore, it is important that students continue to develop the necessary skills to comprehend more complex material to obtain academic success. Disciplinary literacy looks to experts in the field to determine the reading strategies needed for specific fields of study (Moje, 2008). Moje (2008) suggested that it is more important to allow content teachers to teach literacy practices and strategies rather than to build standard disciplinary literacy programs that would be used for every content. Her philosophy of reading is to "build an understanding of how knowledge is produced in disciplines, rather than building knowledge in disciplines" (p.97).

Shanahan and Shanahan (2008) conducted a study to examine disciplinary literacy, as they define it, "advanced literacy instruction embedded within the content-area classes" (p. 40). They worked with both experts in the field as well as secondary teachers to examine how content area teachers in the fields of math, chemistry and social studies, read disciplinary texts, utilize comprehension strategies, and teach those strategies to secondary level readers. Their results indicated that the nature of the discipline itself must be included in the teaching of literacy. "Students' text comprehension benefits when students learn to approach different texts with different lenses" (p. 51).

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Text Differences

Research on disciplinary literature provides information about how experts participate within various disciplines. Each content has different criteria for its text (Draper, 2008) and experts have differing approaches to teaching their texts as well (Shanahan & Shanahan, 2008). For example, science experts tend to focus on both text and graphics while others, such as history experts, demonstrate more value in the writing and the author (C. Shanahan et al., 2011).

In order to clearly understand the differences, Fang and Schleppegrell (2008) use two texts for comparison.

Text 1.

> That night, I had an uneasy sleep. Strange noises emanated from downstairs. It sounded like toenails clicking back and forth on the floor. It must be Bunnicula masking his midnight run, I thought, although I'd never known him to make a sound. And I smelled the funniest odor in the air—something familiar, though I couldn't place it. As the night progressed, it grew stronger and stronger until finally it tickled my nose and I sneezed myself awake. I jumped off Toby's bed, still sniffling, and headed down the stairs for the living room to find Chester, to see if he could smell it, too. (Howe & Howe, 1979, p. 62)

Text 2.

> Organisms made up of one or more cells that have a nucleus and membrane-bound organelles are called eukaryotes. Eukaryotic cells also have a variety of subcellular structures called organelles, well-defined, intracellular bodies that perform specific functions for the cell. (Modern Biology, 2006, p. 75)

Text 1 was taken from Deborah and James Howe's (1979) *Bunnicula*, which is popular humorous children's story. It is easy to comprehend due to sequential flow and lack of technical vocabulary. Clauses in the sentence are linked through coordination and subordination to easily tell a story. In contrast, the science passage, adopted from a high school biology text book, is heavy laden with technical and abstract vocabulary. Without

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a full understanding of the terminology, interpreting the passage may be difficult for most readers.

Every discipline tends to differ in how it communicates and evaluates knowledge. History texts tend to focus on detailed accounts of the past in a straight-forward or narrative sense. Mathematics texts involve written as well as symbolic language with visual displays. Scientific texts are generally multimodal as well consisting of written text, visuals, diagrams, and charts that must be interpreted together for a full understanding. These different forms of language patterns are often unfamiliar to adolescents and in turn present significant comprehension challenges (Fang & Schleppegrell, 2008).

Teacher Preparation

In addition to not spending enough time on reading strategies for middle and high school students (Ness, 2006), Moje (2008) argues that changes in specific reading instruction are also necessary. She argues that students lack the skills necessary to properly dissect the information given to them by the teachers. Reading success in the elementary grades is not the end of the story and will not prepare middle and high school students for the advanced levels of literacy needed to learn effectively from specialized text (Fang & Schleppegrell, 2008). A common theme in content literacy is the role of the teacher and their support for the students. Many science teachers experience anxiety about teaching reading (Osborne, 2014). Many have never studied reading in their content and feel unprepared to teach reading. However, science classes are often the first-time students encounter “challenging expository texts” (Osborne, 2014, p. 40). It is important for science teachers to not only teach content, but also teach skill sets, such as reading, that will enable students to be independent and life-long learners. Roni Jo Draper

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(2008) is a content-area literacy teacher educator. She concludes that content-area teachers who make reading assignments have a responsibility to “direct and supervise the reading and study activities that are involved with those readings” (p. 61). It is important, according to Draper (2008), that students have not only content knowledge but also knowledge regarding skills that required for “using content-area text to communicate and participate as well as to learn” (p. 60).

Bar-Yam (2002) concluded that for our students to be successful today, the transmission of knowledge from teacher to student is not enough. Instead, he suggested a shift in classroom instruction from a teacher-centered approach to more student-centered learning. This shift will help teachers prepare students to be more self-directed and independent learners. However, to make this shift, teachers need to be aware of the skill sets needed when it comes to comprehending their specific text.

For two years, Shanahan and Shanahan (2008) investigated the disciplines of chemistry, history, and mathematics and they reviewed how each discipline used literacy. They found that while mathematician experts were focused on letters, symbols and the role of variables and change, historians emphasized attention to the author or source when reading a text. The chemistry experts were “more interested in the transformation of information from one form to another” (p. 49). Additionally, chemistry experts had to pay attention to alternative representations such as charts and graphs to develop a full understanding of the text. With such a variety of skills needed to comprehend a variety of texts, content-specific reading skills are needed to enable students to be independent learners. In conclusion, they determined that “formulating an appropriate curriculum for secondary teacher preparation is a necessary, though insufficient, condition for improving

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literacy teaching for middle and high school students" (Shanahan & Shanahan, 2008, p. 57). If we want students to improve their level of comprehension of content texts, teachers must be prepared to teach the skill sets needed. To be prepared, teachers need appropriate content-specific training on how to teach independent reading skills. Their study suggested that teachers use and implement reading comprehension strategies that mirror "the kinds of thinking and analytic practices common to their discipline" (p. 56).

Scientific Literacy

"A review of educational history shows us that scientific literacy is a general concept that has had, and continues to have, a wide variety of meanings" (DeBoer, 2000, p. 594). Research on comprehension of scientific text has shown consistent factors such as text structure, prior knowledge, organization of knowledge, interactive knowledge, and comprehension ability to greatly influence a reader's ability to learn from a given reading (Cromley et al., 2010; McCrudden et al., 2010; Ridgeway, 1994). Scientific text, as shown above, is more abstract than many other forms of text. It is noted to have a high degree of nominalized verbs, unfamiliar technical terms, and complex sentence structure (Halliday & Martin, 1993). In addition, it is also multimodal, meaning that it utilizes graphics, charts, and diagrams to explain a given concept fully. Students must interpret both language and visual elements. Most students arrive at the science teacher's classroom knowing how to read, but few understand how to use reading for learning science content (C. Shanahan et al., 2011). Teaching content literacy is important since being able to read and comprehend the material has such a strong association with achievement and success. Additionally, understanding the text structure for science material is an important component to comprehension. The layout of the text often

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provides clues to the reader about terminology, how the content is organized and the general flow of the information. Unfortunately, very little time is utilized to teach interpretation of the structure of the text so that it may benefit the reader (Ness, 2006).

Vocabulary

The average chemistry text book contains more than 3,000 new vocabulary terms (Holliday, 1991). The terms are usually unfamiliar and difficult to understand (Nair, 2007). These unfamiliar terms often decrease the motivation of students and affect students' perceived abilities to understand the material (Mikk & Kukemelk, 2010). As Shanahan and Shanahan (2008) indicated, "Science texts have a high degree of lexical density" (p. 53), meaning they have many vocabulary words embedded in clauses. The following was taken from a chemistry textbook, *Modern Chemistry* (Davis et al., 2002).

> Nonpolar and polar-covalent bonds are compared in Figure 6-3, which illustrates the electron density distribution in hydrogen-hydrogen and hydrogen-chlorine bonds. The electronegativity difference between chlorine and hydrogen is 3.0-2.1 = 0.9, indicating a polar-covalent bond. The electrons in this bond are closer to the more-electronegative chlorine atom than to the hydrogen atom, as indicated in Figure 6-3 (b). (p. 215)

Unlike most common readings students would encounter, this scientific sample illustrates multiple unfamiliar and specialized terms. To fully understand this passage, students must first have a complete understanding of the terms listed. This small passage contains four complex and generally unfamiliar words: nonpolar, polar, covalent, and electronegativity. When students encounter these complex words, they are often left feeling discouraged and frustrated (Mikk & Kukemelk, 2010). Nominalization of vocabulary can be seen here as well. Nominalization is where adjectives and verbs are turned into nouns (Halliday & Martin, 1993). Electronegative is used to describe an atom as an adjective and it is also used in the form of a noun as electronegativity, the state of

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being electronegative. Nominalization is used by science to transition from the specific to the more abstract. However, this tends to make the text more difficult to read because they hide the main action of the sentence (Fang & Schleppegrell, 2008) and makes it more difficult for high school students to comprehend (Shanahan & Shanahan, 2008).

Graphics

The previous passage, along with many others, require students to reference a visual diagram in order to develop full understanding of the concept. While visuals may help a great deal of students due to their method of learning, they may also be a hindrance if students do not take the time to analyze and understand the material. To understand the following figure, students must read the caption and apply the meaning to two different pictures. Students must also understand that the shaded areas are representing the electron density and that the darker areas represent higher electron the density. However, that information is not directly stated in the figure caption. Furthermore, students must have prior knowledge regarding the meaning of density. Analyzing information from this figure requires students to pause their text reading and take time to interpret the information from the figure and the caption.

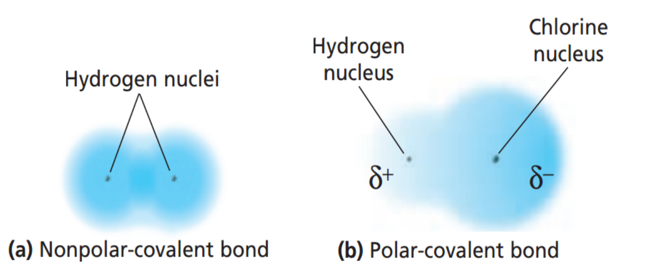

FIGURE 6-3 Comparison of the electron density in (a) a nonpolar, hydrogen-hydrogen bond and (b) a polar, hydrogen-chlorine bond. Because chlorine is more electronegative than hydrogen, the electron density in the hydrogen-chlorine bond is greater around the chlorine atom.

Figure 2.1. Figure interpretation.

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As Pinto and Amettler (2002) indicated, visuals can often be confusing due to their lack of full explanations. They may also lead to misconceptions. The figure uses a new symbol, sigma, to indicate partial charge. However, the text alongside the diagram does not mention its use or purpose. Visuals may increase cognitive load which then will interfere with the processing of information (Kirschner, 2002). The amount and type of information presented along with a graphic may help or hinder the student's ability to further comprehend the text. The overuse of information in graphics is often found to be frustrating and therefore inhibits the students' ability to read and interpret the graphic (McTigue & Flowers, 2011).

In addition to figures, students are also required to read and comprehend information in tables and graphs. The following figure shows a table that students would be required to read and analyze to develop a full comprehension regarding bond lengths and energies. The bonds are shown by lines between the two atom symbols in the left column. Additionally, students must recognize that four types of bonding are presented; carbon to carbon, carbon to nitrogen, carbon to oxygen, and nitrogen to nitrogen. From the chart, students are required to interpret that double and triple bonds are shorter in length and their energies are higher when compared to single bonds. Readers should also recognize that trend applies regardless of the type of atoms that are bonded together. This table could be confusing to students due to the amount of information presented as well as the fact that the table is split into two sections. To fully understand and interpret the information, students would need to carefully read the title, headings, and analyze the types of bonding present. Again, this requires the reader to take additional time to

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analyze the table, interpret it's meaning and use the information to develop a comprehensive understanding of the material presented.

TABLE 6-2 ***Bond Lengths and Bond Energies for Single and Multiple Covalent Bonds***

Bond	Bond length (pm)	Bond energy (kJ/mol)	Bond	Bond length (pm)	Bond energy (kJ/mol)
C−C	154	346	C−O	143	358
C=C	134	612	C=O	120	732
C≡C	120	835	C≡O	113	1072
C−N	147	305	N−N	145	163
C=N	132	615	N=N	125	418
C≡N	116	887	N≡N	110	945

Figure 2.2. Table Interpretation.

Prior Knowledge

As previously indicated with the figures, a student's level of prior knowledge also plays an important role in their level of scientific literacy. Comprehension is influenced by the extent of overlap between the reader's prior knowledge and the new content of the text (Palincsar & Brown, 1984). When students integrate new knowledge into an existing schema, they must be able to active their prior knowledge (Cromley et al., 2010). Students must be able to grasp and make sense of new information in light of what they already know (Barton & Jordan, 2000). Brill et al. (2007) found in their study that comprehension was more difficult for students when the text did not match their prior knowledge. In other words, if students cannot identify with the text, it is more likely they will have trouble connecting to the new information. The level of prior knowledge may also play a role in the ability to comprehend new information. Students with a higher level of prior knowledge are often able to notice more details in the text as well as graphics and therefore develop a higher level of comprehension (Cook, 2006). In their

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study, Cook (2006) determined that students without a strong prior knowledge background often looked over diagrams and text, assumed their interpretation of the material was correct, and moved on to the next topic. However, students with higher levels of prior knowledge tended to question the material and try to make more connections to establish a richer understanding of the material. It is important to engage the student and activate their prior knowledge in order to construct new knowledge (Bybee et al., 2010). Activating prior knowledge and checking for a student's level of understanding allows the teacher to prepare the students for what they are about to read so they can make connections and improve their level of comprehension (Bybee et al., 2010).

Reading Comprehension as Scientific Practice

Reading comprehension is strongly associated with scientific achievement. Students that have difficulty reading and comprehending science related information on their own show lower levels of academic achievement (Cromley et al., 2010). According to the Program for International Students Assessment (1998), scientific literacy is the capacity to use scientific knowledge to identify questions and to make conclusions in order to understand phenomena about the natural world and its changes. Holliday (1994) states that it is important for students to be able to locate and comprehend scientific information and be able to communicate ideas. The process of reading comprehension in science requires a scientific methodological approach. Ratzel (2004) states, "Reading and science are process disciplines that use many of the same techniques. Science teachers can use these science skills to help students construct meaning from texts" (para 3). Identifying the existing information, being actively involved, and the processing of

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information are required for both scientific inquiry and reading comprehension (Ratzel, 2004). As Armbruster (1993) concludes, the same skills that make good readers also make good scientists. These skills include engaging prior knowledge, forming hypotheses, establishing plans, evaluating, determining importance, and making generalizations to only name a few Reading and science are both inquiry processes. Therefore, science teachers can teach both the concept of the scientific method and scientific reading but modeling the process first hand.

The 5E Model

The NRC's *How People Learn* has examined, across disciplines, what processes occur when people learn (NRC, 1999). Their findings suggest that people must be engaged, involved, and they need opportunities to apply what they have learned (NRC, 1999). According to Bybee et al. (2010), in agreement with Dewey (1971) and many others, there is an order in which the events of learning should occur. As previously stated, the use of instructional models and activities is not new to education. In fact, the Biological Science Curriculum Study (BSCS) 5E model describes three phases of inquiry that are similar to the scientific method: exploration, invention, and discovery. In general, students have an initial experience; they are then introduced to new information and terms regarding the experience; and then they are able to apply the gained knowledge to a new situation (Bybee et al., 2010).

The 5E model showcases how ideas of the scientific method can be applied for scientific learning and reading. Engagement, the first phase, allows students to "focus on an object, problem, situation, or event" (Bybee et al., 2010, p. 8). Teachers can initiate engagement by asking a question or showing an object, event or problem. The engagement phase piques the student's interest. It not only activates prior knowledge but

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it also provides the teacher with a visual of the student's current ideas (Tanner, 2010). Teachers will know that engagement is successful if the student has more questions, seems intrigued, or is puzzled.

Following the engagement, students will begin to explore the ideas. This concrete and often hands-on phase uses activities that will help clarify any misconceptions and also ensure that all students have a solid foundation on which to build new knowledge. "The aim of the exploration activities is to establish experiences that teachers and students can use later to formally introduce and discuss concepts, processes, or skills" (Bybee et al., 2010, p. 9). This is the ideal time for student meta-cognition. It is a chance for students to realize what they know and what they do not know (Tanner, 2010).

After the misconceptions are cleared and all students have a firm base of knowledge, students may then begin the explanation phase. During this phase the teacher directs attention to specific aspect of the engagement and exploration phase. Explicit and direct explanations are provided in a way to order the exploratory experience (Bybee et al., 2010). "The key to this phase is to present concepts, processes, or skills briefly, simply, clearly, and directly and to move on to the next phase" (Bybee et al., 2010, p. 9). Tanner (2010) explains that this phase is the most common occurrence in college and university settings. It is often the basis of instructor-led lectures. Techniques such as direct instruction are sufficient; however, other methods such as videos, courseware and guest speakers may also be used.

The elaboration phase is intended to elaborate on the concepts. "This phase facilitates the transfer of concepts to closely related but new situation" (Bybee et al., 2010, p. 10). Group interaction is often used for discussions and cooperative learning.

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Other activities include assigning new problems for analysis, mini-projects, or students may be asked to design new problems (Tanner, 2010). This is a time in which any misconceptions that exist may be clarified. The goal is to allow for generalization of concepts, processes and skills (Bybee et al., 2010).

The final step of the process, evaluation, allows for assessment of understanding. This phase may vary from teacher assessment, self-assessments, or peer assessments (Tanner, 2010). The most important part is that students receive feedback on their adequacy and explanations (Bybee et al., 2010).

While the 5E model was developed to help K-12 science teachers in achieving more effective lesson plans and teaching, Barton and Jordan (2000) used the ideas to develop a book, *Teaching Reading in Science.* Barton and Jordan (2000) state,

> Science teachers are encouraged to use the 5E approach or instructional models that share these components to build students' in-depth understanding of science concepts and strengthen their thinking skills. Reading science text and other materials is an important part of this process. (p. iv)

In agreement with Armbruster (1993) and Ratzel (2004), the authors believe the skills required for good scientists are the same skills required for scientific comprehension. Per Moje (2008), these content-specific skills are what enable students to be successful readers and therefore obtain higher levels of achievement.

Literacy Strategies

While it is necessary to prepare teachers for content specific literacy and there is clear evidence that each content utilizes literacy in different formats, there is still much debate on what learning processes for comprehension are of best practice. As the previously stated research has shown, most scholars agree basic literacy strategies applied to all forms of content are not sufficient. As Palincsar and Brown (1984) state, "One

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daunting problem for those who would engage in the explicit instruction of comprehension skills is that there are so many putative strategies, descriptions of which are often quite vague" (p. 120). However, many researchers agree on some basic underlying activities that should be considered. These activities consist of; understanding the purpose of the reading, activating prior knowledge, emphasizing major concepts over trivial details, evaluation of material for consistency, monitoring comprehension, and drawing inferences (Palincsar & Brown, 1984).

Cognitive processes that involve self-organization of knowledge, mainly constructivism, encourage the learner to build or construct their own knowledge (Brill, Falk, & Yarden, 2007). Constructing information from various forms of text is a complex skill. It involves the "complex interactions between the reader's mind and the text, rather than a one-way flow of information from the write to the reader" (Holliday et al., 1994, p. 15). Comprehension is also influenced by the extent of overlap between the readers' prior knowledge and the content of the text. While reading any form of text for comprehension, the reader must understand how to read for the content while also assessing their mental operations to ensure understanding (Palincsar & Brown, 1984).

With the underperformance in science in the United States, improvement of reading comprehension is critical for science achievement (Otero, Leon, & Graesser, 2002). There is much debate on the exact skills that are needed for comprehension for each discipline. However, most researchers agree that comprehension is a complex phenomenon that is need of being addressed and a one size fit all model is not a probable solution.

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Students are sometimes likely to read without understanding and reading is not the same thing as comprehension. Comprehension, as described by Snow (2002) is "the process of simultaneously extracting and constructing meaning through interaction and involvement with written language" (p. 11). In order for students to be successful readers, and comprehend meaning from the text, they must be able to monitor their comprehension. Comprehension monitoring is a process by which students continually check their reading comprehension while they read (Chamot & O'Malley, 1994).

Before students can comprehend, they must have an understanding of text structures, titles, headings, bolded terms, captions, and much more. "Textbook writers incorporate text structures believe that the reader will use these supports in order to effectively make sense of the text" (p. 60). When students are not aware of the intended supports, they are often left more confused and overwhelmed by the amount of information. Schoenback (1999) explains the importance of engaging students in reading strategies. It may be assumed, the author states, "Simply telling students about a text is a sufficient pre-reading strategy, but it is incorrect to assume that only a brief lecture about the reading will push struggling readers to engage with the text in their own minds" (p. 63). This method causes struggling readers to continue their same ineffective strategies with no intervention.

In their study, Block et al. (2009) looked at the most commonly used literacy approaches and how they affected the readers' comprehension level. Their findings support the idea that teachers must provide both independent and guided reading practice. In addition, providing time for readers to develop their skills of using the comprehension

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strategies has proven beneficial for students to develop more confidence and being successful.

Driscoll (2005), stated, “[Cognitive strategies are] the way that learners guide their own learning, thinking, acting and feeling” (p. 362). Mere reading results in superficial comprehension (Brill, Falk, & Yarden, 2004). In order to move beyond the superficial reading and acquire a more complex understanding, students must be able to monitor their own progress as they read (Gajria, Jitendra, Sood, & Sack, 2007). Skillful readers use multiple strategies to comprehend multiple forms of information. However, in order to be successful, student must first be aware of these strategies. Before, during, and post reading activities help students to ensure learning and assessment of learning from beginning to end.

Pre-Reading Strategies

Following the ideas of the 5E model, pre-reading strategies are designed to activate comprehension and engage the students for what they are about to learn. This study utilized a pre-reading activity in order to introduce the students to the new material. Both science and literacy require student engagement for success. For this study, students were given an anticipation guide prior to their assigned readings. Anticipation guides provide a structured form for students to think about key concepts and identify any misconceptions before they begin to read new information. Students were required to read five statements and mark whether they agreed or disagreed then discuss their responses with their peers. These statements were both literal statements from the text as well as interpretive statements that required the students to investigate. The goal of an anticipation guide is not to get the right answer, but rather to elicit discussion and identify

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misconceptions (Osborne et al., 2016). Anticipation guides help students see, per Schoenbach (1999), "Instead of simply an assignment, reading becomes part of an ongoing conversation students have joined" (p. 66). The purpose of the engagement activity will be to generate interest, activate prior knowledge, and prepare their minds to engage in the text. Post-reading students may revisit the anticipation guide to reevaluate their understanding. Additionally, these statements help students to work on their skill set of citing textual evidence to support their ideas and thoughts (Osborne et al., 2016).

During Reading Strategies

During the reading process, the students should apply comprehension strategies to "make connections, monitor understanding, and stop to ask questions" (p. 70). A teacher may model how to effective read and think about a passage, however, students need to engage in the practice to improve their comprehension and metacognition. Osborne et al. (2016) call these tasks that are directly related to the text, *DART's*. The main focus of during-reading activities is to help students "monitor their evolving comprehension of a passage" and "recognize how the information is organized" (p. 40). The coding of text is one method that can be used during reading. Coding requires the reader to mark information as they read, a strategy that allows science students to organize their information into categories. Coding is an example of what the 5E model describes as "exploring" the new information. For this study, the students were given four codes of analysis. As they read, they were to identify statements according to their thought processes. A check mark was used to identify information that confirmed what the reader already knew. When the student encounters information they are comfortable with and understand, they can check it off and move on. A question mark was used by students to

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indicate information that was puzzling or they did not understand, and an exclamation point is used to identify information the students feel is important. Coding the information allows students to organize the information and focus on the material that needs clarification and additional assistance. This strategy is “highly effective in helping students engage in metacognitive comprehension strategies,” per Osborne et al. (2016, p. 70).

Post-reading Strategies

The process of engagement does not stop after the reading is complete. “To truly foster the active reading and writing skills that carry students to academic achievement, you must guide students as they process information they have read” (p. 74). A concept map is a graphic organizer that can be used after the reading is complete. Developed by Schwartz (1988), concept mapping is a strategy that allows students to graphically organize information for an overall understanding (Barton & Jordan, 2000). It gives students the opportunity to, according to the 5E model, “explain their understanding and “elaborate” by citing examples from their own experiences” (Barton & Jordan, 2000, p. 50). This phase allows students to clarify any misconceptions that may have developed from the new knowledge (Bybee et al., 2010). It also allows students to apply their gained knowledge with similar problems. “Generalization of concepts, processes, and skills is the primary goal” (Bybee et al., 2010, p. 10). Concept maps are tools for “organizing and representing knowledge” (p. 72) that show relationships between two or more concepts. Students can use the coded and categorized information to re-organize the information in way that demonstrates connections among concepts. The construction of a concept map helps students to brainstorm ideas and generate new ones. It allows them the opportunity to integrate prior knowledge with new knowledge. Struggling

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readers need opportunities to "flex their metacognitive muscles" (Bybee et al., 2010, p. 76) by identifying themes and key points after reading has ended. In order to assist students in the processing of new knowledge, it is important that the teacher provides opportunities for discussion and/or correction of the concept map. If given the opportunity to "evaluate" their own work, students are more likely to remember and make sense of the meaning.

Transitioning Beyond High School

These independent learning skills are important for students as they transition through high school into college and their future careers. Having a bank of knowledge is nice, but the ability to independently process new information creates students who can be life-long learners. The College Board (2017) noted that there are essential skills that student need for future success. These skills include, but are not limited to, critical thinking, problem-solving, self-advocacy and independent learning. College entrance exams like the ACT and the SAT are designed to assess students on their college readiness based on what they learned in high school (ACT, 2014). These tests assess students on what research has proven to be the most important skills and facts for academic success in postsecondary education. For science, the ACT focuses on interpretation, analysis, evaluation, reasoning and problem-solving skills, all the skills required by natural scientific experts in the field. The focus is not on scientific facts and memorization, but rather the skill sets of reading comprehension and analysis of information (ACT, 2014). In order to achieve a high score on the ACT science section a student must be able to "quickly read and analyze scientific data" (p. 7). To read and analyze quickly, students need practice with comprehension and analysis with scientific

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text throughout their high school experience. Colleges have found these skills more important for academic success than a bank of knowledge. Therefore, it is the responsibility of the high school science teachers to prepare students with reasoning and comprehension skills not only for the ACT, but also for college (Osborne et al., 2016). "If students are to read to learn science, they must also be taught how to learn to read science" (Osborne et al., 2016, p. 44).

The science section of the ACT contains forty items to be answered within a thirty-six-minute time frame. This gives students an average of fifty-three seconds to answer each question. The curriculum covers biology, chemistry, physics, earth, and space sciences. Three categories of questions are used for assessing knowledge; data representation, research summaries, and conflicting viewpoints (ACT, 2014). Three cognitive levels are required to understand and answer the questions; understanding, analysis, and generalization. Scoring high on the science section is more about the student's ability to read and analyze information than it is to identify scientific knowledge. Students are not given time to grapple with the information or reflect on the information. But, instead, they are expected to be able to read and comprehend the information quickly and efficiently. They are not expected to be experts in the content, but rather demonstrate reasoning and comprehension skills.

As Bar-Yam (2002) pointed out, a shift in classroom instruction is needed to prepare students for their future academic and career success. A focus on independent learning skills incorporated within each discipline is one way to better prepare our students to be life-long learners.

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Gender and Science: Socially Constructed Norms

Following the ideas of Bar-Yam (2002) as well as ideas of the constructivist theory, research shows that a shift from teacher-centered classrooms to student-centered classrooms also provides a more equitable education when it comes to gender. This action research study utilized a co-ed classroom and the data was analyzed as a whole but also reviewed based on gender differences. It is important to note the gender differences that occur in both the field of science as well as the learning styles associated with science materials.

The history of oppression of women in science still plays a role in the make-up of the workforce today. As Evelyn Fox Keller (1995) writes, "Both gender and science are socially constructed categories" (p. 3). She explains that science is a set of practices that are dependent on social aspects of ourselves. The scientist's beliefs and experiences play a vital role in their research. Gender, masculine and feminine categories, are also defined by culture. Gender norms influence scientific research and therefore continue to reinforce inequity between men and women. The roles for both males and females have been determined by society when it comes to science curriculum and careers. However, these society created norms are not static, and can be challenged.

The field of engineering is not only dominated by but also highly associated with the male population. These norms and associations send messages to females to keep themselves in check and stay in their place. Women are often seen as passive individuals that lack certain qualities of men, therefore making them less capable and less valuable in certain fields such as math and science (Tuana, 2008). Society has set norms and expectations for maleness making it a category of privilege and therefore making females

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oppressed. Science curriculum continues to support this privilege oppression relationship by continuing to focus on gendered messages, using research practices that are male-biased, and failing to recognize that scientist's experiences play a role in their research.

These socially constructed norms often interfere with girl's self-confidence and self-esteem. In 1992, the American Association of University Women (AAUW) published a report entitled, *How Schools Shortchange Girls*. This report showed that male and female students do not receive identical or equal educational experiences. Specifically, girl's needs are not being met with curriculum or instructional strategies. The educational experiences of girls are still being marginalized or ignored in many classroom texts. While the discrepancy between girls and boys in math is smaller and declining, that is not the case for science. The achievement gap between girls and boys is increasing. Girls often view science as "something men do" which leaves them feeling disadvantaged and lowers their self-esteem (p. 4).

Unless gendered stereotypes are challenged, girls will continue to feel inferior when it comes to their importance or ability in science. Maher and Tetreault (2001) described the characteristics of a traditional classroom. In the traditional setting, learning environments are competitive. Curriculum is dictated to students and students have specific roles to play in order to achieve success. Achievement, or lack thereof, is measured by the teacher and the student is given no control over their own learning process. In addition to the learning environment, the curriculum itself is often biased toward maleness and geared for male success. For example, science texts often portray important male scientists and how their work has impacted history and our daily lives, while women scientists are often left out, ignored, or minimalized (Maher &Tetreault,

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2001). The lack of empowerment to female students in science often discourages them from enrolling in higher level courses, feeling confident in their abilities, and pursuing STEM related fields for careers.

In order to change the dynamic and provide equitable science education for both male and female students, these stereotypes and assumptions must be deconstructed. Maher and Tetreault (2001) suggest that to provide equal opportunities to girls in science education, a shift from the traditional classroom to the feminist classroom is needed. In a traditional, male biased classroom, science instruction is delivered by the teacher, students play their roles as receivers of information, and the teacher assigns the grade based on his/her opinion of student performance. Students are taught what to think instead of how to think. The feminist classroom would shift the focus from the teacher to the student. A student-centered classroom focuses on collaboration, sharing experiences and knowledge, and examining data from multiple perspectives. A feminist classroom values students' experiences and provides opportunities for the student to take control over their own learning. They define their own role in the classroom and the teacher is viewed as an assistant to the learning process instead of the director. Students are taught to question material, interpret information from their own experiences, and collaborate with others to interpret information and draw conclusions. In the real world, scientists are required to collaborate, network, peer review, and dialogue across differences. Classrooms that incorporate similar experiences for students are not only preparing students to be future scientists, but also challenging the gendered stereotypes that currently exist.

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Conclusion

This action research study utilized the look, think, act model (Stringer, 2007) to examine the impact of the SRIM on student's ability to read and comprehend scientific text. The SRIM consisted of three reading strategies selected by the researcher-participant and the teacher-participant based on their perceived effectiveness with scientific material.

Research shows that students are taught basic reading strategies in the primary grades. However, these strategies are not effective for more complex expository texts that students encounter in high school. Many reading strategies exist but the application of basic level strategies to all content has proven to be ineffective (Shanahan & Shanahan, 2008). Instead, research shows that a discipline specific approach to reading would be more effective in improving comprehension (Moje, 2008).

In order to improve scientific literacy, teachers need training on how to facilitate change and enable their students to become more independent learners (Bar-Yam, 2002). Teachers need to assist students when it comes to activating their prior knowledge (Barton & Jordan, 2000) and construct their own meanings based on experiences with the context. Teachers can facilitate this change by implementing strategies that require students to evaluate and monitor their own comprehension (Palincsar & Brown, 1984). This action research study utilized three strategies that made up the SRIM. This model was designed to equip students with strategies that would enable them to independently think and monitor their own comprehension.

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Chapter 2 provided a summary of the literature used for this study. Chapter 3 describes the methodology used for this quantitative action research. It details the design of the study including instrumentation and the data collection process.

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CHAPTER 3. METHODOLOGY FOR QUANTITATIVE STUDIES

Introduction

The present study is a quantitative investigation of how the SRIM used in the honors chemistry curriculum may impact student's ability to read and comprehend scientific text. This study was conducted with eighteen tenth grade students enrolled in honors chemistry at a private high school in southeast South Carolina.

With a high level of underperformance in the United States, improvement in reading comprehension is critical for science achievement (Otero, Leon, & Graesser, 2002). Students today are not equipped with reading strategies that enable them to independently comprehend more complicated expository texts such as their science book (Shanahan & Shanahan, 2008). Therefore, this study examines the impact of three complex reading strategies, collectively referred to as the SRIM, on student-participant's ability to read and comprehend scientific text.

Using the concepts of the scientific method, I explored the impact of the SRIM in the honor's chemistry curriculum on student's ability to read and comprehend scientific text. The present study contributes to the research on scientific reading because it focuses on improving skills sets needed for reading comprehension. The research reviewed has focused on reading strategies intended for general purpose, the need for improvement in scientific literacy, and importance of teaching practices regarding scientific reading. These research studies used quantitative methods to analyze student performance when students use common reading strategies (Mikk & Kukemelk, 2010)

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and the impacts of multimodal text on comprehension (Pinto & Amettler, 2002). The previous studies have identified the need to examine how science specific reading strategies may impact student comprehension.

As the researcher-participant and the curriculum director for our district, I am interested in reviewing methods that may help students improve their academic abilities and become independent life-long learners. I have worked as a science teacher for ten years teaching various subjects from biology, chemistry, and anatomy and physiology. I have taught both low level students as well as courses for the International Baccalaureate Program and Advanced Placement. I taught at both private, high socio-economical schools as well as public and low socio-economical settings. Additionally, I have served on a variety of school committees and science department chair. I have observed both teachers and students and their methods of teaching and learning. I double majored in biology and chemistry for undergraduate studies, then obtained master's degrees in both biology and education. Being a long-time science student and teacher, I have a personal understanding of what students face and the feelings they may encounter in dealing with science material.

I remember the feelings I experienced when reading my college science text for the first time. The book was overwhelming. The text included diagrams, figures, charts and fine print text with subtext for every picture. It seemed impossible to grasp all the material. Before entering college, I was a successful student who graduated high school with high honors, had multiple scholarships, and felt confident in my own abilities. My first science class in college was a rude awakening as I realized how underprepared I was for independent reading and learning. As a teacher, I have seen the same expressions and

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heard the same comments from my high school students. Some students shut down and lose interest in anything related to chemistry.

The framework of the 5E Model (Bybee, 2006) and the manual for scientific reading (Barton & Jordan, 2001) helped guide the development of the SRIM and this action research study. While multiple research studies exist regarding basic reading strategies, these strategies are not designed to help students comprehend the amount and level of information that exists in a standard high school or college text book (Shanahan & Shanahan, 2008). For this specific study I investigated three methods that may help students improve their scientific literacy, which in turn will help prepare them for college and beyond.

Research Design

This action research study utilized a quantitative model for the primary data collection. Quantitative data was collected from a pre-test (Appendix A) and post-test (Appendix B) design. To determine the impact of the SRIM on student comprehension, a pre-test was given prior to the treatment and a post-test was administered after the treatment ended. The pre-test and post-test scores were compared individually, averaged for whole-class comparison and disaggregated based on gender. Using pre-and post-test instruments allowed for data to be collected “from numerous individuals simultaneously” (Mertler, 2014, p. 138). This data collection allowed the researcher-participant and the teacher-participant to directly answer the research question and measure the impact of the SRIM on student comprehension. An increase in the mean score from the pre-test to the post-test could indicate the SRIM was effective for improving student’s ability to read and comprehend scientific text.

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The pre-test/post-test design measured the student's ability to answer questions based on their comprehension of the scientific reading passages presented. The post-test, of similar design to the pre-test, measured their ability level after the treatment had been implemented. Comparison of the before and after scores allowed the researcher to determine if the SRIM impacted their abilities. While outside variables play a role, a net gain in score would indicate improvement in comprehension.

Qualitative data was collected to possibly enhance the primary quantitative data. Semi-structured interviews (Appendix C) were conducted with the student-participants at the end of the treatment to gain insight into their perceived effectiveness of the SRIM and its impact on their level of reading comprehension. However, using a qualitative approach as the primary data source would not have allowed the researcher to directly answer the research question. Qualitative data such as student opinions, observations and interviews alone would not provide concrete evidence for determining if the SRIM was effective for improving comprehension levels.

Researcher

For this action research study the data was collected and analyzed by both myself, the researcher-participant, and Mrs. Brown, the teacher-participant. The role of the action researcher is to "systematically inquire into one's own practice" (Mertler, 2014, p. 4). Researchers are participants and neither Mrs. Brown nor myself were "disinterested outsiders" (p.20). We were both interested in developing a better understanding of the learning process, testing our theories and ideas about selected reading strategies, and connecting theory to practice. Together, we reviewed the research and comprehension

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strategies commonly used for scientific text, selected three strategies we felt were most appropriate then developed and implemented the SRIM.

All students were informed about the study and we received their permission to be involved. Mrs. Brown explained how this study is reciprocal in that it is designed to help improve their reading comprehension but also provide more research on the effectiveness of the selected reading strategies. To maintain reciprocity with the students, all data collected was shared in a timely manner and the results were discussed with the class.

Mrs. Brown administered the pre-test to her students during class before the start of a new content unit. I scored the tests and reviewed the results with Mrs. Brown. She then reviewed the results with the students one day later. At the end of the treatment, a post-test was administered and the results were shared in the same way. Mrs. Brown and I spent several hours after school analyzing both the pre-test and post-test scores. We also worked with the AP Statistics teacher to further analyze the data. The final quantitative results and findings were also shared with the student-participants.

In addition to quantitative data collection, we also collected qualitative data in the form of semi-structured interviews. I conducted the interviews at the end of the study and noted the responses from each student. Mrs. Brown and I reviewed the responses, identified themes and used the constant comparative method to apply the results to the quantitative data (Mertler, p. 2,014). Finally, Mrs. Brown and I presented all findings to the students during class and their feedback was solicited through a whole-class discussion.

Throughout the study, we used monitoring strategies during the study to help identify areas that needed immediate attention and action. I kept an informal journal of

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activities including the lesson plans for the unit used for the study, schedules, and informal conversations with Mrs. Brown. These reflections allowed us to identify our observations and make modifications where needed. In addition, Mrs. Brown also reviewed our study before, during, and after the treatment to provide insight. Her observations and feedback were imperative to the research as she deals with the students daily and has a better understanding of their innate abilities and attitudes.

Sample

This research study took place in a private high school in southeast South Carolina. According to the U.S. Census Report (2016), the city population is 125,458 with a mean household income of $61,993 compared to the state income average of $47,238. The report describes the city population as being comprised of 71.6% Caucasian. This setting is appropriate for this study because there is a large emphasis on STEM related careers. The area is home to a major-medical research institution as well as international industries. There are many jobs in the research area that pertain to health, medical, engineering, and technology. In addition, many students in the study come from families that are involved with medical or technological careers.

The school where the research occurred has a population of 702 students with 49.9% female and 50.1% male. The school has a total minority population of 16% that consists of Asian, Black, Hispanic, Native American, White and two or more races. The tuition rate is roughly $12,000 per year of attendance, with 19.3% of the population receiving some form of need-based assistance. Twenty-four percent of the population has a diagnosed disability that may range from dyslexia, attention disorders or severe and profound disabilities such as autism or Downs syndrome.

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The selected sample consisted of eighteen students enrolled in 10^{th} grade honors chemistry for the 2016-2017 school year. The population consisted of 61% female and 39% male students. One student was Black and the other seventeen were White. All students had their own computers and access to the internet at both home and school. Many students also utilized other technological devices such as iPads, eReaders and cell phones during class time. All students have access to the course textbook online as well as a printed copy of the unit text for coding.

The sample for this study was chosen based on convenience. Convenience sampling is a non-probability method where participants are chosen based on their availability (Mertler, 2014). First, the school was chosen based on the teacher-participant, Mrs. Brown, and our collaboration efforts as fellow chemistry teachers. While I was the chemistry teacher for a different private school, I took a new job and I am no longer in the classroom setting to conduct the research. No specific criteria had to be met to participate in the study other than being enrolled in the honors chemistry course at the high school. The honors chemistry course was also chosen based on convenience. Mrs. Brown, the teacher-participant, taught two sections of general level chemistry and one section of honors level. To contain the study to one class and provide fair treatment, Mrs. Brown preferred to use the honors level course for the study. She felt that conducting the study with only one of the two general courses would not be fair to those students who were in the other general section. Mrs. Brown wanted to make sure all students in the section received the same treatment. If the SRIM proved effective, one group would receive the benefit and the other would not. She was fearful that parents may be upset if their child was not in the general courses selected. Additionally, she did

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not want to run the study with two courses at the same time. Therefore, selecting the one and only honors course helped eliminate these concerns. Using one section, as opposed to two, allowed the teacher-participant to work more closely with the students during the implementation of the SRIM. However, a smaller sample size does increase the margin of error. Since this is an action research study and the results are not generalizable to the larger population, this sample was determined to be the best fit.

To abide by ethical standards, permission for the study was granted by the principal, academic dean and teacher-participant of the school. Each student signed and returned a consent to use data form. The informed consent form described the "nature of the research study as well as the level of involvement of the participants" (Mertler, 2014, p. 108). Because the students were not of legal age at the time of the study, a parent consent form was also required. As Mertler (2014) states, "[Data must be] kept secure and confidential" (p. 151). Therefore, the names of the students were not used in this report. To provide fairness to all students, a control group was not used for the study and all participants received the same treatment. While standard daily activities continued to count towards the student's course grade, students were not rewarded or penalized based on the data from pre-tests and post-tests.

This study followed the principle of beneficence which states that the study was conducted "to acquire knowledge about human beings and the educational process" (Mertler, 2014, p. 108). It is assumed that if the SRIM is effective, students will benefit from the study. The researcher also benefits from the study by gained knowledge regarding the effectiveness of the SRIM. The principle of honesty was also followed throughout the research process. The study was organized, data was collected and

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analyzed on sound principles. The researcher-participant and the teacher-participant were honest about the implementation, data collection and analysis procedures. Finally, this study supports the principle of importance meaning that it was conducted with beliefs that the findings would be useful in the field of education.

Reciprocity

This study was conducted with a teacher-participant, Mrs. Brown. Mrs. Brown and I have worked together as fellow chemistry teachers for the past four years. We have attended trainings and conferences together including our week long advanced placement chemistry training. We have spent a great deal of time working together on lessons, lab plans, and assessment formats. Mrs. Brown and I have a friendly and professional working relationship and share a love for helping our students be successful.

Mrs. Brown has a doctoral degree in the field of chemistry and worked as a scientist for five years before entering the classroom. Her advanced degree and understanding of the material helps her to serve as a role model for future scientists. She focuses on empowering all students, but especially female students like herself who are often viewed as an accessory to the man's world of science. Mrs. Brown believes in helping all student achieve success and empowers her students to take risks and think critically. She has the desire to better serve her students and recognizes the need to make changes to her instructional practices. She does not have a degree in education and therefore, she desires to learn more about instructional strategies to help her students be successful in her classroom and prepare them to be lifelong learners. Additionally, Mrs. Brown, through her college level teaching experience, agreed that students lack the ability to comprehend text when they take college courses. For these reasons, I felt Mrs.

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Brown was an excellent teacher-participant for the study. We discussed and agreed upon the strategies to be used as part of the SRIM in hopes of improving student's reading comprehension ability, and therefore their science achievement.

Reciprocity was established with both the teacher-participant and the student-participants. The relationship between the researcher-participant and the teacher-participant was reciprocal in that the researcher was provided with an opportunity to implement and review reading comprehension strategies for scientific comprehension. The data collected was important to the researcher-participant in that it would either support or negate previous research on scientific literacy. The teacher-participant benefited from the research study in that it provided her with an opportunity to implement new teaching strategies that may better serve her current and future student populations. She could learn, implement and analyze the effectiveness of the strategies chosen for the SRIM. The relationship between the researcher-participant and the teacher-participant was reciprocal in that it was a "relationship in which each contributes something the other needs or desires" (Trainor & Bouchard, 2010, p. 986). The researcher-participant needed a setting for the study and the teacher-participant desired assistance in changing her instructional methods. The reciprocal relationship was established and enhanced by mutual involvement throughout the study. Mrs. Brown was involved in the creation, implementation and analysis of the SRIM. Her feedback helped drive the study and provided insight for adjustments that were needed as the study progressed. She was also involved in the creation of the action plan and will be the person responsible for carrying out the plan with support from her department. Her desire to change her instructional

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methods for the betterment of her students is what made her an excellent candidate for this study.

Similarly, the relationship between the researcher-participant and the student-participants was also reciprocal. The students had not been exposed to textbook reading during the course of the year with Mrs. Brown. As the research indicates, independent reading skills are needed for future academic success. Therefore, the students received an added benefit from the study in that it provided them with strategies they may use to breakdown complicated text. The researcher-participant benefited from this relationship because the students provided data that could be used to determine the effectiveness of the SRIM. Again, this reciprocal relationship was established and maintained by keeping clear communication with the student-participants at all times. Their opinions of their perceived effectiveness of the study were also gathered and reviewed with the quantitative data. In addition, they provided ideas and suggestions for the development and implementation of the action plan. The interconnectedness and reciprocity between the researcher and the participants, both teacher and student, showcase how this action research was designed to "help participants understand and change their situation" (Robertson, 2000, p. 311).

Instrumentation and Materials

The National Research Council (NRC, 1999) analyzed decades of research about how people learn. They concluded that people must be interested and engaged in the material. They must actively be involved in the process of constructing new ideas, and they need opportunities to apply what they have learned to new situations (Tanner, 2010). The 5E model, based on a conceptual change model and a constructivist view of learning,

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states there are five key elements for an effective lesson in science: engagement, exploration, explanation, elaboration, and evaluation (Bybee, 2010). Using this model for the conceptual framework for the study along with suggestions from Barton and Jordan (2001), the following treatment was designed and was administered to students in an effort to improve their scientific text reading comprehension.

An important part to comprehending scientific text is the understanding of how the text is organized. Students who understand text structures are more able to access information in the text (Schoenbach, 1999). Text structures common to scientific text include: chapter titles, section heading, subheadings, bolded terms, figures, and captions. Textbook writers "use text structures believing that readers will use these supports in order to effectively make sense of the text" (p. 60). However, when students do not properly understand these "signposts," they often miss clues and connections that allow for comprehension.

To help students enrolled in honors chemistry, Mrs. Brown spent approximately twenty minutes reviewing text features with all students at the start of the treatment. She pointed out the headings, subheadings, figures, and tables that are common in the modern chemistry textbook. She further explained the importance of all structures, how they are related and the need to review all information when reading for comprehension.

Comprehension is more than being able to answer a few questions at the end of the test. "Comprehension begins prior to reading and extends into the discussions they have after they've finished reading" (Schoenbach, 1999, p. 63). For this study, students participated in pre-reading, during-reading, and post-reading activities that were designed to engage the reader in predicting, questioning, clarifying, connecting, and evaluating as

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they read. The three specific strategies, chosen by the researcher-participant and the teacher-participant based on effectiveness for scientific material, were collectively referred to as the Scientific Reading Intervention Model (SRIM). This model was implemented for one unit of study in the honors chemistry course.

Prior to the each of the five assigned readings, students were given an Anticipation Guide (Appendix D). Anticipation guides are a set of carefully selected questions that serve as pre/post inventory for a reading selection. They are designed to activate and assess students' prior knowledge, to focus reading, and to motivate reluctant readers by stimulating their interest in the topic (Barton & Jordan, 2001). The anticipation guide consisted of five statements related to the content. The statements chosen for the anticipation guide were not statements that were obviously true or false. Instead, they were statements that could be debatable without having read the material. The students individually identified if they agreed or disagreed with each provided statement. The statements are also designed to activate prior knowledge and encourage students to critically think about how that knowledge may be linked to new knowledge they will discover in the reading. At least one question is related to a figure or table included in the section. After the students individually assessed each statement, Mrs. Brown guided a class discussion and encouraged students to share their thoughts. Mrs. Brown did not confirm or deny any statements as being true or false, but encouraged students to look for answers as they read.

Before the first reading, Mrs. Brown explained the strategy of coding. The students were given a handout (Appendix F) that explained how to code text. As they read, the students identified information by writing symbols in the margin of the text.

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They used a check mark (√) to indicate material that confirmed what they originally thought to be true, a question mark (?) to indicate material that they did not understand, and an exclamation point (!) to identify information they felt was essential. This strategy allowed the reader to practice metacognitive thinking that is needed for independent reading. Students were encouraged to identify and mark information that is provided in tables, figures, and captions as well as headings and subheadings.

When the reading and coding was complete, the students formed groups of three to four students per group. Each group started by reviewing and correcting their pre-reading anticipation guide. This allowed the readers to discuss how their original stances were either strengthened or challenged by the text. Next, the groups discussed their coding to determine any similarities and differences. Finally, as a post-reading strategy, students independently identified the key concepts and created a concept map to show the connections. Concept mapping is a strategy for teaching students the meaning of key concepts, making comparisons and visualizing connections (Schwartz, 1988). Mrs. Brown provided instructions for creating a concept map (Appendix E) and an example of a concept map on a different topic and instructed students to create something similar with the main ideas and their connections for their reading. Students demonstrated difficulty in understanding the expectations of the concept map. Therefore, Mrs. Brown and I designed a rubric (Appendix G) with details to help guide students when they construct their ideas. Mrs. Brown also collected the concept maps and provided ungraded feedback to each student until she felt they could successfully construct meaning.

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Instruments. Pre-test and post-test designs are "used primarily for the purpose of comparing groups and/or measuring change resulting from experimental treatment" (Dimitrov, 2003, p. 1,051). The measurement of change can provide a "vehicle for assessing the impact" (p. 1,051). Both the pre-test (Appendix A) and post-test (Appendix B) for this study were selected by the teacher-participant and the researcher-participant from *McGraw-Hill's ACT Practice Questions* book (Dunlan, 2008). Practice passages were chosen to mimic the ACT science tests which measure student's ability to comprehend scientific information (ACT, 2014). Each test included two scientific passages with a graphical representation of data to correspond to the reading. Students were given five multiple choice questions for each passage that required them to draw conclusions from both the reading passage and the graph. ACT assessments require students to use three main levels of cognitive processing; understanding, analysis, and generalization. In addition, three different formats of multiple-choice questions are used to assess knowledge after reading. They include questions on data representation, research summaries, and conflicting point of views. Based on ACT science test design, a high score on the pre-test or post-test indicates that students could interpret data from tables and other schematic forms, generalize research findings, and analyze hypothesis or information provided from different point of views.

The students were given the pre-test prior to the start of the new unit. They read each passage and circled the correct answer for each question following the passage. The pre-test scores were calculated and shared with the students two days later. The post-test was administered at the end of the treatment, scored and shared with the students. The pre-test and post-test scores were compared to determine the effect of the treatment on

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student's ability to read and comprehend scientific text. A simple t-test was used to compare the pre-test and post-test values. A p-value was calculated for the sample and compared to the alpha value, set at 0.05 for educational research, to determine the "probability of chance occurrences in the actual study" (Mertler, 2014, p. 176). In addition, the quantitative data was analyzed for trends between pictorial questions, those that use a graph or table, versus text only related questions. This analysis provided more insight into the difficulties students face when analyzing multi-modal scientific text.

Semi-structured interviews (Mertler, 2014) were also conducted with each student at the completion of the study. These interview questions were selected to gauge the perceived effectiveness of the SRIM. Student responses were collected and analyzed along with the primary quantitative data. I asked several base questions to each participant. Alternative optional questions were also used depending on the student's response. Depending on the student response, the sub-questions may or may not have been asked. A separate interview sheet was filled out by hand for each participant (Appendix C).

1. What type of strategies have you used in the past for reading scientific information such as your textbook, journal articles or lab reports?
    a. Were they effective? Why or why not?
2. Do you feel the added SRIM strategies were beneficial for you?
    a. If yes, what evidence do you have that makes you think the treatment was beneficial?
3. Do you think you are able to independently read and comprehend a scientific text?

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   a. Why or why not?

4. Do you plan to attend college?

   a. If yes, what field of study would you like to pursue?

   b. If yes, do you feel prepared?

   c. If no, what are your post-high school plans?

5. Did the SRIM help you when it comes to comprehension of information from graphs or tables?

The pre-test and post-test instruments were used to directly measure the impact of the SRIM on student's level of reading comprehension of scientific text. The data collected from these instruments was considered the primary data set as it measured the student's ability. The qualitative data, semi-structured interviews, was used to gather student opinions and ideas on the effectiveness of the SRIM, their experience with specific reading strategies, and allow an opportunity for the student-participant to provide information for future action.

Data Collection

The data collected for this action research study was based on the purpose of the study and the research question. To assist students in reading comprehension of scientific text, specific reading strategies were chosen as part of the SRIM. The pre-test and post-test instruments were designed to measure student's abilities to read and comprehend multi-modal expository text. In addition, the qualitative data was collected to determine the student's perceptions of the effectiveness of the model. Together, the quantitative and qualitative data provided the researcher with a direct measure of ability as well as feedback on the model's strengths and weaknesses.

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Both the pre-test and post-test scores were calculated based on ten questions. Each question that was answered incorrectly was identified as one missed point. Students were given a score based on the number of correct responses out of a total of ten possible points. The same grading strategy was used for the post-test and the scores were compared to determine if there was a gain after the treatment was implemented.

The semi-structured interviews were conducted at the end of the treatment and after the post-test had been administered and the results had been discussed. The participant-researcher met with each student and asked a series of questions. Student responses were recorded by hand. The student names were also identified to correlate their perceptions to their quantitative scores. The interviews were conducted outside of the classroom and were informal in nature.

Data Analysis and Reflection

The data was analyzed by both myself and Mrs. Brown, the teacher-participant. Together, we examined the pre-test scores for outliers and trends. We broke down the results to determine the most commonly missed questions. The pre-test data was categorized into two types of questions; text only and pictorial questions. Pictorial questions are those that required students to answer information based on a chart or table in addition to the text. In addition, the data was also disaggregated by gender to determine if one sub-population benefited more than the other.

After the pre-test was scored and examined, we reflected on those results and decided that the student-participants needed extra assistance with the skill of graph and table interpretation. We did not change the SRIM strategies since the model was already in place; however, Mrs. Brown made verbal recommendations for students to pay

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attention to the tables and graphs in their text during their coding and concept mapping. The post-test data was analyzed in the same manner as the pre-test. Then, the pre-test and post-test scores were compared. The overall scores were compared both as a class and individually to determine any gains in scores. Then, the pictorial question scores were analyzed for both the pre-test and post-test to determine if students improved in their abilities to interpret information provided in tables or charts. The text-only related questions were also compared from the pre-test to the post-test to determine if there were gains in scores. Finally, the overall scores as well as the category scores were analyzed based on gender to determine if the SRIM was more effective for one sub-population. The AP Statistics teacher at the high school helped in the numerical data analysis, calculating the p-values and running the t-test.

The semi-structured interview data was collected by hand and analyzed with Mrs. Brown. The responses for each question were analyzed and organized to identify common themes. Student responses were also organized by gender to determine if one sub-population felt more confident in the effectiveness of the SRIM. Finally, the quantitative results were compared to the qualitative results to determine if the student's perceptions matched or contradicted their indicated performance.

Data was analyzed by both the teacher-participant and researcher-participant throughout the study. In addition, data and feedback was also shared with the student-participants. The pre-test scores were reviewed with the students two days after completion. They were provided feedback, both written and oral, on their participation with the reading strategies multiple times throughout the study. Specifically, we noticed that the concept maps that were produced from the first reading were not sufficient.

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Therefore, we created a rubric (Appendix G) to help guide students in the mapping process. Not only did the quality of their work improve, but students claimed the rubrics were helpful. At the completion of the study, Mrs. Brown and I shared the analyzed results with the class through a presentation we had created together. The presentation identified strengths and weaknesses noted based on the quantitative data and key findings from the qualitative data. Student names and individual scores were not used in the data presentation. Instead, the mean scores were shared along with the gain mean scores, question style breakdown and sub-population analysis.

Conclusion

The present action research study collected quantitative data through a pre-test and post-test design. The pre-test, given prior to the treatment, was of similar design to the post-test and was designed to measure student's ability to read and comprehend scientific text. Comparison of the pre-test score to the post-test score provided information regarding student's improvements, or lack thereof, due to the implementation of the SRIM. Building on the previous research, this study focused on how the addition of reading comprehension strategies may enable students to be more independently successful in science.

Descriptive statistics were used to identify measures of central tendency and measures of dispersion within the data. We also utilized a repeated t-test to calculate the p-value and compare it to the alpha value to determine if the differences between the pre-test and post-test were considered significant. A repeated t-test was used because the study utilized two measures that were taken on the same population. In addition to whole-class analysis, Mrs. Brown and I analyzed the data for each question, breaking the

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data down into two categories; text-only based questions and questions that required interpretation of a graph or table. We also disaggregated the data based on gender to determine if the performance of the subpopulations of male and female.

The semi-structured interview data was analyzed using an inductive process. The purpose of the interview data was to help "confirm or contradict" the quantitative data (Mertler, 2014, p. 165). The student responses were organized and the key findings were identified. Using the constant comparative method, "a means of applying inductive analysis to multidate sources" (p. 167), we reviewed the qualitative data and its relationship to the quantitative pre-test/post-test findings.

Chapter 3 described the methodology for the current study. Chapter 4 describes the findings and implications that were determined from the previously described design and data collection. It entails a detailed analysis of the study as well as the reflective stance taken by the researcher.

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CHAPTER 4. FINDINGS AND IMPLICATIONS

Introduction

The purpose of Chapter 4: Findings and Implications is to present in detail the action research findings and data analysis. Thinking, rethinking, discussion and learning during the action research process is detailed to contextualize the findings and implications.

The purpose of this study was to examine the impact of the SRIM on scientific reading comprehension of students enrolled in honors chemistry. The study was conducted at a private school in southeast South Carolina. The student population for the study consisted of 61% female students and 39% male students. The study was conducted by a teacher-participant, Mrs. Brown (pseudonym) under the guidance of the participant-researcher, myself. Mrs. Brown and I have a close-working and trusting relationship. We have assisted each other with various classroom and chemistry related problems. We have both observed, in accordance with the research conducted by Korpershoek et al. (2014), how a student's reading ability impacts their level of scientific understanding and therefore academic achievement. Reading ability is positively related to achievement in the areas of mathematics, physics and chemistry (Korpershoek et. al., 2014). Being able to comprehend scientific text means students must be able to "understand and use written documents containing both verbal and pictorial information, for example, texts, pictures, charts, and tables" (p. 1015).

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The identified problem of practice for the action research study involved students who are required to read scientific text as part of their science class. After reviewing student quiz grades and reflecting on the low level of in-class student participation post-reading, the SRIM was developed by the participant-researcher to help students improve their abilities with scientific reading. The intent of this study was to describe the noted phenomenon in one classroom setting and examine how the addition of the SRIM may impact the student's ability to read and comprehend scientific information.

SRIM (Scientific Reading Intervention Model)

The SRIM consists of three evidence-based strategies that were chosen to assist students prior to their reading, during their reading, and after they have completed the reading. Mrs. Brown and I selected strategies based on the perceived effectiveness, the ease of implementation, and skill sets required of the students.

An anticipation guide (Appendix D) was chosen for the pre-reading strategy because it is quick, easy to answer, and activates student's prior knowledge. Anticipation guides, developed by Herber (1978), were designed to activate prior knowledge and provide a focus for the reading. In addition, the anticipation guides used for this study were used to stimulate interest in the upcoming topics. Five statements were provided for each section of reading material. The students were instructed to identify the statements as either true or false. After reading the material, the students were instructed to review their five statements and determine if they agree with their original choice or if they now have evidence to make a better selection. These statements provide students with a purpose for reading and help stimulate their interest.

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The coding of information has been used for years and is used with many academic areas and professions. Coding information requires the information to be grouped or classified according to different specificities. The coding method for reading was selected for the during-reading activity because many students have utilized and are familiar with how to code information at the basic level. The SRIM required students to identify and code information into one of three categories as they read; confirming, confusing and/or important. In addition to drawing their attention to the information as they read and making students more cognitive of their reading processes, this strategy also prepared the students for their post-reading activity, the concept map.

The concept map was developed by Joseph Novak during the 1970s at Cornell University. It originated during the constructivism learning movement as a way for students to organize their scientific knowledge. Creating a concept map requires a learner to actively construct their knowledge and represent their findings in an organized manner. Student constructed concept maps have proven to "increase long-term retention and increase student achievement" when used over time (Nuri, 2014, p. 288). These factors as well as the fact that concept maps can be completed individually, reviewed as a group and do not require right or wrong answers, is what led to the selection of concept mapping for the SRIM. Concept mapping allows students the opportunity to organize information as it makes sense to them. It requires students to re-think the concepts they have read and put them together in way that establishes big picture comprehension.

Following the ideas of the scientific method and the 5E model (Bybee, 2008), these three strategies were chosen to be used in conjunction with each other to aid students in reading comprehension. The SRIM was created to engage students in the

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reading process, encourage them to think about their reading, and reflect on what they have read to make connections between the key findings. The SRIM was designed to aid students in becoming more independent readers and therefore independent learners.

Data Collection Strategy

Both qualitative and quantitative data was collected and analyzed. The question that guided this study was what is the impact of the SRIM on a student's ability to comprehend scientific text. The quantitative data served as the primary data source. Quantitative data was collected from the pre-test and post-test. Both the pre-test and post-test were designed to assess the student's ability to read scientific information and answer a series of five questions that required analysis and comprehension of text and pictorial information. Two passages with five questions each were used for both the pre-test and the post-test. While the pre-test and post-test were of similar design, the content for each passage was different to eliminate the possibility of students selecting the correct answer based on any other factor than their reading ability.

Qualitative data consisted of observations with field notes and semi-structured interviews with both the teacher-participant and all student participants. Throughout the 6-week period of treatment, I observed the student-participants 7 times and collected field notes for each visit. At the completion of each visit, Mrs. Brown and I reviewed the field notes together to ensure accuracy of the documentation. I also conducted semi-structured interviews with each student to assess their use of reading strategies prior to the intervention, their perceived feelings about the effectiveness of the SRIM and their feelings about feeling prepared for college.

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The constant comparative method (Mertler, 2014) was used to analyze the data as it was collected. It is a "means of applying inductive analysis to multidate sources within a given study" (Mertler, 2014, p. 167). This method involved continual analysis, comparison and reflection throughout the study. A four-step process described by Dana and Yendol-Hoppey (2014) was also used as a summative analysis. This four-step process required the entire data set be read, re-read and analyzed for trends and connections. Data was re-grouped, re-organized and condensed to make sense of the information. After the data was sorted, patterns and trends were used to make interpretations. Finally, the information was used to generate the action plan.

Data Analysis and Interpretation

Pre-test

The pre-test (Appendix A) consisted of two scientific passages with both text and pictorial information. Five of the six text only questions came from the same passage that was on the topic of astronomy. Passage one was on the topic of speed and friction and had approximately 228 words and two tables. Passage two included 414 words on the topic of astronomy and did not include tables or graphs. The students answered five questions about each passage. Material for the pre-test was chosen because students had not yet studied these concepts as part of their curriculum. Using material that is not related to the current curriculum helps ensure students are not answering questions based on their prior knowledge, but rather select their choice based on their ability to read and comprehend the provided material.

The pre-tests were scored and the data was grouped based on the number of correct responses. Three participants scored between 0% and 60%, indicating their inability to answer the questions correctly from the provided text. Ten students scored

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between 70% and 80%, indicating they were able to successfully answer more than half of the questions. Five students scored between 90% and 100% indicating a high ability level to comprehend the text and successfully answer the questions.

Type of Question

Reference to graphics made up approximately 40% of all questions. Three questions required students to interpret information from the table data only. One question required students to utilize the text along with the provided table of information. Six questions required students to select the correct choice based on text only. Of the six text-related questions, 50% of the questions required students to draw conclusions from the information given, 25% of the questions required identification of information, and the last 25% required students to summarize the information they had read.

Table 4.1

Breakdown of Pre-Test Scores

Type of Question	Pre-test Question Number	Percent Incorrect
Text Only Required	4	16.7
	6	16.7
	7	22.2
	8	16.7
	9	11.1
	10	16.7
Graphic Required	1	44.4
	2	11.1
	3	50
	5	33.3

In considering results, students were required to answer five questions pertaining to the first passage that was related to speed. Of the five questions, four of these questions required students to utilize one of three provided tables to infer information.

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The first question required students to identify information from a table and use information in the passage to make a conclusion. Eight students answered this question incorrectly indicating their inability to either identify the appropriate information or make the connection from the table to the text.

Question two provided a reference point and required students to make a conclusion from information in the table. Only two students were not able to answer this question correctly.

The third question required student to use the combination of both text and table information and compare information for all three trials. This was the most commonly missed question with half of the student-participations selecting the wrong answer.

Question number four provided a prompt, was shortly worded and had brief answer selections. Only 3 students were not able to answer this question correctly.

The last question for the first passage required students to analyze information from all three tables and make a comparison. The majority of the students were able to answer this question correctly.

The second passage also contained a short reading passage about the solar system with five questions to follow. However, all five questions for this passage were text-only related questions. No pictorial information was provided for this passage. The passage was divided into three sections; a brief introduction, a passage about the viewpoint of the first scientist and a passage about the viewpoint of the second scientist.

Questions six and seven provided a prompt and required the students to identify the difference between the two scientists' viewpoints. Only three and four students, respectively, were not able to correctly identify the appropriate answer.

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Question eight asked students to identify which choice was not in alignment with the scientist viewpoints. Like question number six, only three students missed this question.

The ninth question was lengthy; however, the answer selections were short. Students were given additional information in the question itself and they needed to draw conclusions from both passages. Despite the uniqueness of this question, most of the student-participants selected the correct answer.

Finally, the last question provided four detailed answer selections and asked the student to identify which statement would pair best with both scientists point of views. Only three students selected the wrong answer.

These results show the highest number of incorrect responses is associated with the questions that required information be interpreted from either a table or graph. These results indicate that students struggle more often when it comes to comprehending information from both text and pictorial format. The questions with the lowest number of incorrect responses are those that required the students to read text only. These results indicate that students are more successful in comprehending information, even if the question format is more complex, if the provided information is in one format as opposed to text that is multi-modal.

Post-test

The post-test (Appendix B) was of similar design and was administered at the end of the treatment. Passage one of the posttest consisted of five text-only related questions that required students to read the information about fossils. Passage two consisted of three questions in which students had to gather information from both text and a graphical representation, and two questions that required students to analyze a graphic

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only. The content for passage two included information about prescription drug use over time. Again, the information used in all passages was chosen because it is not likely the students have encountered this information in any previous science course. To truly examine the reading ability of the student, the information selected should not contain material that would allow students the opportunity to use prior knowledge.

Type of Question

Reference to graphics made up 50% of all questions. One question required students to interpret information from the table data only. One question required students to utilize information from a graph only, and three questions required the reading of text along with a graph or table. Five questions were based on text only. Of the five text-related questions, 60% of the questions required students to draw conclusions from the information given, and 40% of the questions required identification of information.

Table 4.2

Breakdown of Post-Test Scores

Type of Question	Pre-test Question Number	Percent Incorrect
Text Only Required	1	5.60
	2	0.00
	3	0.00
	4	0.00
	5	5.60
Graphic Required	6	33.3
	7	16.7
	8	38.9
	9	27.8
	10	16.7

In consideration of results, students were required to answer five questions pertaining to the first passage on fossils. Like the pre-test, this post-test passage contained viewpoints from two scientists, specifically paleontologists. The questions

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required students to identify information, compare point of views and make assumptions based on the information provided.

The first question provided a prompt and required students to identify information based on the point of view for the first paleontologist. Only one student missed this question, indicating that most students were able to make the correct assumption based on their reading.

Number two required students to make a conclusion based on the first paleontologist's point of view. The information was not directly stated, therefore, students needed to apply their reading to conclude which selection would be most appropriate. All student-participants were able to answer this question correctly indicating they were able to read and make conclusions.

The third question provided an assumption and asked the students to conclude, based on passage two, what would most likely occur. All student-participants answered this question correctly indicating they could understand the new information and make the connection to previous information in order to select the best response.

Question four provided a prompt and used short and exact phrases for the selections. This question could have been answered on the basis of identification of facts. All students successfully answered this question.

Finally, the last question required students it identify supporting details for a point-of-view. Again, only one student missed this question.

The second passage of the post-test contained five questions that required students to use pictorial information, either in a figure or table, to select the appropriate answer. The pictorial information included two figures and one table with multiple components.

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Each figure contained a graph along with an informational key. The first graph compared four substances with independent and dependent variables. The second graph compared two substances with independent and dependent variables. A brief informational section was included at the top to explain the passage.

The first question provided a prompt and required students to analyze one figure for two substances. Reading text material was not necessary to correctly answer this question. Six students missed this question indicating a struggle with data interpretation.

The second question required students to make a conclusion based on interpretations of both graphs. Three student-participants were not able to successfully answer this question. It is also worth stating that two of the three students selected the correct figure, figure two, for answering the question, but did not correctly identify the conclusion. This indicates that they could determine the appropriate figure to use for the question but they were not able to make the appropriate conclusion.

The third question required the use of one figure. However, the answer selections contained time periods that were not clearly marked on the x-axis of the graph for time. Therefore, to answer this question successfully, students would need graph reading skills to be able to interpret the approximate time intervals on the graph. This was the most widely missed question with seven students answering incorrectly. This indicates that many students are not able to identify numerical values on a graph when they are not clearly stated. No conclusions or text reading was needed for this question.

The next question required students to interpret information from one table that contained four categories of information. The reader needed to identify the appropriate subcategory of information and make a conclusion. Five student-participants were not

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able to answer this question indicating they had difficulty identifying the information and drawing a conclusion.

Finally, the last question prompted the students to examine a figure at a specific marking and make a conclusion. Three students were not able to answer this question indicating they were not able to make the appropriate conclusion from the chart.

Overall, these results indicate that students had more difficulty with questions that required them to read and interpret information from charts or tables. Of the five question that required pictorial interpretation, at least three students missed every question. On the contrary, questions that did not utilize pictorial information and instead required text reading showed a higher success rate for student performance. Only two of the five questions were missed and each question was only missed by one student. These results are indicative that students are more successful when it comes to reading scientific information if it is presented in text format alone and does not contain additional information in another format such as a table or graph.

Semi-structured interviews

All student-participants were interviewed by the participant-researcher after the study was complete (Appendix C). The interviews were semi-structured and each student was allowed the opportunity to respond freely to the questions provided. Each student received the same series of questions. The interviews were conducted individually outside the classroom in a nearby office. The rest of the class was working on a reading assignment while the students were called out one by one. The following questions were asked and the discussions are described below.

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What type of strategies have you used in the past for reading scientific information such as your textbooks, journal articles or lab reports? Were they effective? Why or why not?

Eighty-three percent of the students stated that they did not use any strategies when it came to reading scientific information. Two students stated that they highlight the information they think is important as they read so they will come back to it for review. However, one student stated that, "I never really go back and read the information again. It really just helps me to pay attention to what I am reading and what I might not understand." Both students stated that highlighting the material was somewhat helpful but they ultimately relied on the teacher, Mrs. Brown, to explain the material. One student stated that he skimmed the sections and never read the text thoroughly. Instead, he paid attention to the headings, key words, charts and figures. He stated, "If I just review the main ideas and terms, Mrs. Brown makes the rest make sense."

The student responses to this question suggest that they have not received appropriate training on how to read text that is multi-modal. Additionally, the students suggest they rely on the teacher when it comes to the interpretation of material. When analyzing the data with Mrs. Brown she informed me that she has observed the students read the text line by line. When she asks them questions about the material immediately after the reading concludes, the students are not able to provide answers if the question is higher order or requires them to draw information from more than one sentence. In addition, she stated that the two students who highlight material as they read pay close attention to the details, however, they often miss the big idea questions she asks during

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class discussion. Mrs. Brown stated that they students do rely on her lectures to develop a full understanding of the material. She stated, "I want to help my students, but at the same time I want them to develop the skills necessary to be independent learners."

Do you feel the SRIM strategies were beneficial for you? If yes, what evidence do you have that makes you think the treatment was beneficial?

Eighty-nine percent of the students responded that they did believe the strategies were helpful for their success in reading scientific information. However, the degree of helpfulness and evidence was varied. Three students stated that the anticipation guide questions helped them to see the purpose of the section as well as provided them with a check of their current knowledge. One student stated, "It helped me to think about what I already know on this topic before we learn about it." On the contrary, six students stated that the strategies helped them, but the anticipation guide was the least helpful. One student stated, "I didn't really take the anticipation guide seriously. It wasn't for a grade." Another student claimed the anticipation guide was interesting but did not help her to understand the material. Overall, half of the students did not even mention the anticipation guide when they described the benefits of the SRIM strategies. This indicates that the pre-reading strategy may not have played a role in the overall improvement from the pre-test to the post-test scores.

Sixty-seven percent of the students identified coding as beneficial when it comes to comprehending scientific text. Two students stated that identifying, coding, the information helped them to pinpoint what they did not understand. One student stated, "The statements I marked with a question mark are the ones I made sure to get answers to during the class discussion and lecture." Another student commented that she "purposely

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listened for her questions when Mrs. Brown lectured." Other students claimed that by coding the information they paid more attention to the big ideas rather than all the minor details. Another student claimed, "I tried to memorize every fact and thought that every detail was the most important. Coding helped me realize what was most important."

Six students stated that coding did not benefit them when it came to comprehending the material. One student stated, "I already do this in my head. I don't need to write it down." Another student stated that he does better if he reads it at all at once and then re-reads the information to make sense of what he might have missed. Four students did not provide explanation as to why they felt the coding strategy was not beneficial.

Mrs. Brown and I reviewed the student coding sheets for the entire unit. Every student fully participated in the coding of the text. Three coding exercises were completed in class and two were assigned as homework. Mrs. Brown observed the students while they were coding in class. She noted that students were not reading or marking the additional information provided outside the basic paragraph style text. When we observed the student coding sheets, we realized her speculation from her observation was correct. Not one student coded information related to figures, charts or tables. This indicates that students did not pay attention to the additional information provided in the margins or the text, but instead read the material section by section and line by line. The previously stated student interview responses confirm this speculation.

Eighty-eight percent of the students mentioned that the concept mapping strategy was particularly helpful in comprehension of the reading material. Students stated that the concept map helped them to focus on the big ideas, avoid getting hung up on the

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detailed scientific vocabulary, organize the information into chunks and helped them when it came to studying for the unit test. Eight students commented that they were not familiar with how to construct an effective concept map and the rubric helped them to better understand how to organize their ideas. Ten students mentioned the helpfulness of being able to collaborate with their peers after they constructed their maps. The collaboration allowed students an opportunity to review their organization of ideas and compare it to the way their peers organized the information. Students could make adjustments as they saw fit. Six students stated that they appreciated that the concept maps were not graded on a right versus wrong basis, but instead they could make mistakes and corrections. They appreciated the opportunity to learn from their mistakes without penalty. Only two students did not mention the concept map as being helpful. They did not indicate that it was not helpful, rather they found the coding strategy more beneficial.

Mrs. Brown and I reviewed the concept maps for all students. We observed that after the rubric (Appendix G) was provided, the quality of the concept map improved. The maps for section one, prior to the rubric, contained many details that were not thoughtfully organized. However, section two maps were better and section three, four and five showed significant improvements. Two students color coded the information on their maps to match the color they used in their coding strategy. The concept maps were created out of class as homework. Students were allowed collaboration time the following day to review their work. Mrs. Brown stated that they were given approximately five minutes to collaborate and most students were engaged in this activity for each review. She commented that all students created maps, but two students did not

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regularly participate in the collaboration time. She did not force them to collaborate. Mrs. Brown stated that after the rubric was provided, the students were more comfortable and created more concise concept maps. She also noted that their discussion and collaboration improved. The rubric helped students understand the expectations of the concept map and allowed them to organize the concepts from their reading in a way that allowed for better comprehension. This is evidenced by the student responses as well as the improved concept map quality.

Overall, the response to the concept map strategy was most positive for its perceived effectiveness in reading comprehension. One student stated that organizing the information helped her to "understand how the textbook was organized." Other students stated, "the homework was easier," "her confidence level on the test had improved" and "mapping the concepts gave him a head start on the lectures." Students felt, after practice and with the aid of the rubric, that the concept map helped them to understand how the details fit the big topic concepts.

Do you think you are able to independently read and comprehend scientific text? Why or why not?

` Seventy-seven percent of the student-participants answered no or somewhat to this question. The primary reason stated for their inability to read and comprehend on their own was that they needed their teacher to explain it to them. Three stated they were auditory learners, four stated they have not had enough practice with reading complicated material with difficult vocabulary, and seven stated they needed the teacher's help to understand material. Four students stated that they felt confident in their own abilities to read and comprehend scientific material. Of those four, one stated that he has been an

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independent reader for a long time and enjoys reading scientific journals for fun. The other three students responded that they understand how the text is organized, they are used to utilizing resources other than the teacher, or they learn better if they can read and understand it for themselves.

Most of the students responded that they relied on the teacher's help to understand the material. In discussing the results with Mrs. Brown, she indicated that she has not utilized the text or other methods of intendent learning throughout the year. She follows a similar format for each section with includes lecture with notes from slides, homework questions for reinforcement, and quizzes to check for their level of understanding. She uses labs as culminating activities but also noted that she must explain the details of the lab to them before they begin. She stated that the students have difficulty when it comes to independent understanding of material. We both agreed that the teacher-centered teaching practices may have impacted the student's level of confidence in their own abilities to read and comprehend scientific material. In their study on active learning in chemistry classrooms, Bullard, Felder and Raubenheimer (2008) showed that the absence of active learning negatively impacts student achievement. Additionally, Trilling and Fadel (2009) concluded that teacher dependency does not create self-directed learners. The teacher observations, teacher feedback and student feedback all indicate that Mrs. Brown's classroom is a classroom that utilizes teacher-centered strategies for instruction. These strategies, according to both Mrs. Brown and her students, continue to create dependency on the teacher for instruction. In conclusion, the feedback from Mrs. Brown regarding her instructional strategies agrees with the student feedback that they do not

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feel confident in their abilities to independently read and comprehend scientific information.

Do you plan to attend college? If yes, what field of study would you like to pursue? If yes, do you feel prepared? If no, what are your post-high school plans?

All student-participants responded that they plan on attending college after they graduate from high school. Thirteen students indicated that they plan on majoring in a math or science related fields. These fields included; biomedical, medical, physical therapy, engineering and dermatology. Four students plan to pursue fields that are not related to math or science and one student is uncertain. Of the thirteen student-participants who plan to major in science or math related fields, only four students claimed they felt prepared. Five students responded that they did not feel prepared and four students responded that they felt somewhat prepared. I did not specifically ask students why they did not feel prepared, however, four students provided explanations on their own. One student stated that he was afraid college would be more self-directed and he was not sure he could stay on task by himself. Two students stated that they felt their college professors would not care about them as much as their high school teachers. They felt their high school teachers provided individualized help when they needed it and they were afraid that was not going to be the case when they go to college. One student stated, "the more I learn the more I realize I don't know and that scares me." He continued to say that his high school did not offer engineering courses and he feels that when he goes to college he is going to be behind his peers because they will have had more instruction on the field of engineering.

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The four students who stated they would not pursue math or science fields of study also provided explanations. These explanations include; “I have more of a creative mind and I want to go into the performing arts programs,” “I am not good at math,” “I have no interest in math or science” and “I don’t like science.”

These student responses indicate that, as expected for an honors level chemistry course, all students plan to attend college after high school. However, five students are enrolled in an honors level science course even though they do not plan to major in a science or math related field. Mrs. Brown indicated that she discusses the honors choice with each student before they enroll. She commented that many students at this school like to take honors level courses to boost their overall GPA, be competitive for college acceptance and be eligible for scholarships.

Several students indicated that they did not feel prepared for college and identified the lack of professor assistance as their primary reason. This information coincides with the previously discussed topic of teacher dependency. The students are aware that college may require them to be more independent learners; however, they do not believe they are receiving an education that is preparing them to be independent thinkers.

Did the SRIM help you when it comes to comprehension of information from graphs or tables?

After reviewing the post-test data, Mrs. Brown and I felt the need to add this question to the survey. Students demonstrated an inability to successfully answer questions that required them to gain either all or part of the information from a graph or table. We did not feel that the SRIM strategies were successful in helping students with

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this skill set. However, it was important for us to gather their thoughts on the perceived ineffectiveness. Their responses confirmed our original suspicion.

Of the eighteen students surveyed, only one student stated that she believed the SRIM helped her to be able to comprehend information from the graphs or tables. She stressed that the coding strategy helped draw her attention to graphical information. She continued to say that before coding the information she used to only read the text and did not pay attention to the additional information. She also stated that she is a visual learner and can understand information better when it is in the visual format. The other seventeen students responded that the SRIM did not assist them in being able to interpret information from graphs or tables. Additionally, one student stated that "the information in the graphs was confusing."

Data Analysis

Data was analyzed both individually and as a class. The mean scores for each group were calculated and then compared (Mertler, 2014). Additionally, the data was disaggregated by style of question, text-only versus graphical interpretation, and by gender. Table 4.3 shows the individual scores for the pre-test and the post-test. Pseudonyms were used for the student names.

Table 4.3

Pre-test and Post-test Data Comparison

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Student	Pre-test Score	Post-test Score
Rebecca D.	7	10
Celia	9	9
Megan R.	8	10
Elanor C.	7	8
Josie	10	10
Crista	7	9
Grace Ann	9	9
Morgan	5	7
Megan D.	6	8
Erin P.	8	8
Marisa	8	7
Sullivan	9	10
Jacob	9	8
Jack	7	8
Ty	7	5
Josh	7	8
Mac	6	10
Sanders	8	10

The pre-test and post-test mean scores were calculated for the class. The measure of variance, standard deviation, was also calculated for each mean score. Comparing the pre-test and post-test scores, a gain score mean was also calculated to determine the degree of improvement after implementation of the SRIM.

Table 4.4

Pre-test Post-test Mean Score Comparison

Pre-test Mean Score	Pre-test Standard Deviation	Post-test Mean Score	Post-test Standard Deviation	Gain Score Mean
7.63	+/- 1.29	8.55	+/- 1.38	0.94

A p value was calculated for the population to “indicate the probability of chance occurrences in the actual study” (Mertler, 2014, p. 176). The p value was then compared to the alpha value “which is set at 0.05 in educational research studies” (p. 176). This

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value indicates that only 5% of the time the results are due to chance. If the p value is less than the alpha value, the differences are considered to be statistically significant. If the p value is greater than the alpha value, the difference is not statistically significant. A repeated measures t-test was used because two measures, the pre-test and post-test, were taken on the same population.

The p value was calculated to be 0.027 which is less that the alpha value of 0.05. Therefore, the null hypothesis that there was no change between pre-test and post-test scores is rejected. These results indicate that the SRIM was effective for the student population.

Data was also analyzed based on responses to the two different formats of questions; questions that required students to draw conclusions from text-only and questions that required students to interpret information from graphical representations in addition to the text. Table 5 shows the question format comparison.

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Table 4.5

Question Format Comparison

Test	Text-only Question Mean Score	Graphical Representation Question Mean Score
Pre-test	7	3.75
Post-test	9.6	5.2

These results indicate that students improved 2.6 points on the text-only related questions and only improved 1.45 points on the graphical representation questions. While both question formats show an overall improvement, there is great improvement for the text-only related questions indicating the SRIM was effective for improving reading comprehension, but most effective for text that does not require graphical interpretations.

Finally, the data was disaggregated by gender to determine the effectiveness of the SRIM for each sub-population. Pre-test and post-test means were calculated for both male and female populations along with standard deviations for each. A gain score mean was calculated to measure the impact of the SRIM on each gender category. Table 6 shows the results from these calculations.

Table 4.6

Pre-test and Post-test Gender Comparison

Gender	Sample Size	Pre-test Mean	Post-test Mean	Gain Score Mean
Female	11	7.63 +/- 1.43	8.64 +/- 1.12	1
Male	7	7.57 +/- 1.13	8.42 +/- 1.81	0.86

The p value for the female student-participants was calculated to be 0.042 which is less than the alpha value of 0.05. Therefore, the null hypothesis that there was no change between the pre-test and post-test scores is rejected. Based on an average

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increase of one point from the pre-test to the post-test, these results indicate the SRIM was effective for the female population. The p value for the male student-participants was calculated to be 0.157 which is greater than the alpha value of 0.05. Therefore, the null hypothesis that there was no change between the pre-test and post-test scores is not rejected. Although the gain score mean indicates an increase of 0.86 from pre-test to post-test, the p-value comparison indicates these results are more likely due to chance.

This data indicates that the SRIM was overall effective for the student-participants. The overall mean score increased by an average of 0.94 points from the pre-test before the treatment to the post-test after the treatment had ended. Therefore, the reading strategies were effective in helping student improve their ability to read and comprehend scientific information. However, upon analysis of the subpopulations based on gender, the data reveals that the female population showed more significant gains with the mean gain score of 1.0 when compared to their male peers who only showed an average gain score of 0.86. Furthermore, the statistical analysis reveals the male population p value was less than the alpha value of 0.005 which would indicate their results are not statistically significant and could be due to chance.

Reflective Stance

As the participant-research, it was important that I establish and maintain both an insider and outsider role throughout the research process. Reflection was an important component to this action research project. Reflection was ongoing and occurred both independently as well as with Mrs. Brown, the teacher-participant and the student-participants. Reflecting on the SRIM strategies, implementation processes and reviewing both formal and informal student feedback allowed us the opportunity to make

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adjustments and implement an effective study. The following describes our analysis, changes that had to be made and our efforts to re-think and re-plan our implementation. In addition, the following describes additional information that could have been collected to make a more effective study.

Pre-test

The pre-test data and initial observations were collected, scored and analyzed before the SRIM treatment began. Based on previous personal experiences, we believed that students have difficulty understanding scientific information when they are required to read and comprehend without any assistance from the teacher. Thirteen out of eighteen students scored at or below the 80% mark indicating that our initial judgement was correct. We were surprised to see that students struggled more often with questions that required analysis of data in the form of a graph or table as opposed to questions required students to interpret information from text only.

Additionally, Mrs. Brown did not project enough in-class time for students to finish the test. She suspected the students would be able to finish the reading and questions in approximately ten to twelve minutes. However, she had to adjust her class schedule and allow up to twenty minutes for two students to finish. The students took more time to complete the test than expected.

Post-test

The post-test data and initial observations were collected, scored and analyzed at the completion of the SRIM treatment. Based on the observations from the treatment as well as informal student feedback, we believed students would score higher on the post-test compared to the pre-test. Our predictions were correct. On average, most students scored higher on the post-test at the completion of the treatment. However, we did not

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expect to see a variance between the type of questions. We expected an increase in both text and data related questions. The results indicate that students performed higher on text related questions when compared to the pre-test. However, their post-test scores did not indicate a significant increase for questions that required data interpretation from tables or charts.

Reading Strategies

Initial observations and discussions with Mrs. Brown revealed that, contrary to our beliefs, students did not have an appropriate level of understanding on how to construct a concept map. Mrs. Brown spent additional time reviewing the first assigned concept map with the students and explained how they should construct concept maps for future readings. After two assigned readings, Mrs. Brown informed me that students were not “taking the concept map seriously.” They were not fully engaged and were doing minimal work to receive the participation credit. Mrs. Brown and I discussed the issue after a class observation and decided together that the students needed more accountability. As previously stated, we developed a grade-free rubric (Appendix G) that students could follow when they construct their concept maps. We agreed that the rubric should provide guidance without setting an assigned grade that may add pressure to the students. The goal was for the students to be reflective on the concepts of the unit and there was not a single right or wrong answer to be given. Therefore, Mrs. Brown agreed to prompt the students for higher quality work, provide the rubric for student self-assessment, and give individual feedback on rubrics where needed. She collected the maps and assessed them and provided feedback without grades before returning them to the students to analyze as a whole-class with her assistance. Examples of student concept

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maps are included (Appendix I). Based on informal conversations with the students and critique of their work, we concluded that the additional review and the rubric were successful in helping students create higher quality concept maps. However, due to time constraints for the unit, the concept map exercise was assigned as homework. This may have negatively impacted the usefulness of this strategy because it was difficult to determine if student-participants were merely writing information from their text or if they were carefully thinking about the concepts. The concept map strategy would benefit students more if it were performed as an in-class activity where the teacher could monitor the students as they construct meaning from the information. Organizing the information is still a benefit to the student, but it was difficult to determine if they received the optimal benefit intended. Mrs. Brown did indicate that after the rubric was in place, the students were more engaged in the concept map collaboration with their peers.

The feedback from the students confirmed our original thoughts that the anticipation guide would be the easiest reading strategy for the students. The anticipation guide required students to respond to five statements before reading and coding their material. These statements were designed to be easy to understand, related to real-world situations, and engage students in thought processes prior to the introduction of new material. The students decided if they felt the statements were true or false and then discussed the ideas with their peers. Observations of the students' participation in this activity revealed active engagement in discussions with their peers and many students were determined to prove themselves right by finding the answers in their text. Based on these observations, we agreed the goal of the anticipation guide, to engage learners in the concept and activate prior knowledge, was successful.

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Observations negated our original thoughts that the during-reading strategy of coding may be easier for the female students than the male students. Based on our experiences, we have seen more female students highlight their text and attempt to organize information in a meaningful way. However, we found that female students tried to code more information and focused more on the details than the overall big picture of understanding. The male student-participants coded less information but the information highlighted was more on point and contributed to the overarching section topics. During class observations, the male students were seen following along with their coded text material while the teacher instructed from PowerPoint slides. The female students were observed writing down every word from the slides in their notes and none of them had their coded text material present on their desk. No prompts from Mrs. Brown were given to tell students what should be present on his/her desk. This led the researcher-participant to believe the male students were finding connections from the reading material to the in-class material while the female students were more focused on obtaining the information. Mrs. Brown indicated that several female students need to write everything down to take it home and process the information, however, do well on their unit tests.

Additionally, Mrs. Brown noted in our discussion that when she reviewed the student's work she noticed they were not coding information included with figures and graphs. Examples of student coding are included (Appendix J). She provided a verbal prompt to all students that they should be paying attention to information provided in tables, graphs and figures as well as the paragraph text. After reviewing the student work, I did not see coding for pictorial information for the first section, but it was present for most students for the following sections.

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Interviews

The semi-structured interview questions were created and reviewed with Mrs. Brown. However, after analyzing the post-test data, we needed to rethink the questions and adjust according to the results. Because we saw such a discrepancy in student scores when it came to text verses data interpretation, we felt the need to ask students about the SRIM and strategies they used for answering data related questions. We felt their feedback about this topic would be beneficial when describing the effectiveness of the study. Additionally, we wanted to know if the students utilized the SRIM strategies on the post-test and if so, how. Therefore, we added two questions to our initial survey.

Based on student observations as well as the pre-test and post-test data, we felt that students would feel the SRIM was beneficial to some degree. The interview data with students confirmed our assumption. While the student responses varied, most students felt some degree of improvement with their scientific reading comprehension after having utilized the strategies from the SRIM.

Additional Data

Reflecting on the action research, additional data regarding students experience with data interpretation would have been beneficial before the study began. Having known that students struggle with interpreting information from tables and graphs would have allowed myself and Mrs. Brown to select strategies that could possibly improve this area of comprehension. Mrs. Brown stated that they students are not required to interpret information from tables or charts for in class activities or assessments. She believes an adjustment in her instructional strategy and incorporation of data into her lectures and tests may help her future students be more successful with this skill set. As Shanahan and Shanahan (2008) concluded, scientific text is often more difficult for students to

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comprehend, when compared to other courses such as History, due to its utilization of both text and graphical information. Mrs. Brown and I felt our coding strategy would address this issue as well as the difficulty students experience with complicated vocabulary terms. After realizing that students were not coding non-textual information, Mrs. Brown provided verbal prompts for the students to pay attention to the information included with the graphics. However, we believe our assumption that students knew how to read and comprehend basic data tables and charts was incorrect. A student survey or assessment before the study began would have helped us to develop strategies that tailored to their individual needs.

Answering the Research Question

This study investigated the impact of the scientific reading intervention model (SRIM) on student achievement of students enrolled in honors chemistry at a private school in South Carolina. The SRIM was developed by both the researcher-participant and teacher-participant in response to observations of students' inabilities to express comprehension of scientific text. Analysis of the quantitative and qualitative data reveals that the SRIM had a positive impact on student achievement when it comes to being able to read and comprehend scientific information. However, the data also revealed the improvements were associated with an increase in performance with text only related questions and the pre-test/post-test data did not show a significant increase in the gained mean score for questions that required interpretation of data from tables or graphs. Therefore, the SRIM was effective for improving scientific reading text but did not aid students in improving their abilities for non-textual information.

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Conclusion

The data analysis from this quantitative action research study revealed that the SRIM was effective in improving student's ability to read and comprehend scientific text. However, it proved to be more effective in assisting students with text-only related questions and did not show significant improvements with comprehension questions that relied on data analysis. Furthermore, this study proved to be more beneficial for the female population indicating the strategies selected were in alignment with how the female student-participants learn best.

Being an active interested participant yet also conducting the study with another teacher's students positioned the action researcher as both an insider and an outsider. Data was analyzed with Mrs. Brown and shared with the student-participants throughout the study. In addition, reciprocity with the student was established by the use of semi-structured interview to collect their feedback on the successfulness of the SRIM as well as their input for the future action plan. Their feedback coincided with the quantitative data. Students indicated that prior to the study they did not utilize any strategies when reading their text. Furthermore, they stressed a strong reliance on their teacher for new knowledge. They recognized their lack and need of independence when it comes to learning.

Chapter 4 detailed the findings and implications from the data analysis. It described the thinking, re-thinking and learning that occurred during the action research process. Chapter 5 describes how these findings are used to make conclusions and develop a plan of action for future improvements.

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CHAPTER 5. SUMMARY, CONCLUSIONS, AND ACTION PLAN

Introduction

According to Cromley et. al. (2010), students are not performing at appropriate levels when it comes to scientific literacy. While scientific reading comprehension is a skill that is needed for academic success, students are not equipped with strategies that enable them to comprehend complex expository texts such as their science book (Shanahan & Shanahan, 2008). The purpose of this quantitative action research study was to describe a reading strategy intervention for scientific text with low level readers. This study utilized pre, during and post reading strategies as part of the Scientific Reading Intervention Model (SRIM) that would enable readers to identify key concepts, pictures, charts, and graphs that relate to the various chemistry topics of study, thus making connections and developing a better understanding. This action research study utilized eighteen student-participants who were enrolled in Honors Chemistry in a private high school in southeast South Carolina. To measure the impact of the SRIM on student's ability to read and comprehend scientific text, the primary data was collected utilizing a pre-test/post-test design. Secondary data, in the form of semi-structured interviews with the student-participants, was collected to better understand student perceptions of their abilities, effectiveness of the SRIM, and suggestions they may have for adjustments to the model.

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The results of this study are not intended to be applied to all students enrolled in Chemistry, but rather are unique to the selected participants enrolled in honors chemistry at the specific high school. It is, however, my hope as the researcher that the study and its findings may provide insight for other educators considering the use of reading strategies for their curriculum.

Both the quantitative and qualitative data collected indicates that students improved in their ability to read and comprehend scientific text by utilizing the reading strategies of the SRIM. However, a more detailed analysis of the data also revealed that the SRIM strategies were more beneficial for text-only related questions as opposed to questions that required graphical interpretation. In addition, the female population showed a more significant gain in the mean score than their male counterparts. These results indicate the strategies chosen for the SRIM could be adjusted to be more effective by addressing the skill of data interpretation.

It is my suggestion that the SRIM be modified to include a strategy that would help students improve their skills for data analysis. The integration of reading strategies, as well as data analysis strategies, will be an ongoing endeavor for Mrs. Brown's Chemistry courses as part of the Action Plan for this study. With my assistance, she will be utilizing an adjusted SRIM for both her honors level and general level students over the next year. Additionally, other science teachers at this private high school have indicated interest in adding reading strategies to their curriculum and will be working with Mrs. Brown to select an appropriate data reading strategy to implement as part of the SRIM.

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In Chapter 4, the collected data was presented and analyzed. The purpose of Chapter 5 is to describe the major conclusions and action plan. The following chapter is divided into three sections, Summary of Major Points, The Action Plan and Recommendations for Future Research.

Summary of Major Points

The data from this research study provides evidence that the SRIM reading strategies were effective in improving student's ability to read and comprehend scientific text. The data collected from the semi-structured interviews with the student-participants indicated that students felt confident that the strategies were helpful not only in aiding their comprehension, but also in preparing them to be more independent learners. Specifically, students felt most confident with the strategies of coding and constructing a concept map. Many students stated that they had little to no experience with reading strategies prior to the study. Instead, they read their textbook, as well as other scientific text such as journals and lab reports, in the same manner they read a novel for English class. They believed these strategies enabled them to organize the in-depth scientific information in a way that allowed for better understanding.

More detailed analysis of the quantitative data revealed that while students showed improvement in their overall score from the pre-test to post-test, their improvements were due to a higher gained score for text-only related questions and there was not a significant improvement in their scores with questions that required data analysis from graphs or tables. These results indicate that the SRIM strategies were not effective in significantly improving the student's ability to comprehend information when it is provided in a format other than written text. The qualitative data supports this claim

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in that students reported that they did not feel the SRIM strategies were helpful with comprehension or analysis of graphs and tables. At the completion of the study they did not feel more confident in their abilities to answer such questions.

Additionally, students revealed they did not feel prepared for college due to their lack of ability to independently learn. They stressed a reliance on the teacher for their understanding. The students, along with Mrs. Brown, indicated that the class activities did not allow opportunities for independent or cooperative learning. Instead, all information was delivered by the teacher to the student. Students were only tested on the material that was provided to them by the teacher. Additional readings or activities were not utilized for enhancement of the chemistry curriculum.

Key Questions

Several key questions emerged from the findings of this study. First, based on the data collected, I would like to see if a change in the SRIM strategies would show a more significant gain in improvement. How would the addition of data analysis strategy improve student's overall ability to comprehend scientific text? Scientific text is multi-modal, meaning it requires interpretation of text, graphs, tables and pictorial information (Lemke, 2004). I believe an additional data analysis strategy could further improve students' comprehension. Additionally, I would like to examine the impact of the modified SRIM on student comprehension over a longer period of time. The student-participants showed an overall improvement from the SRIM strategies by utilizing them for a 6-week period. However, would this model have a greater impact on student success if it were utilized over a semester or even a year? Another idea for consideration would be to examine the impact on general level chemistry students. This study was

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focused specifically on the honors level students who tend to be more motivated and driven for science achievement (Beghetto, 2007). What would be the impact of the modified SRIM on students enrolled in general level Chemistry courses? Based on the results of this action research study, I believe these questions are worth considering when thinking about future research in scientific literacy.

Action Researcher

Action research was the most appropriate approach for this study because it required planning, acting, developing, and reflecting (Mertler, 2014). Reflection was a large component for this study. Mrs. Brown and I spent a lot of time designing the SRIM, collecting data, analyzing data, and making changes along the way. We also worked closely with the student-participants reflecting on their work examples and sharing results with them throughout the study. The researcher-participant, myself, and the teacher-participant, Mrs. Brown, both served as curriculum leaders in this action research study.

This action research study investigated the impact of adding new instructional strategies to Mrs. Brown's classroom. Specifically, we examined how the SRIM may assist students with reading comprehension. In doing so, this required a shift in Mrs. Brown's teaching practices and required the students to be more active members in their learning process. While Mrs. Brown still utilized the lecture format, she incorporated group work and peer reflection which she had not done in the past. She also required reading prior to her lectures. Our goal, as curriculum leaders, was to collect data that would provide us with more descriptive information on the specific struggles students face with reading comprehension. To make effective change, the data was analyzed to find deeper meanings and causation for the improvements and deficits. Identifying the

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strengths and weaknesses allowed us to adjust the SRIM and identify how it may be improved to maximize the benefits to the students.

In order to successfully analyze the data and develop an effective SRIM, I maintained constant and open communication with both Mrs. Brown and the student-participants throughout the study. While Mrs. Brown was equally involved in the creation, implementation and analysis of the SRIM, the student-participant feedback was also solicited and used to make modifications and assist in the development of the action plan.

For this action research study, I held both the inside and outside researcher roles. Being an active and interested participant in the study identifies me as an insider. I have vested interest in the study and its findings. However, not being in the classroom daily and not working with my own students also identifies me as an outsider. To establish reciprocity with the student-participants, I introduced the study by explaining the expectations and possible benefits students may receive from their participation. I also attended class sessions, conducted the semi-structured interviews and shared the data throughout the study.

As the action researcher, I encountered several challenges during the planning, implementing and analyzing phases of the study. To begin with, I developed the SRIM and planned on implementing this treatment at a different private school that consisted of an all-girls population. However, one week prior to the start of the study the designated teacher developed health issues and was not going to be available to conduct the study. Therefore, I moved the study to another school with a different Chemistry teacher. While this was a challenge, I do believe this change of schools and teachers provided a more

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effective study. The new teacher-participant, Mrs. Brown, and I have worked together for several years and share similar ideas regarding progressive education. Mrs. Brown had indicated to me last year that she was looking to improve her teaching and try new methods to help her students be more successful. Once the decision was made to work with Mrs. Brown, we sat down and reviewed the SRIM to ensure it would be a good fit for her population of student-participants. She only taught the honors level chemistry courses; therefore, the study did not examine the impact of SRIM on general level students.

Additionally, selecting the appropriate unit for the treatment was a challenge. In order to examine the impact of the SRIM, we needed to select a unit of curriculum that was not heavy with mathematical operations. We wanted to use a unit that was more conceptual. Therefore, Mrs. Brown and I worked together to select the content to be used and develop a timeline for the implementation. This required us to postpone the treatment for two weeks so that she could finish the previous unit of study and allow for a smooth transition in curriculum. Despite the challenges and efforts required to switch the study location, I believe Mrs. Brown and her students were the best choice in the end. Her excitement and willingness to reflect on her own teaching practices to better serve her students is what allowed this study to be successful.

There were several challenges with the implementation of this study. First, Mrs. Brown and I underestimated the student's abilities to adequately construct a concept map, the third strategy of the SRIM. We both went over the strategies and guidelines at the start of the treatment. We provided instructions and I did a basic demo of how to construct a concept map as a class activity. However, after the first concept maps were

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turned in for review, we noticed the students wrote down too many facts and did not categorize information based on the major concepts. Therefore, we created a rubric to provide guidance and details to describe how an effective concept map should appear. Mrs. Brown went over the rubric with all students in class. Their feedback was positive and their concept maps showed improvements for the next section.

The implementation of the SRIM was challenging due to multiple unplanned school interruptions. Throughout the treatment period, the students missed four class periods for school related events. In efforts to stay on schedule for the treatment and her yearly curriculum plan, Mrs. Brown adjusted the implementation. We originally planned for the coding and concept map construction to be done during class time. However, with the schedule changes, we agreed to assign those tasks as homework and allow time for collaboration at the start of the next class period instead. The collaboration time provided students with an opportunity to discuss their work with their peers and make any adjustments they felt necessary. The student feedback revealed that they appreciated this time and felt the collaboration was beneficial to their understanding of the material.

While analyzing the data, we realized that the strategies chosen for the SRIM, while effective, could have been more effective if we had incorporated strategies for data analysis. Reflecting on the SRIM and data collection methods, we concluded that a pre-treatment survey may have provided student-feedback regarding their perceived areas of weakness. We identified the fact that scientific text is multi-modal and utilized pretest and posttests that contained multi-modal information. However, we must admit that the strategies chosen for the SRIM were not designed to specifically address the skill of analyzing pictorial information.

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In addition to challenges throughout the study, Mrs. Brown and I also faced challenges in finding time to collaborate and review the student data. We often met after school hours to review the progress and discuss changes. I would travel to the school for observations and meetings with Mrs. Brown. In addition to working full time, making the time to meet was sometimes difficult and we often had to reschedule due to one of our personal schedules. Carrying out this action research required dedication to helping the students from both of us. While it was sometimes exhausting, we both believe the results and action were well worth our endeavors.

Action Plan

Action research is conducted under the premise that the information gathered will be used for some type of action (Mertler, 2014). The purpose of this action research project was to determine the impact of the SRIM on the student-participant's abilities to read and comprehend scientific text. As a professional curriculum leader and serving as the curriculum director for a district of thirty-three schools, I plan to use the results of this study and the said action plan to bring about awareness of the need for scientific literacy as well as provide recommendations for improving scientific comprehension.

The purpose of this action plan is to help science educators, specifically high school science educators, recognize the need and importance of incorporating reading skills into the existing curriculum. Additionally, this plan is designed to provide teachers with reading strategies that have been proven effective when utilized with science content so they may implement reading activities in their own classrooms. Finally, this action plan is designed with collaboration in mind so that teachers may share their feedback and work together to help students improve their reading comprehension.

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My district, under the leadership of our superintendent, is creating a four-year professional development program for all teachers. The title of this program is "Shifting from a teacher-centered to a student-centered classroom." The district is working to shift the focus from the teacher to the student. The goal is to train and encourage teachers to utilize teaching practices that are centered to the student, provide opportunities for the students to take control of their own learning and focus on helping students be more independent and critical thinkers. Part of this program involves two district-wide professional development workshop days in which teachers participate in topic specific courses and listen to guest speakers on the topic of student-centered instruction. Seeing that reading comprehension is a skill set that will enable students to become more independent learners, this professional development program provides the perfect opportunity and correlation for my plan of action.

The first action for the plan includes a presentation at the fall professional development conference on Wednesday, August 16, 2017. I will be conducting the science seminar session from 9:00 am until 10:30 am for all middle school and high school science teachers. This seminar session is divided into two parts; the presentation regarding scientific literacy and guided collaboration time. During the first ten minutes, I will provide a welcome, introduction of myself and a description of my role for the district. Then, I will spend fifteen minutes presenting an overview of my action research, the relevance of the study and the findings. I will share the feedback from my student interviews with my audience so they may gain insight on how one particular group of students responded. Next, I will spend approximately twenty-five minutes reviewing 8 different reading strategies that teachers may adopt in their own classroom. I will

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provide handouts and examples for each strategy to go along with the presentation. Throughout the presentation, I will stress the importance of reviewing text features, activating prior knowledge, and monitoring student progress. These are key feature that can help educators teach students how to interpedently read and comprehend. Additionally, based on the results of this study, a key focus will be on how to help students read and comprehend graphical information. I will review the importance of teaching students how to interpret charts, tables and graphical information in addition to the text. I will explain my own hurdles and the inability of my students to interpret graphical information so my audience may better understand what may happen in their classrooms. Finally, I will spend the last ten minutes concluding the presentation by reminding science teachers of our district theme, the importance of teaching students skill sets as part of the curriculum and encouraging them to try implementing these strategies in their own classrooms. The last thirty minutes of the session will be utilized for guided collaboration. Teachers will be encouraged to collaborate on what strategies they have used, what they have found effective/ineffective and what strategies they would like to implement. At the end of the session, I will provide teachers with a quick pen and paper survey regarding their feedback of the session. This will help me as a curriculum leader understand how I may adjust my presentation skills as well as provide feedback on their understanding and/or interest in the topic.

The next step in the action plan involves visitation to all science teacher classrooms. As part of my job, I travel with the superintendent to visit all schools at least once a year. During that visit, I observe each classroom and meet with each teacher. These observations are not for evaluation and instead and intended to be viewed as

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helpful to the teachers. I work with teachers regarding the curriculum or instructional issues they may encounter. When I visit the science classrooms for the middle and high school level, I will be making a point to talk with each teacher about their implementation of reading strategies. I will solicit and record their feedback. Additionally, I will try to provide assistance if and where it may be needed. If teachers want additional materials or ideas, I will work to help meet their needs.

As I meet with science teachers throughout the district, I will be soliciting and recording their feedback regarding their implementation of specific reading strategies. Collaboration and the sharing of ideas has been a large focus for my district over the last two years. Therefore, the feedback I receive will be logged on our established internal collaboration board, Edmodo, for science teachers to see and respond. Edmodo is designed so that all middle school and high school science teachers have a small online group for collaboration. Currently they utilize this space for collaboration regarding teaching strategies, project ideas and sharing current trends or news in science. In addition to sharing the feedback, I will also utilize this group space to promote content literacy, share materials and resources, and be available to assist teachers with questions.

The spring professional development day will be held on May 1, 2018 and will be of similar design to the fall meeting. The science session will be led by another member of our science curriculum team; however, I will attend this session and gather more feedback during the group collaboration time. I will ask teachers what strategies they tired to implement and their thoughts regarding the impact on student comprehension. I will record all data collected and review it comprehensively with data gathered throughout the year. Finally, I will write a summary report that will describe the teacher

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feedback and my observations of the science classrooms. I will review this data with our superintendent to determine our next step.

Facilitating Educational Change

Making changes in education begins with reflection on current practices and a vision of what new practices may enable our students to be more successful and competitive in a changing world. The educational needs of students today are not the same as they were in the 1950's or even ten years ago. The typical workplace today requires skill sets of cooperation, problem-solving, diverse perspectives and life-long learning skills. The rapid change in today's workplace places higher demands on our educational system. The transmission of knowledge from teacher to student, convergent teaching, is not sufficient to prepare our students for their future (Bar-Yam, et. al., 2002). Instead, a divergent approach to teaching is needed. One that is student-centered and students are active participants in their own learning. With the expansion of knowledge and rapid change in most fields as well as the appearance of many new fields, it is critical to develop students' capacity for self-directed learning and self-growth (Bar-Yam, 2002).

This action research study investigated the impact of the SRIM on student's ability to independently read and comprehend scientific material. The future goal for implementing the SRIM is to enable students to be more independent thinkers and self-learners. For teachers, especially veteran teachers, shifting the focus to the student and incorporating new teaching strategies can be fearful. The best way schools can address the challenges of the changing classroom is to continue to provide professional development and training. Administrators can encourage teachers to begin by incorporating small student-centered tasks and activities. Creating professional learning

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communities where teacher can work together to facilitate change could ease the fears and unknowns. The action plan for this study requires Mrs. Brown to make a cultural shift in her teaching strategies by incorporating more student-centered activities. However, she is comfortable with this plan because it allows her to make small changes over time and provides opportunities for her to discuss her successes and failures with her peers. This action plan ensures that the teacher making change, Mrs. Brown, is not left on her own. Instead, she has a network of support and collaboration.

Summary of Research Findings

This action research study was conducted in an effort to bring about educational change. Enabling students to be independent learners better prepares them for their future education endeavors as well as their future careers. This study examined the impact of the SRIM on students' abilities to independently read and comprehend scientific information. Research has proven that students struggle when it comes to reading multi-modal, vocabulary dense informational text. This study aimed to equip students with strategies they may use to improve their level of comprehension. The data indicates the SRIM was successful in improving student comprehension levels. However, further analysis of the data reveals that the SRIM did not assist students when it comes to analyzing information in graphs or tables. Student feedback also revealed that while they found the SRIM effective, it was not effective in helping them improve their skill sets of data analysis. Therefore, the action plan recommends a modification to the SRIM to include graph and table analysis questions throughout each unit of study. It is believed that the practice, both cooperative and individual, of interpreting information

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from pictorial formats will bring about a greater level of improvement in student comprehension of scientific material.

Suggestions for Future Research

Moving beyond the ideas in this narrowed and specific action research study, there are other aspects that could be explored that may provide more insight when trying to improve student reading comprehension levels. For example, it would be worthwhile to investigate the impact of adding content reading strategies to the middle school science curriculum. Equipping students with the tools to digest expository text at an earlier age and developing the skills needed for analysis could better prepare them for the more complicated text they encounter in high school and college. Instead of stopping at the basic reading strategies in elementary school (Roe, Stoodt, & Burns, 1995), continuing the focus of content literacy throughout middle and high school could help students to become more efficient readers and therefore improve their academic success.

In addition to adding content reading to the curriculum, it would also be beneficial to examine middle school and high school curriculum to assess the skill sets that are being taught in addition to the content objectives. For example, for this study, the students would have been more successful with comprehension if they had developed the skill of data analysis. Future research regarding what skills are being taught and at what grade level would be beneficial for creating a spiraling comprehensive curriculum. Skill sets such as data analysis, content reading and writing and lab techniques such as measuring and calculating are all needed for high school science courses. However, the important question is, when were the students supposed to learn these skills. High school science teachers need to have an understanding their student's current knowledge and

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abilities. Otherwise, as realized in this study, teachers often need to take a step back when they realize their students are not academically ready for the new knowledge.

Finally, another question of consideration for future research is, how does improved reading comprehension benefit students in their post-secondary experiences. If students are equipped with reading strategies and demonstrate a high level of reading comprehension, does this help them to be more independent learners in college or their careers? The impact of reading comprehension on future success would be an area worth researching in order to provide more evidence of its importance for middle school and high school teachers. Many current research studies indicate that reading levels at early ages dictate future success. However, it would be worth knowing the impact on future success from reading strategies that were incorporated at the middle and high school levels. Does reading comprehension ability impact the student's ability to be an independent learner? Do they have more success in college courses? Are they more prepared to read, interpret, and figure things out on the job? These are all questions that would be worth an investigation and would help both primary and secondary teachers prepare students for their future.

Conclusion

This action research focused on improving student's ability to read and comprehend scientific text. Scientific text, being multi-modal (Ratzel, 2004), is often difficult for students to understand due to presentation of material. This study utilized the SRIM in an effort to assist students with comprehension of expository text like their science textbook. Quantitative data was collected to measure the impact of the SRIM on comprehension. Qualitative data was also collected to gain insight from the student-

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participants regarding their perceptions of the treatment and their reading abilities. The findings from this study indicate that the SRIM was effective in helping students improve their reading comprehension. However, the SRIM was not as effective in aiding students with analysis of data that is needed for understanding. The data shows that students are still in need of assistance when it comes to interpreting tables and graphs as well as being able to independently learn. The qualitative data revealed that the student-participants in this study directly rely on the teacher-participant to receive knowledge. However, they expressed understanding that they need to be more independent learners to be successful in college.

Recognizing the needs of the student, the action plan was developed to help aid teachers when it comes to teaching literacy within their content, specifically science. This action plan will be implemented through the already established professional development program for the district. While I will be the primary leader of the action plan, other individuals in my district will assist with the planning and implementation of the professional development in-service days. The purpose of this action plan is to bring about awareness regarding the need for content literacy, equip teachers with strategies to better prepare their students for reading comprehension and therefore help create students that are self-directed and independent learners.

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APPENDIX A. PRE-TEST

PASSAGE I

Some students performed three studies to measure the average speed on a flat surface of a remote-controlled car with different types of wheels. Each study was conducted indoors in a temperature-controlled room. A straight track was constructed and measured to be 75 feet long. The car's travel time was measured from start to finish with a stopwatch. The temperature in the room was kept constant at 20° F and the surface was returned to its original condition after each trial. No modifications were made to the car aside from changing the wheels, and the car's batteries were fully charged before each trial.

Study 1

The students fitted the car with hard rubber wheels, which had deep treads, and placed it on the surface. One student started the car as another student simultaneously started the stopwatch. The student stopped the stopwatch as the car crossed the 75-foot mark. The students calculated the results of three separate trials and averaged the results (see Table 1).

Table 1		
Trial	Time (s)	Speed (ft/s)
1	22.8	3.28
2	23.2	3.23
3	22.5	3.33
Average:	22.8	3.28

Study 2

The students repeated the procedure used in Study 1, except they fitted the car with soft rubber wheels, which were smooth and lacked treads. The results are shown in Table 2.

Table 2		
Trial	Time (s)	Speed (ft/s)
1	57	1.31
2	56.4	1.33
3	56.7	1.32
Average:	56.7	1.32

Study 3

The students repeated the procedure used in Study 1, except they fitted the car with hard rubber wheels, which had studs imbedded into them instead of treads. The results are shown in Table 3.

Table 3		
Trial	Time (s)	Speed (ft/s)
1	11.3	6.64
2	11.6	6.47
3	12.1	6.20
Average:	11.7	6.44

The fastest times resulted from using which wheels?

A. The speeds remained constant.
B. Hard rubber wheels with studs imbedded in them.
C. Soft rubber wheels with no treads.
D. Hard rubber wheels with deep treads.

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PASSAGE II

The ninth planet of our solar system, Pluto, was discovered in 1930. It is the smallest planet in the solar system, with a surface area more than 300 times smaller than Earth's. Recently, Pluto's categorization as a planet has been debated. Two scientists discuss whether Pluto is a planet or another celestial object.

Scientist 1

Pluto is most certainly a planet. Some astronomers have suggested that Pluto be stripped of its planetary status, arguing that it is more accurately categorized as an asteroid or comet. However, with a 1,413 mile diameter, Pluto is almost 1,000 times bigger than an average comet, and it does not have a tail of dust and gas as comets do. A planet can be described as a non-moon, sun-orbiting object that does not generate nuclear fusion and is large enough to be pulled into a spherical shape by its own gravity. Strictly by definition alone, Pluto is a planet. Pluto is clearly not a moon, as it does not orbit another planet. Although Pluto's orbital path is irregular as compared with the other planets of the solar system, it undisputedly orbits the sun. Pluto does not generate heat by nuclear fission, distinguishing it from a star. It is large enough to be pulled into a spherical shape by its own gravitational force, distinguishing it from either a comet or an asteroid.

Scientist 2

There are many facts about Pluto suggesting that it is actually not a planet but a member of the Kuiper Belt, a group of sizable comets that orbit the sun beyond Neptune. First, Pluto is composed of icy material, as are the comets in the Kuiper Belt, while the other planets of the solar system fall into one of two categories: rocky or gaseous. The four inner planets, Mercury, Venus, Earth, and Mars are rocky planets; Jupiter, Saturn, Uranus, and Neptune are gaseous. Pluto is neither rocky nor gaseous but has an icy composition. In addition, Pluto is much too small to be a planet. It is less than half the diameter of the next smallest planet, Mercury. The Earth's moon is even larger than Pluto. Finally, the eccentricity of Pluto's orbit indicates that it is not a planet. Pluto is generally considered the ninth planet, but for twenty years of its 249 year orbit, it is actually closer to the sun than is Neptune, making it the eighth planet during that period of time. This irregular orbit is shared by over seventy Kuiper Belt comets.

Which of the following phrases best describes the major point of difference between the two scientists' viewpoints?

F. The actual location of Pluto in the solar system.
G. The length of Pluto's orbit.
H. The shape of Pluto.
J. The classification of Pluto as a planet.

According to Scientist 2's viewpoint, compared to other planets of the solar system, Pluto's surface is:

A. less icy.
B. more icy.
C. more gaseous.
D. more rocky.

Scientist 1's viewpoint indicates that Pluto differs from asteroids and comets in all of the following ways EXCEPT:

F. Pluto can generate heat through nuclear fission.
G. Pluto is pulled into a spherical shape by its own gravitational force.
H. Asteroids and comets have a tail of gas and dust particles.
J. Asteroids and comets are much smaller than Pluto.

The polar ice caps on Pluto's surface melt one time during every 249-year orbit, exposing Pluto's truly rocky surface, which is similar to that of Mars. Based on the information provided, this finding, if true, would most likely weaken the position(s) of:

A. Scientist 1 only.
B. Scientist 2 only.
C. both Scientist 1 and Scientist 2.
D. neither Scientist 1 nor Scientist 2.

With which of the following statements would both scientists most likely agree?

F. The size of Pluto indicates that it could actually be a satellite of another planet.
G. Pluto should be classified as neither a planet nor a comet; a new category is indicated.
H. The surface composition of Pluto is irrelevant and should not be considered in its classification.
J. Pluto's erratic orbit differentiates it from all other planets in the solar system.

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APPENDIX B. **POST-TEST**

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PASSAGE

Researchers conducted trials on a certain prescription drug delivered in immediate-release capsules and extended-release capsules.

Figure 1 shows the mean concentration (nanograms per milliliter [ng/mL]) of the two active ingredients of the prescription drug in patients' blood plasma over time (hr).

In clinical trials of the prescription drug, subjects given the prescription drug were interviewed at regular intervals about the symptoms the prescription drug is meant to relieve. After each interview, the subjects were assigned a symptom score. A high symptom score corresponds to high intensity of symptoms, and a low symptom score indicates low intensity of symptoms. Figure 2 shows the mean symptom score over time (hr) for subjects who took the prescription drug.

In the clinical trials, some subjects were given the prescription drug and some subjects were given a placebo (an inactive pill). Table 1 shows the percentage of subjects from both groups who reported various adverse side effects.

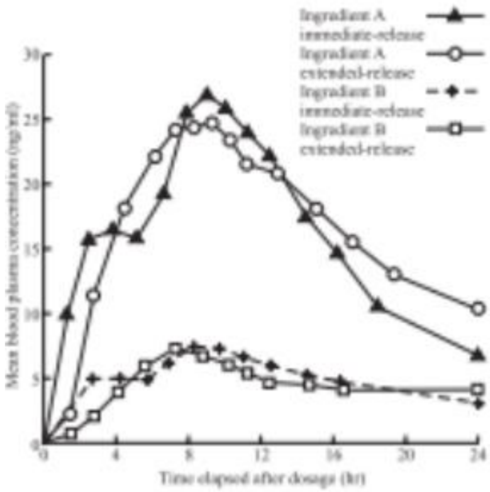

Figure 1

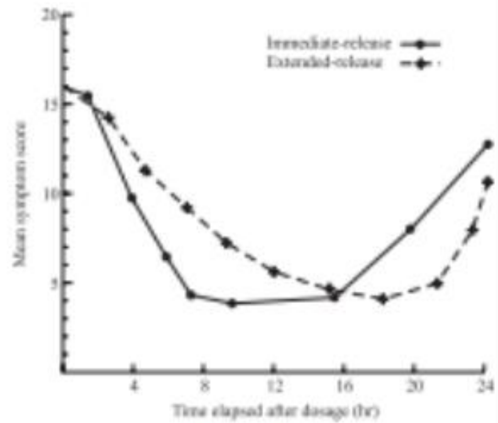

Figure 2

Table 1			
Body system	**Side effect**	**Prescription drug group (%)**	**Placebo group (%)**
General	Feeling of weakness	6	5
	Headache	26	14
Digestive system	Loss of appetite	32	5
	Diarrhea	8	0
	Dry mouth	31	5
	Nausea	14	0
Nervous system	Anxiety	7	4
	Dizziness	9	0
	Insomnia	25	11
	Irritability	11	4
Cardiovascular system	Rapid heart rate	10	2
Nutritional	Weight gain	15	0

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According to Figure 1, 16 hours after taking the extended-release form of the prescription drug, the difference in mean blood plasma concentration between Ingredient A and Ingredient B is closest to:

A. 7 ng/ml.
B. 9 ng/ml.
C. 11 ng/ml.
D. 16 ng/ml.

Based on the data in Figures 1 and 2, the researchers should make which of the following conclusions about the overall change in mean blood plasma concentration and mean symptom score over time following dosage?

F. Both mean blood plasma concentration and mean symptom score increase then decrease.
G. Both mean blood plasma concentration and mean symptom score decrease then increase.
H. Mean blood plasma concentration increases then decreases, and mean symptom score decreases then increases.
J. Mean blood plasma concentration decreases then increases, and mean symptom score increases then decreases.

According to Figure 1, mean blood plasma concentration of Ingredient A administered in immediate-release form increases most during which of the following time periods?

A. From the moment of dosage to 3 hours after dosage.
B. From 3 hours after dosage to 10 hours after dosage.
C. From 10 hours after dosage to 14 hours after dosage.
D. From 14 hours after dosage to 24 hours after dosage.

Which of the following conclusions about adverse side effects caused by the prescription drug is consistent with the results shown in Table 1?

F. Results from the placebo group most question the number of instances of feeling of weakness caused by the prescription drug.
G. Results from the placebo group most question the number of instances of insomnia caused by the prescription drug.
H. Results from the placebo group least question the number of instances of anxiety caused by the prescription drug.
J. Results from the placebo group least question the number of instances of irritability caused by the prescription drug.

The symptom score of a clinical trial subject given the extended-release form of the prescription drug remained unchanged for 8 hours. Based on Figure 2, the 8-hour period most likely began:

A. 3 hours after dosage.
B. 5 hours after dosage.
C. 9 hours after dosage.
D. 14 hours after dosage.

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PASSAGE

While digging in a remote site in Africa, paleontologists discovered a collection of fossilized dinosaur bones. The bones were dated back to the Jurassic period, and have been confirmed to be from a dinosaur known as a velociraptor. Two paleontologists discuss the finding.

Paleontologist 1

Once the well-preserved bones are assembled it is clear that they are velociraptor bones from the Jurassic period. The bones are long in the arms, indicating that the velociraptor was definitely capable of flight. You can see that there are cuts within the arm/wing bones of this dinosaur, indicating that it was caught while in flight. Perhaps it was attempting an escape from a more predatory dinosaur, such as tyrannosaurus rex. It is obvious from the body structure of the velociraptor that it was an effective hunter and predator. It was most likely quick to swoop in on its prey and was more than able to carry the prey away on its own. The form and function of the velociraptor has been misunderstood until this important discovery. The condition of these bones offers a clear picture of the way in which the velociraptor lived.

Paleontologist 2

Indeed, the velociraptor bones are in excellent condition. The long arm bones are indicative of the dinosaur's ability to scavenge prey and fend off larger predators. The cuts within the arm bones show that the velociraptor often stole its meals—the marks resemble defense wounds, perhaps from forcing other would-be scavengers away from the free meal. The structure of the velociraptor's feet indicates that it was a fast runner and was able to maneuver well through the high trees and undergrowth. This would certainly have allowed the velociraptor to quickly escape predators and possibly arrive at a kill-site before other larger dinosaurs, such as tyrannosaurus rex, descended upon the leftovers. The bones that were discovered answer many questions about the velociraptor, but they also bring up many new issues to consider.

Paleontologist 1's viewpoint contains the basic assumption that the velociraptor must have been:

F. unknown until the discovery of these bones.
G. an ineffective hunter.
H. previously mischaracterized.
J. unable to escape large predators.

Paleontologist 1 would most likely state that the cuts on the velociraptor bones were the result of:

A. failed attempts to fly.
B. fending off a competing scavenger.
C. an attack by a larger predator.
D. mistakes made in assembling the bones.

24. Suppose that the fossilized remains of another dinosaur species with long arm bones were discovered, and scientists determined that this dinosaur lived at the same time as the velociraptor. According to the passage, Paleontologist 2 would most likely conclude that:

F. the new dinosaur could fly.
G. the new dinosaur could be a scavenger.
H. the new dinosaur could not escape from predators.
J. the new dinosaur could swoop in on its prey.

Paleontologist 2's viewpoint regarding the velociraptor as a scavenger was based on the dinosaur's:

A. strong musculature.
B. excellent condition.
C. long arm bones.
D. ability to fly.

Paleontologist 1 would most likely support which of the following statements about the lifestyle of the velociraptor?

F. The velociraptor was a predatory dinosaur capable of flight, and is only now being understood.
G. The velociraptor was a dinosaur who scavenged other dinosaurs' kills.
H. The velociraptor was a fast runner that could easily out-maneuver its predators in order to survive.
J. The velociraptor was hunted by many other dinosaurs during its time on Earth.

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APPENDIX C. SEMI-STRUCTURED STUDENT-PARTICIPANT INTERVIEW

Student Name: ______________________

1. What type of strategies have you used in the past for reading scientific information such as your textbook, journal articles or lab reports?
    a. Were they effective? Why or why not?
2. Do you feel the added SRIM strategies were beneficial for you?
    a. If yes, what evidence do you have that makes you think the treatment was beneficial?
3. Do you think you are able to independently read and comprehend a scientific text?
    a. Why or why not?
4. Do you plan to attend college?
    a. If yes, what field of study would you like to pursue?
    b. If yes, do you feel prepared?
    c. If no, what are your post-high school plans?
5. Did the SRIM help you when it comes to comprehension of information from graphs or tables?

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APPENDIX D. ANTICIPATION GUIDES

Section 1

Pre-Reading True or False	Statement	Post-Reading True or False
	There are no forces of attraction between gas particles.	
	Gas particles travel in straight-line motion.	
	If temperature increases, gas molecules move faster.	
	If pressure increase, gas molecules move faster.	
	Gas molecules that are heavy stay low to the ground.	

Section 2

Pre-Reading True or False	Statement	Post-Reading True or False
	Liquid are the least common state of matter in the universe.	
	Some liquids can flow uphill against gravity.	
	Diffusion occurs because particles are always moving.	
	Some bugs can walk on water.	
	Vaporization and evaporation are the same thing.	

Section 3

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Pre-Reading True or False	Statement	Post-Reading True or False
	Crystals are very geometric and neatly organized.	
	At the melting point, both solid and liquid states exist.	
	Solids can easily be compressed.	
	Most crystals have the same type of bonding.	
	You cannot melt a crystal.	

Section 4

Pre-Reading True or False	Statement	Post-Reading True or False
	Condensation is the change from liquid to gas.	
	When liquids vaporize, they cause an increase in pressure.	
	Alcohol is slow to evaporate.	
	Water boils at the same temperature in the Colorado mountains as it does at the beach in South Carolina.	
	Solids can change directly to the gas phase without ever existing as a liquid.	

Section 5

Pre-Reading	Statement	Post-Reading

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True or False		True or False
	The empty space between molecules is what makes ice denser than water.	
	Water is important for controlling body temperature.	
	Water boils at 100 degrees Fahrenheit.	
	Bonds in water are weak and therefore easily broken.	
	Steam can be dangerous to humans.	

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APPENDIX E. CONCEPT MAP INSTRUCTIONS

Purpose

- The purpose of a concept map is to graphically organize and represent knowledge. Concept maps should depict suggested relationships between concepts.

Designing a Concept Map

- **Begin with a domain of knowledge.** The big idea! Think about the topic of the chapter or unit. Think about focus questions. This is your central bubble.
- **Think about associated concepts.** Make a list of ideas. Try to write around 15-20 key concepts that you think fit under the main idea. Use text headings and bold vocabulary words to help you. Describe each concept in one to two words.
- **Use a flow chart to show the relationship.** Draw smaller circles or bubbles to show smaller ideas and connect them to the main idea. If ideas are connected to each other, and they will be, draw lines between the small ideas. If ideas flow in sequence, indicate the sequence. Order the concepts in a hierarchical format. You may need to use "linking words" to show how they are connected. Write the linking words on the line.
- **Fine tune the map.** Once you have finished with the ideas, review your finished product and make adjustments if needed. Make sure the big idea is supported with details.

Example

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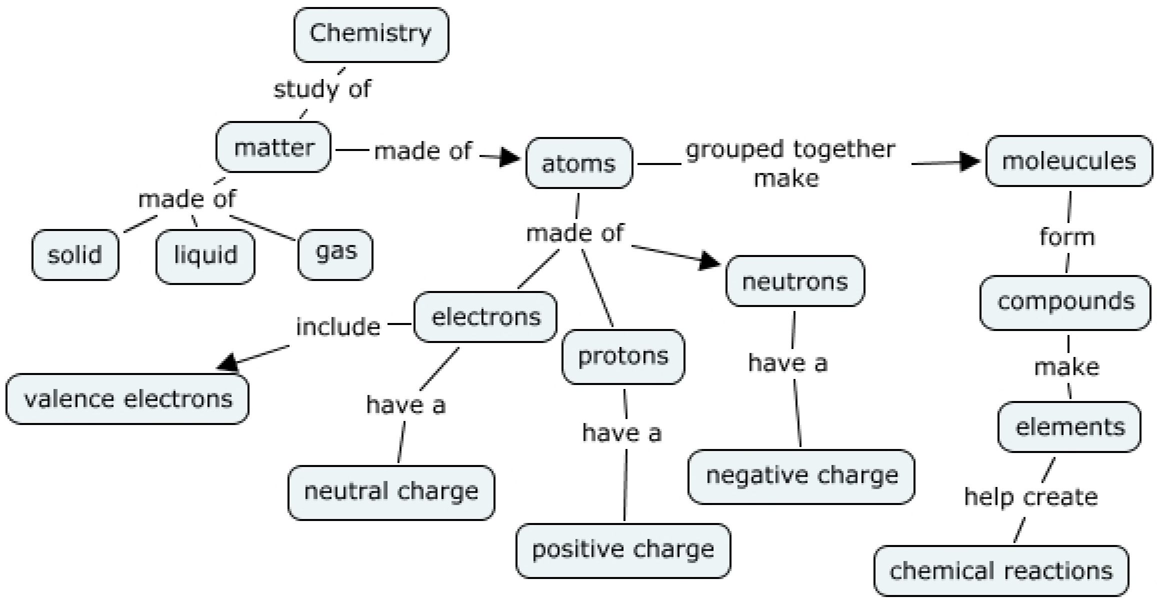

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APPENDIX F. TEXT CODING INSTRUCTIONS

Instructions: As you read the assigned section in your text, use the following codes to identify the information. You may identify specific sentences, groups of sentences or entire paragraphs. Information in charts, tables and figures should be read and coded as well.

(√) Check Mark. Use a check mark to identify material that confirms what you know to be true or that you fully understand.

(!) Exclamation Point. Use an exclamation point to identify material that you think is important. Identify key concepts with this symbol.

(?) Question Mark. Use a question mark to identify information that you do not understand, find confusing or causes you to have further questions.

After you have read and coded your text, you will review the entire section to identify how much you understand. Things to ask yourself:

- How many question marks do I have in this section? Do I understand it well?
- How many check marks do I have in this section? Is there a lot of information I am familiar with?
- How many exclamation points do I have in this section? Do they identify the most important facts?

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APPENDIX G. CONCEPT MAP GRADING RUBRIC

University of Minnesota's Concept Map Assessment Rubric

criteria	Excellent	Good	Adequate	Marginal	No credit; is unacceptabl to review
structure	non-linear structure that provides a very complete picture of your ideas	non-linear structure that provides a complete picture of your ideas	non-linear structure that provides a picture of your ideas	non-linear structure that shows some relationships between ideas	inappropriate structure
relationships	relative importance of ideas is indicated and both simple and complex relationships are very effectively mapped	relative importance of ideas is indicated and relationships are very effectively mapped	relative importance of ideas is indicated; relationships are mapped	importance is evident but not very distinctive; relations are somewhat clear but lacking	no differentiation between ideas; no evidence of meaningful relationships
exploratory	map shows complex thinking about the meaningful relationship between ideas, themes, and the framework	map shows effective thinking about the meaningful relationships between ideas, themes, and the framework	map shows definite thinking about relationships between ideas, themes, and the framework	map shows some thinking about relationships between ideas, themes, and the framework	thinking process is not clear
communication	information is presented clearly and allows for a high level of understanding	information is presented clearly and allows for a good level of understanding	information is presented clearly and allows for a basic level of understanding	information is presented and some understanding can be gained	information is not clear, very difficult to understand

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APPENDIX H. TIMELINE FOR THE ACTION PLAN

When	Who	Task
Wednesday, August 16th, 2017 9:00am-10:30am	Myra Finneran, Curriculum Director Superintendent	Present findings of the study to all middle school and high school science teachers in the district. As well as provide information on reading strategies that can be used for science text. Explain the importance of content literacy and encourage teachers to implement strategies in their classrooms.
Throughout the year	Myra Finneran, Curriculum Director Superintendent	We will both visit each school throughout the year. During the school visit I will observe all science classrooms and speak with each science teacher regarding implementation of reading strategies. Feedback will be recorded.
Throughout the year	Myra Finneran, Curriculum Director MS and HS science teachers	Feedback as well as suggestions and materials will be provided on the district's internal collaboration site, Edmodo. Science teachers will be encouraged to respond and collaborate with each other regarding their challenges/successes with various reading strategies.
March 2nd 2018	Myra Finneran, Curriculum Director Superintendent	Spring Professional Development Meeting. I will attend the science break out session to gain more feedback and share ideas with science teachers regarding their implementation of reading strategies throughout the year.
April 30th 2018	Myra Finneran, Curriculum Director Superintendent	I will write a summary report describing the details of the action plan including teacher feedback and usage of reading strategies. I will review the results with the superintendent and we will determine the next step.

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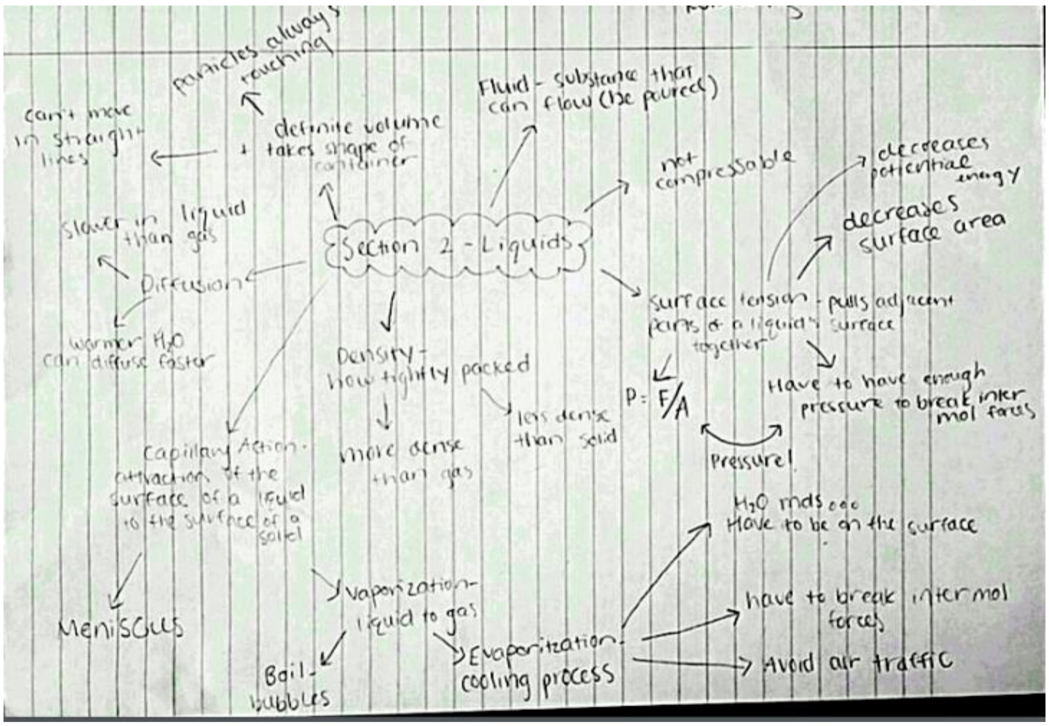
APPENDIX I. STUDENT EXAMPLES OF CONCEPT MAPPING



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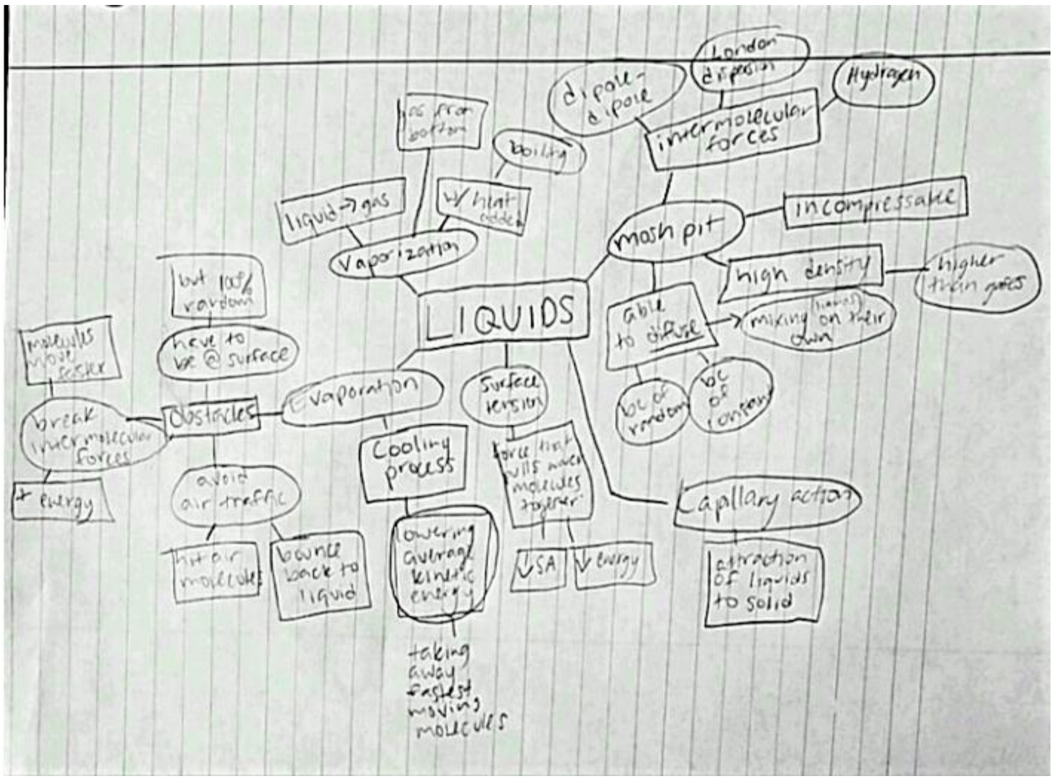

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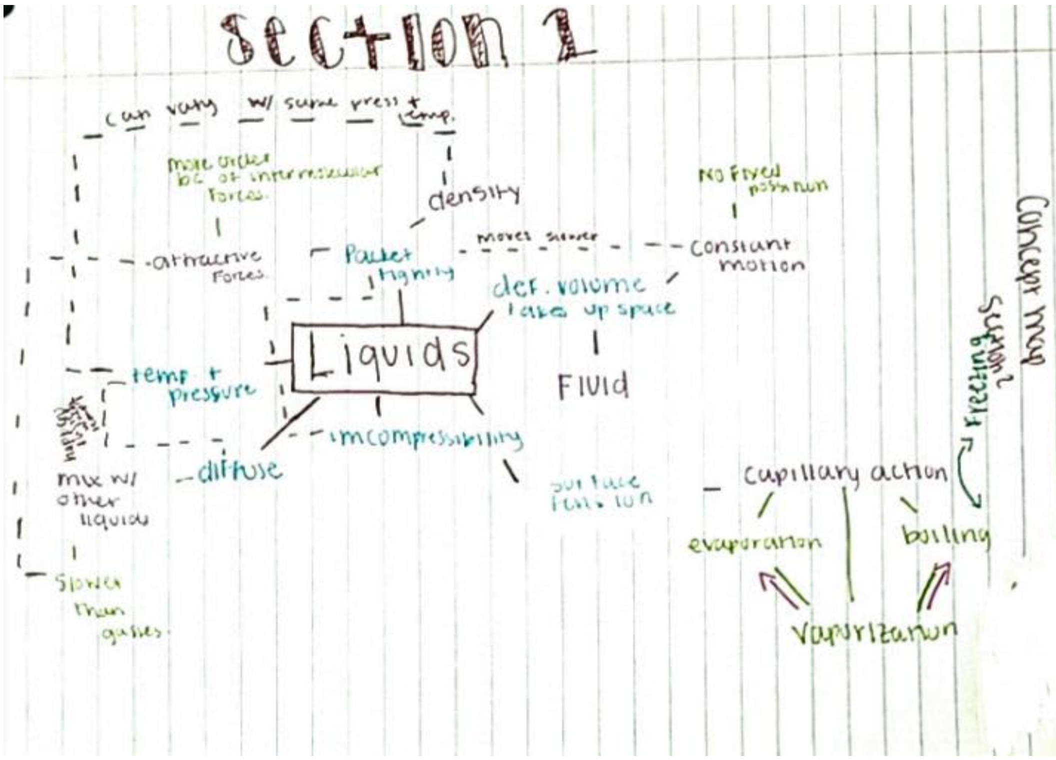

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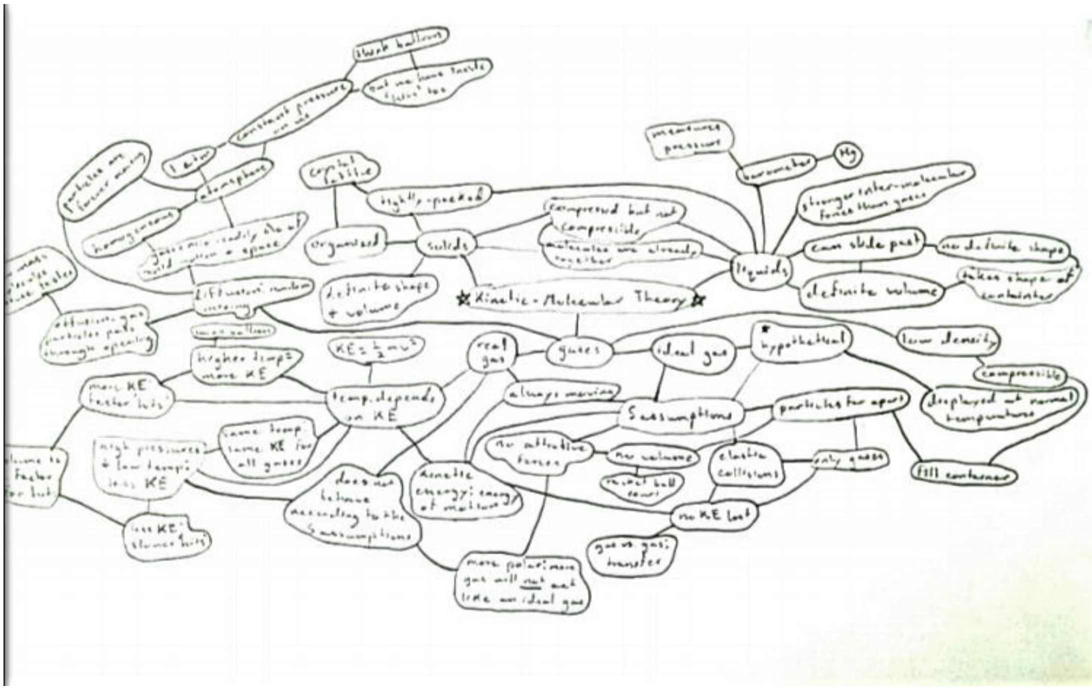

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APPENDIX J. STUDENT EXAMPLES OF CODING

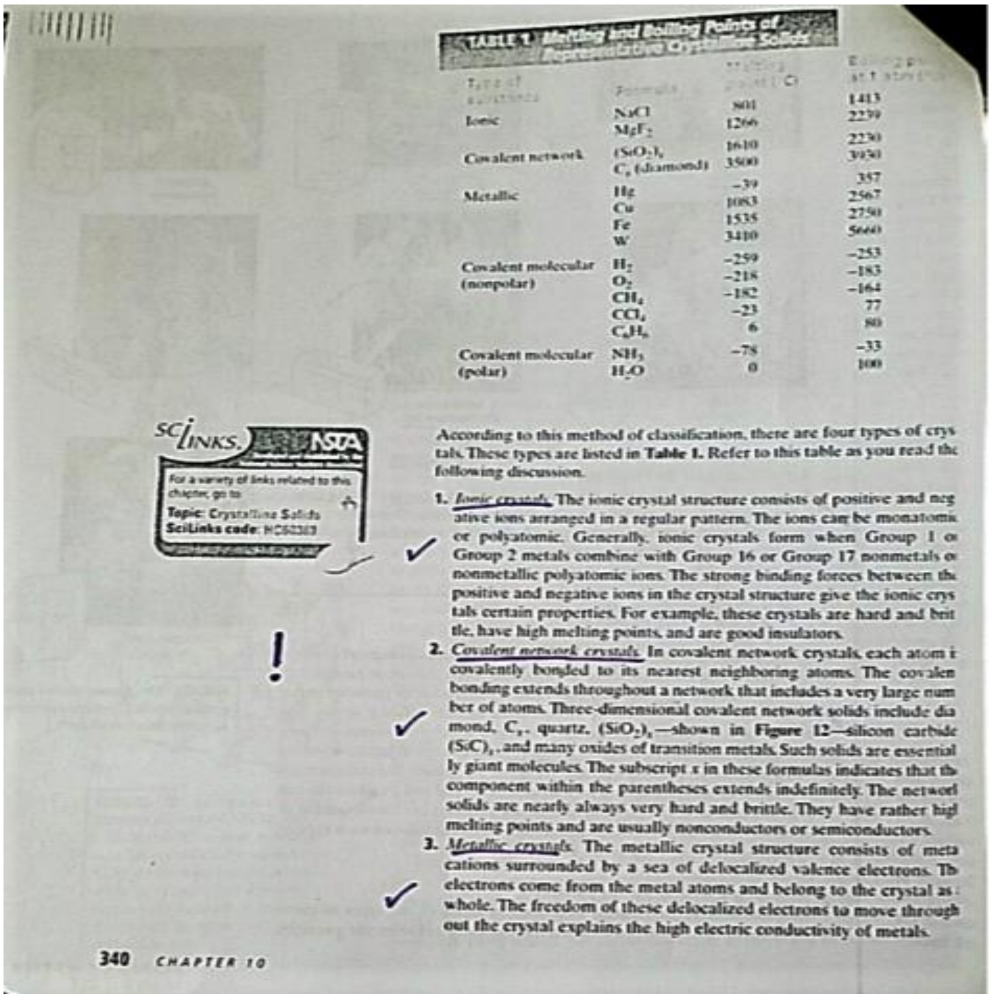

TABLE 1 Melting and Boiling Points of Representative Crystalline Solids

Ionic	NaCl	801	1413
	MgF_2	1266	2239
Covalent network	$(SiO_2)_x$	1610	2230
	C_x (diamond)	3500	3930
Metallic	Hg	−39	357
	Cu	1083	2567
	Fe	1535	2750
	W	3410	5660
Covalent molecular (nonpolar)	H_2	−259	−253
	O_2	−218	−183
	CH_4	−182	−164
	CCl_4	−23	77
	C_6H_6	6	80
Covalent molecular (polar)	NH_3	−78	−33
	H_2O	0	100

SciLinks. NSTA
For a variety of links related to this chapter, go to
Topic: Crystalline Solids
SciLinks code: HC60383

According to this method of classification, there are four types of crystals. These types are listed in **Table 1.** Refer to this table as you read the following discussion.

1. *Ionic crystals.* The ionic crystal structure consists of positive and negative ions arranged in a regular pattern. The ions can be monatomic or polyatomic. Generally, ionic crystals form when Group 1 or Group 2 metals combine with Group 16 or Group 17 nonmetals or nonmetallic polyatomic ions. The strong binding forces between the positive and negative ions in the crystal structure give the ionic crystals certain properties. For example, these crystals are hard and brittle, have high melting points, and are good insulators.
2. *Covalent network crystals.* In covalent network crystals, each atom is covalently bonded to its nearest neighboring atoms. The covalent bonding extends throughout a network that includes a very large number of atoms. Three-dimensional covalent network solids include diamond, C_x, quartz, $(SiO_2)_x$—shown in **Figure 12**—silicon carbide $(SiC)_x$, and many oxides of transition metals. Such solids are essentially giant molecules. The subscript *x* in these formulas indicates that the component within the parentheses extends indefinitely. The network solids are nearly always very hard and brittle. They have rather high melting points and are usually nonconductors or semiconductors.
3. *Metallic crystals.* The metallic crystal structure consists of metal cations surrounded by a sea of delocalized valence electrons. The electrons come from the metal atoms and belong to the crystal as a whole. The freedom of these delocalized electrons to move throughout the crystal explains the high electric conductivity of metals.

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liquid → solid + energy
solid + energy → liquid
liquid has more energy than solid

is a loss of potential energy that was present in the liquid. At the same time energy decreases, there is a significant increase in particle order because the solid state of a substance is much more ordered than the liquid state, even at the same temperature.

Melting, the reverse of freezing, also occurs at constant temperature. As a solid melts, it continuously absorbs energy as heat, as represented by the following equation.

$$\text{solid} + \text{energy} \longrightarrow \text{liquid}$$

For pure crystalline solids, the melting point and freezing point are the same. At equilibrium, melting and freezing proceed at equal rates. The following general equilibrium equation can be used to represent these states.

$$\text{solid} + \text{energy} \rightleftharpoons \text{liquid}$$

At normal atmospheric pressure, the temperature of a system containing ice and liquid water will remain at 0°C as long as both ice and water are present. That temperature will persist no matter what the surrounding temperature. Adding energy in the form of heat to such a system shifts the equilibrium to the right. That shift increases the proportion of liquid water and decreases that of ice. Only after all the ice has melted will the addition of energy increase the temperature of the system.

Chemistry in Action

Surface Melting

Freezing of water and melting of ice are phase changes that are familiar to all of us. Yet physicists and chemists have only recently begun to understand the basic aspects of these phase changes, with experimental and theoretical studies of a phenomenon known as surface melting. Experimental studies in the mid-1980s confirmed that the rigid surface arrangements of metals can become increasingly disordered several degrees below the melting point of the metal, forming a "quasi-liquid layer." Many different techniques have now shown that ice also has such a fluid surface layer just a few molecules thick. This surface melting of ice might explain observations as diverse as the origin of lightning, the unique shapes of snowflakes, and ice skating.

Molar Enthalpy of Fusion

The amount of energy as heat required to melt one mole of solid at the solid's melting point is the solid's **molar enthalpy of fusion,** ΔH_f. The energy absorbed increases the solid's potential energy as its particles are pulled apart, overcoming the attractive forces holding them together. At the same time, there is a significant decrease in particle order as the substance makes the transformation from solid to liquid. Similar to the molar enthalpy of vaporization, the magnitude of the molar enthalpy of fusion depends on the attraction between the solid particles.

Sublimation and Deposition

At sufficiently low temperature and pressure conditions, a liquid cannot exist. Under such conditions, a solid substance exists in equilibrium with its vapor instead of its liquid, as represented by the following equation.

$$\text{solid} + \text{energy} \rightleftharpoons \text{vapor}$$

The change of state from a solid directly to a gas is known as **sublimation.** The reverse process is called **deposition,** *the change of state from a gas directly to a solid.* Among the common substances that sublime at ordinary temperatures are dry ice (solid CO_2) and iodine. Ordinary ice sublimes slowly at temperatures lower than its melting point (0.°C). This explains how a thin layer of snow can eventually disappear, even if the temperature remains below 0.°C. Sublimation occurs in frost-free

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Type of substance	Formula	Melting point (°C)	Boiling point at 1 atm (°C)
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	Cu	1083	2567
	Fe	1535	2750
	W	3410	5660
Covalent molecular (nonpolar)	H_2	−259	−253
	O_2	−218	−183
	CH_4	−182	−164
	CCl_4	−23	77
	C_6H_6	6	80
Covalent molecular (polar)	NH_3	−78	−33
	H_2O	0	100

SciLINKS. NSTA
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