Conceptual Change: The Power of Refutation Text

by

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Abstract

Using a mixed method research design in which qualitative techniques were embedded in a quasi-experimental approach, I investigated the use of refutation text as a strategy for correcting science misconceptions. Forty Grades 3 and 4 students at an elementary school situated in an economically and ethnically diverse Victoria neighborhood participated in this study. A true or false pretest identified which of eight target misconceptions were held by individual participants and indicated that all but three participants held four or more misconceptions. During the intervention phase, participants read text passages about four of the misconceptions they held: two refutation text passages and two expository text passages. A posttest was administered immediately after the intervention, and a delayed posttest was administered six weeks later.

I followed an open coding procedure to analyze qualitative data, and, where appropriate, I used Chi-square (X^2) to determine the statistical significance of the results. The readability levels of the 16 text passages used in the study were determined by the Dale-Chall readability formula and Fry's Readability Graph. Data collection instruments consisted of a researcher-developed pretest, posttest, and delayed posttest; the Reading Comprehension subtest of the *Canadian Tests of Basic Skills* (*CTBS*); and a semi-structured interview guide. Results indicated that refutation text passages were significantly more likely than traditional expository text passages to result in the

immediate correction of a target misconception. The corrections of misconceptions were more often maintained after six weeks if they resulted from reading a refutation text passage rather than from reading a traditional expository text passage, regardless of grade level, although the differences were not significant. While text passage effectiveness could not be correlated with textual characteristics, it was influenced by the reader characteristics of gender, grade level, and reading comprehension ability.

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CHAPTER 1

INTRODUCTION

> Movies sometimes show octopuses attacking divers and squeezing them to death. However, if an octopus really saw a diver nearby, it would quickly swim away. Octopuses are actually quite timid. They do not often hunt for their food. They hide in holes or cracks and wait for their food to come near. They eat crabs, clams, and shrimp—not people!

After reading this passage, which is an alternative text type known as refutation text, Michael, a Grade 4 student, remarked, "*I learned that octopuses don't attack divers. I always thought they did, but I was wrong.*" Michael's comment demonstrated how reading a refutation text passage led to the correction of his misconception about octopuses. Research has shown that refutation text can lead to conceptual change for readers in high school and university. This thesis study investigated whether students in Grades 3 and 4 would be more likely to experience conceptual change after reading refutation text passages than after reading regular expository text passages. In addition, the study explored some of the factors contributing to the effectiveness of both types of text passages.

Positioning the Author

I am a teacher and a researcher. At the time this study was conducted, I had been teaching for 10 years and was in my second year of teaching students in Grades 3 and 4. One of my roles as a teacher is to facilitate conceptual change for students, and I implement new techniques and strategies in a

continuing effort to improve my ability to fulfill that role. As a researcher, I am interested in the theoretical aspects of the techniques and strategies that I implement in the classroom. The use of refutation text is a strategy that has resulted in the successful correction of misconceptions for students in Grades 6 and higher. I designed the thesis study to provide more information about the effectiveness of refutation text in facilitating conceptual change and about the appropriateness of its use with younger students.

Theoretical Framework

Most refutation text research has been conducted from constructivist perspectives, which include cognitive constructivist and social constructivist perspectives (Guzzetti, Snyder, Glass, & Gamas, 1993). The main tenet of constructivism is that a learner actively participates in the acquisition of skills and knowledge. Cognitive constructivism, based on the work of Piaget (Bringuier, 1977/1980; Piaget, 1975/1977), emphasizes that knowledge is built through personal experience. Social constructivism, based on the work of Vygotsky (trans. 1986), acknowledges the role of experience in knowledge building, but places an emphasis on the social nature of experience. In both perspectives, meaning is constructed as the learner interprets events through the lens of prior knowledge. This thesis study was situated in a cognitive constructivist framework, because the refutation text passages were designed to activate the readers' prior knowledge, and the reading activities and the assessment measures were designed to be completed independently.

Research on the use of refutation text arose from conceptual change research. Since the early 1980s, researchers have investigated conceptual change and conceptual development in the domain of science. That much of the research has been conducted in a constructivist framework is an indication of the important role of prior knowledge in conceptual change. However, prior knowledge is not always accurate knowledge. Most people, regardless of age, gender, or nationality, possess science misconceptions (Dole & Smith, 1989; Maria, 2000). These misconceptions, sometimes called alternative conceptions, are often beliefs that have developed as a result of an individual's effort to make sense of the world, and are highly resistant to change. The correction or modification of misconceptions occurs during a process called conceptual change (Gordon & Rennie, 1987; Hewson, 1992).

A Text-Based Strategy for Conceptual Change

Several researchers seeking effective methods for facilitating conceptual change have focused on text-based methods because print texts, especially textbooks, despite being viewed negatively by both teachers and students, are the dominant method of science instruction (Freeman & Person, 1998; Newton, Newton, Blake, & Brown, 2002; Yore, 1991). Traditionally, science textbooks contain expository text, which may be written to include structures such as cause and effect or compare and contrast. Researchers focusing on text-based methods of facilitating conceptual change have adapted traditional expository text in an attempt to create alternative text formats that would be more effective than traditional expository text. Two alternative text formats, based

on the conceptual change model proposed by Posner, Strike, Hewson, and Gertzog (1982), are conceptual change text, developed by Roth (1985), and refutation text, the focus of this thesis study. Conceptual change text differs from refutation text in that readers are asked to make predictions about the particular concept, but both conceptual change text and refutation text explicitly state the misconceptions that may be held by readers, which can cause them to experience cognitive conflict as they become aware of the inadequacy of their current schemata. In fact, refutation text has been described by Guzzetti (2000) as one of the most effective means of producing the cognitive conflict that can result in a change of readers' misconceptions.

Importance of Refutation Text

An international interest in using text to facilitate conceptual change is reflected in the global nature of research focusing on refutation text and conceptual change text. The majority of published refutation text studies have been conducted in the United States (e.g., Dole, 2000; Hynd & Alvermann, 1986a, 1986b; Maria & MacGinitie, 1987). However, research focusing on the use of refutation text and conceptual change text has also been conducted in Australia (Palmer, 2003), China (Chiu & Wong, 1995), Cyprus (Diakidoy, Kendeou, & Ioannides, 2002), Finland (Mikkilä-Erdmann, 2001), Taiwan (Tsai & Chou, 2002), and Turkey (Sungur, Tekkaya, & Geban, 2001; Tekkaya, 2003; Yuruk & Geban, 2001). To date, however, no published studies on refutation text have been conducted in a Canadian setting.

Refutation text passages can be developed for any misconception in any domain. Researchers have investigated the use of refutation text with social studies topics (e.g., Guzzetti, 1990; Stahl, Hynd, Montgomery, & McClain, 1997). However, most refutation text research has been conducted in the context of science, because of the high proportion of misconceptions that exist in the domain of science (e.g., Guzzetti, Snyder, & Glass, 1992; Palmer, 2003). The eight target misconceptions that were the topics of the text passages used in this study are all based on science concepts.

Research Approach and Questions

The research design for this study was quasi-experimental; the quantitative data generated by the quasi-experimental methods were supplemented by qualitative data collected during individual interviews and large group discussions. The study was based upon a pilot study which was an action research project, as I conducted it in my own classroom during the course of regular instruction. Due to the constraints posed by my university's human research ethics policies and because the methodology required that preliminary data be analyzed before the study implementation continued, the thesis study took place at a school at which I did not teach. I collected data during four visits to the research site within a three month period. The study was based upon the following three questions:

1) Is refutation text an effective and appropriate strategy for correcting the science misconceptions of students in Grades 3 and 4?
2) How effective is refutation text at correcting misconceptions held by

students at these grade levels when compared with traditional expository text?

3) How do gender, reading comprehension ability, and grade level of the reader influence the effectiveness of both traditional expository text and refutation text passages in facilitating conceptual change?

These three focus questions provided the starting point for an analysis of the quantitative data that were collected using a variety of measures, both standardized and researcher-designed. Qualitative data collected during individual interviews, as well as during group discussions, allowed me to examine other factors such as student preference for text format and to explore the influence of student preference on the effectiveness of text passages.

Limitations of the Study

The results of the thesis study are subject to a number of general limitations. First, the focus of the study was an isolated strategy for facilitating conceptual change that was presented out of context for the participants. Although the activities I implemented during the thesis study were usually conducted in the participants' classrooms, they were not conducted in the context of on-going classroom activities. However, the lack of context may have served to reduce the reactivity of the activities and collection instruments. According to Isaac and Michael (1997), in order to reduce the Hawthorne effect, "alternative teaching procedures [can be] presented without announcement or apology in the regular teaching process" (p. 96).

Second, the study was based on a single intervention; that is, the participants received text passages only once during the course of the study. The thesis study must therefore be considered as a snapshot, and the results are not as generalizable as they would have been if the study design had included a repetition of the intervention and data collection procedures.

Third, the number of study participants was small, which also limits the generalizability of the results. However, participants were drawn from four different classes, with four different teachers, which is a better research condition than if the study had been conducted with only one class. Further, despite the limited generalizability, the results of the thesis study indicate the need for replication studies comparing the use of refutation text and expository text with students in Grades 3 and 4.

Finally, because the study took place during a three month period, the conceptual change experienced by participants during the course of the study may have been due to factors other than reading refutation and expository text passages. For example, the maturation process may have contributed to the results (Isaac & Michael, 1997). In Chapter 5, I address these four general limitations in the context of the thesis study and discuss three additional limitations which are specific to the study.

Significance of the Study

Despite its limitations, the thesis study helps to fill two gaps in the body of refutation text literature. The study was designed to compare the efficacy of refutation text and expository text passages in correcting science

misconceptions held by students in Grades 3 and 4. Few published studies have focused on a comparison of refutation text and traditional expository text with students in grades lower than Grade 6. In fact, I located only four studies with participants in Grades 5 or younger. Those four refutation text studies had participants who were: (a) a mixed group of gifted Grades 5 and 7 students (Maria & Johnson, 1989); (b) a group of Grade 6 students (Diakidoy et al., 2002); (c) a mixed group of Grades 5 and 6 students (Maria & MacGinitie, 1987); and (d) a mixed group comprised of four students at each grade level from Kindergarten to Grade 3 (Mayer, 1995). A recent study compared the use of conceptual change text with traditional expository text for students in Grade 5 (Mikkilä-Erdman, 2001). However, no published study has focused on the use of refutation text with students in Grades 3 or 4.

Additionally, the research was conducted in a Canadian setting. As noted previously, although refutation text research has been conducted in countries around the world, the majority of the refutation text research has taken place in the United States, and there have been no published studies undertaken in Canada to date.

Organization of the Thesis

In this chapter, I provided a brief discussion of the theoretical framework for the thesis study. I also discussed the research approach and the questions upon which the study was based, as well as the limitations and significance of the study.

In Chapter 2, a review of refutation text literature, I describe the

theoretical framework for refutation text research, which includes models of reading in science, knowledge structure and conceptual change. The review also includes a history of refutation text research and an overview of the results of refutation text research. Following a description of current trends in refutation text research, I conclude the review with brief discussions of gender and of readability, issues pertinent to the thesis study.

In Chapter 3, I discuss the methods used in the thesis study. I begin with a brief description of the research design, continue with a summary of the pilot study upon which the thesis study was based and then provide a detailed discussion of the development and implementation of the methodology of the thesis study itself. I conclude the methodology chapter with a description of the statistical procedures used to analyze the data.

In Chapter 4, I present and interpret the data that I collected during the thesis study. I begin with a general examination of the effectiveness of refutation text as compared to expository text in correcting the science misconceptions held by students in Grade 3 and 4. Next, I explore some factors that may have contributed to the effectiveness of refutation text. These factors include the readability levels of the individual text passages, reading comprehension ability of the participants, gender of the participants, and text passage preferences of the participants.

In Chapter 5, I provide a summary of the results of the thesis study, and compare the results to previous findings of refutation text research. I review the conditions required for conceptual change and describe how refutation text

meets those conditions. I discuss the limitations of the study in more detail. Then, using the results of the thesis study as a starting point, I discuss several important implications for educators. I conclude the chapter with my recommendations for future refutation text research.

CHAPTER 2

LITERATURE REVIEW

This literature review describes the theoretical framework for refutation text research, which includes models of reading in science, knowledge structures, and conceptual change. The review also provides a history of refutation text research and an overview of the results of the research on this topic. Following a description of current trends in refutation text research, the literature review concludes with brief discussions of gender and of readability, issues pertinent to my study.

Theoretical Background for Refutation Text Research

The majority of refutation text research has been based in constructivist theory, which emphasizes the active participation of the learner in the acquisition of skills and knowledge (Guzzetti et al., 1993). The two predominant perspectives of constructivism are cognitive constructivism and social constructivism. Cognitive constructivism, based on the work of Piaget, emphasizes that knowledge is built through personal experience (Bringuier, 1977/1980; Piaget, 1975/1977), while social constructivism, based on the work of Vygotsky (trans. 1986), acknowledges the role of experience in knowledge building but places an emphasis on the social nature of experience. From a constructivist point of view, the prior knowledge that a reader possesses will naturally affect the acquisition of new information from text (Kearsley, 2003). Many factors influence whether or not conceptual change will occur when a reader encounters new information. These factors include the structure and

accuracy of the reader's prior knowledge, as well as the presence or absence of the conditions required for conceptual change to occur. Figure 1 shows the relationships between the various models that form the theoretical framework for the thesis study. Constructivist theories, which are indicated by the colored background in Figure 1, provide the context for the models of knowledge structures, conceptual change, and science reading that are briefly summarized in the following sections.

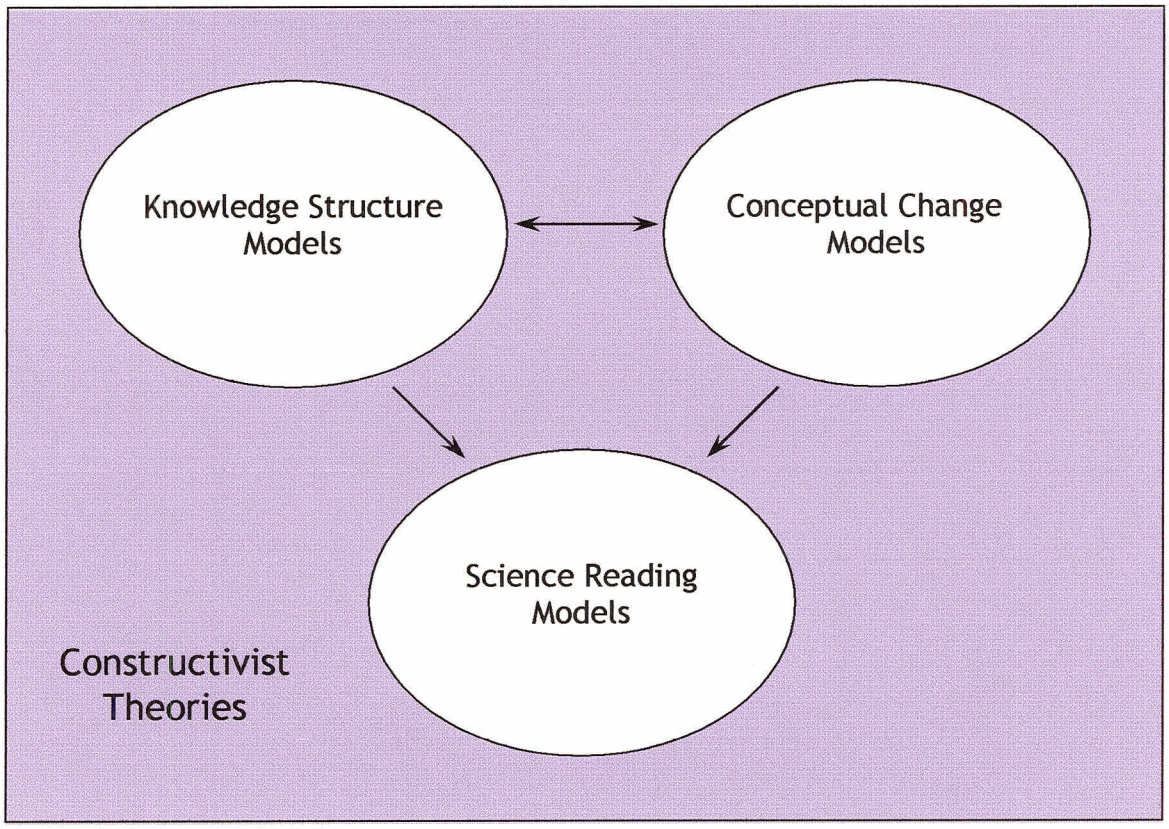

Figure 1. The relationship of the models that create the theoretical framework for the thesis study.

Knowledge Structures

Two distinct categories of knowledge structure models are described in the literature on learning and conceptual change (Southerland, Abrams, Cummins, & Anzelmo, 2001). The first is the mental-model category, which is exemplified by schema theory, and the second is the fragmented knowledge category, which is exemplified by diSessa's (1988) p-prim model. These two examples are the most commonly cited knowledge structure models in the conceptual change literature.

Schema Theory

According to schema theory, an individual's knowledge exists as a framework. The singular *schema* describes a node that stores and represents knowledge (Dole & Sinatra, 1994) as well as the interaction of that knowledge with incoming information (Bigenho, 1992). *Schemata* are complex clusters or networks composed of a number of nodes linked together. The links that form schemata are relationships such as identifying characteristics, functions, propositions, and associations (Bigenho). Additions to and deletions from schemata, as well as changes in the relationships between individual nodes, are made in a process called conceptual change (diSessa & Sherin, 1998; Gordon & Rennie, 1987).

P-Prims

A second model of knowledge structures was described by diSessa (1988). In this model, a knowledge system is made up of a number of small knowledge structures called phenomenological primitives, or p-prims. These

small structures are formed during superficial evaluations of experienced events and in turn they provide the lens through which the world is seen and understood. P-prims may be isolated mental structures and they may be behavioral. The p-prim model describes a knowledge structure that is "a fragmented collection of ideas, loosely connected and reinforcing, having none of the commitment or systematicity that one attributes to theories" (diSessa, 1988, p. 50). In this model, knowledge is developed and refined rather than replaced (diSessa, 1993).

The most prevalent knowledge structure model in conceptual change literature is the mental-model model, in which learning takes places as a series of cognitive restructurings, and the emphasis is on the accumulation of scientific information and the elimination of incorrect information (Southerland et al., 2001). The fragmented knowledge model, in which learning is spontaneous and does not result in a systematic restructuring, emphasizes altering the reasoning process rather than the content of the knowledge structure (Southerland et al.).

In the context of my study, schema theory provides the most appropriate representation of knowledge structures, as I focused on eliminating incorrect information. However, both types of models acknowledge the importance of prior knowledge in the learning process.

The Accuracy of Prior Knowledge

Unfortunately, knowledge structures, regardless of the model one uses, do not always contain accurate knowledge. Knowledge structures may be based

on naïve theories, or contain information that is not scientifically accurate. Although there is a lack of agreement about what to call the misconceptions that are present in the knowledge structures of many learners, a large body of literature indicates common characteristics of those misconceptions (Wandersee, Mintzes, & Novak, 1994).

What is a misconception?

In general terms, a misconception is a belief that conflicts with currently accepted explanations. Throughout the literature, many other terms have been used in place of misconception, including alternative conception, preconception, preinstructional conception, intuitive conception, naïve conception, naïve theory, persistent pitfall, erroneous idea, spontaneous reasoning, alternative framework, inaccurate prior knowledge, intuitive science, nonscientific ideas, and children's science (Chinn & Malhotra, 2002; Guzzetti et al., 1993; Guzzetti, Williams, Skeels, & Wu, 1997; Pace, Marshall, Horowitz, Lipson, & Lucido, 1989; Wandersee et al., 1994).

Wandersee et al. (1994) compiled a comprehensive review of alternative conception research, which they refer to as Alternative Conceptions Movement (ACM) research, in the area of science. In their review, they present eight assertions that have arisen from research in the field of alternative conceptions. These eight assertions are shown in Table 1.

Table 1

Assertions Based on Alternative Conception Research

1. Learners possess a variety of alternative conceptions regarding the objects and events in their surroundings.
2. All learners may possess alternative conceptions regardless of age, ability, gender, and culture.
3. Alternative conceptions are resistant to change.
4. Alternative conceptions frequently resemble historical explanations of natural phenomena.
5. Alternative conceptions are based on personal experience, observation, and interpretation of events, explanation, and instruction.
6. Teachers may hold alternative conceptions that resemble those of their students.
7. Prior knowledge interacts with information presented during instruction and may yield unintended and inaccurate learning.
8. Teaching strategies can effectively promote conceptual change.

Note. Adapted from Wandersee, Mintzes, and Novak, 1994, p. 195.

Further, they describe two types of alternative conception research: nomothetic and idiographic. Nomothetic research compares learners' knowledge with accepted scientific knowledge, and often utilizes an experimental design. Nomothetic research involves tests, quantitative results,

and inferential statistics. Nomothetic literature contains terms such as naïve conception, preinstructional conception, and misconception. Idiographic research, on the other hand, attempts to describe the learners' knowledge in depth, and usually employs a naturalistic design. Idiographic research produces qualitative data based on interviews and students' self-reporting. Idiographic literature will contain terms such as alternative conception, children's science, and intuitive conception (Wandersee et al., 1994).

Although I conducted interviews that provided some qualitative data, the research undertaken for the thesis was largely nomothetic, as I compared the participants' knowledge with accepted scientific knowledge, used tests, and generated quantitative results and inferential statistics. Additionally, the participants' knowledge that I focused on in my research consisted of simple rather than complex concepts. Therefore, I have used the term *misconception* in the remainder of the literature review and in the discussion of the data that I collected during this study.

Science misconceptions.

Although misconceptions exist in every subject area they seem especially prevalent in science, an observation supported by Maria (2000), who suggested that science is the area that encompasses the most counterintuitive concepts. A science misconception might be as simple as the belief that camels store water in their humps, or it could be as complex and fundamental as a belief in Aristotelian impetus theory. Research from the fields of reading education and science education has included studies based on misconceptions

from one end of the spectrum of complexity to the other. Some researchers have even attempted to differentiate between misconceptions that have been learned through incorrect instruction and those that have been learned through everyday experiences (Guzzetti et al., 1993). Table 2 contains examples of common science misconceptions.

Table 2

Common Science Misconceptions

All stars are the same size.
The sun boils the sea to create water vapor.
Objects float in water because they are lighter than water.
The Earth is molten, except for its crust.
A camel stores water in its hump.
The heart beat is a reflex action.
Some organisms do not have a role in nature.

Note. Adapted from AIP Operation Physics Project, 1998; Maria and MacGinitie, 1987; Palmer, 2003; Sungur, Tekkaya, and Geban, 2001.

Conceptual Change

It is evident that an individual's knowledge structures may include misinformation or misconceptions. The focus of my study was on facilitating conceptual change, the process through which those misconceptions are eliminated or corrected.

As is the case with many constructs, a number of different interpretations of the construct of conceptual change exist. According to Hewson (1992), there is general agreement that the process of one idea or concept being exchanged for another is conceptual change. However, this definition is rather limiting, since it describes conceptual change as an exclusive process, as if only one concept or idea exists at any one time, implying that any new idea therefore excludes the old. A second, more encompassing view of conceptual change also includes an extending process, where connections are made between new and existing ideas. The new idea does not exclude the old, but adds to it. As Hynd (2001) explains, while

> conceptual change involves the rejection of a prior understanding in favor of a new one . . . [t]he old idea often remains and, indeed, may need to be intentionally inhibited. What changes is the level of belief that is placed in the old idea. (p. 701)

Perspectives on Conceptual Change

A number of different theories or models have been developed to describe what occurs when individuals are presented with new scientific information. In this section, I describe four perspectives on both individual models and overviews of alternative models; the authors of the cited articles are referred to frequently in the refutation text literature.

Posner, Strike, Hewson, and Gertzog (1982).

One of the most frequently cited models of conceptual change is that proposed by Posner, Strike, Hewson, and Gertzog (1982). This model consists of

four alternatives for students dealing with new information. If the new information is not counterintuitive, it can be assimilated into the student's previously constructed schemata. If the new information is counterintuitive, however, there are three possibilities: the information might be rejected outright; the information might be memorized, but not assimilated into pre-existing schemata; or the existing schemata might be restructured to accommodate the new information.

Vosniadou and Brewer (1987).

In their widely referenced article, Vosniadou and Brewer (1987) classify theories of knowledge restructuring as global models or domain-specific models, citing Piaget's model as a global model and Posner et al.'s (1982) model as a domain-specific model. The authors continue their classification with a discussion of weak and radical restructuring. Weak restructuring occurs during a novice to expert shift, where expert knowledge is organized in more abstract schemata and contains more and different relationships between concepts than novice knowledge (Vosniadou & Brewer). Radical restructuring occurs when a learner possesses a *different* theory, rather than a less refined or less developed theory, and is the type of knowledge restructuring represented by diSessa's (1988) p-prim model.

Chinn and Brewer (1993).

A more elaborate model of conceptual change than Posner et al.'s (1982) model was proposed by Chinn and Brewer (1993) in an effort to more fully describe how students respond to anomalous data. Chinn and Brewer

suggest that when faced with new information that is contrary to their current schemata, students might: (a) ignore the new information; (b) reject the new information because of perceived flaws; (c) exclude the new information from previous schemata, as it is not supposed to be explained by the schemata; (d) keep the new information on hold; (e) accept the information but reinterpret data to remain consistent with pre-existing schemata; (f) accept the information and make minor changes to pre-existing schemata; or (g) accept the information and change pre-existing schemata.

This more elaborate model also acknowledges the relationship of factors that determine how an individual responds to anomalous data. These factors include the individual's prior knowledge, the plausibility of the new theory, the strategies used to process the inconsistent data, and the characteristics of the inconsistent data (Chinn & Brewer, 1993).

Pintrich, Marx, and Boyle (1993).

An alternative model of conceptual change is the "hot cognition" model proposed by Pintrich, Marx, and Boyle (1993). These researchers believe that "cognition-only models of student learning do not adequately explain why students who seem to have the requisite prior conceptual knowledge do not activate this knowledge for many school tasks" (p. 167). Their model is based on an interactive relationship between the conditions for conceptual change proposed by Posner et al. (1982) and motivational factors such as goals, values, and personal interest. The result is a constructivist model that also incorporates classroom context as a factor in conceptual change.

In fact, the emphasis on motivation and social context in more recent models of conceptual development led to a revision of the conceptual change model first described by Posner et al. (1982). Strike and Posner (1992) include among the modifications to their original theory the need to account for the motivation of the learner and the social contexts of the learner's goals. In addition, they clarify their interpretation of conceptual change as an interactive, developmental process that is based upon a learner's conceptions and misconceptions. These modifications and clarifications notwithstanding, their revised theory of conceptual change remains similar to the process that Piaget (1975/1977) called accommodation, and includes the conditions for conceptual change that I briefly describe in a later section.

The conceptual change models discussed here emphasize the role of prior knowledge in conceptual change, although the organization or structure of that prior knowledge is not the same in all models. Additionally, in all of these models of conceptual change, there are more options that result in the rejection rather than the acceptance of information that conflicts with pre-existing schemata, an indication of the difficulty of effecting conceptual change.

Conditions for Conceptual Change

Effecting conceptual change is difficult, as indicated by the models outlined above. Not only are there a number of different ways that new information can be processed, there are also certain requirements that must be met before conceptual change can occur. Posner et al. (1982, p. 214) describe

four conditions that must be met before students are likely to experience conceptual change and restructure their schemata to include new information: (a) the student's current schemata must appear inadequate to solve the problem, (b) the new information must be understandable (intelligible), (c) the new information must be useful in solving the current problem (plausible), and (d) the new information must appear useful in solving future problems (fruitful).

Chinn and Brewer (1993) also describe factors that contribute to the likelihood of conceptual change. These factors include prior knowledge, the possible new theory, and the new information. Prior knowledge characteristics include the individual's commitment to the current belief and the individual's ontological and epistemological beliefs. Characteristics of a new theory that are likely to lead to conceptual change include plausibility, accuracy, usefulness, and consistency. New information, or anomalous data, that is credible, unambiguous, and presented a number of times is also likely to lead to conceptual change.

Model of Reading in Science

In the thesis study, I examined the use of refutation text, which was specifically developed to meet some of the conditions for conceptual change, as an isolated strategy to promote conceptual change for students in Grades 3 and 4. Because I used a text-based strategy and the text passages were based on selected science topics, I briefly describe a model of reading in science that provides an appropriate theoretical context for the study. Reading in science

can be viewed as an interactive constructive process that involves a reader, a text, and a social context (Yore, Craig, & Maguire, 1998). The interactive-constructive model describes reading in science as a generative process through which a reader accesses prior knowledge and makes interpretations of the information presented in a text. According to Yore et al., "readers make meaning by using top-down processes in which tentative mental models are constructed from the new information and tested against prior knowledge and socially shared standards" (p.29). Although acknowledging the importance of social influences upon the reader, the interactive-constructive model of science reading emphasizes the individual nature of learning through text. The model assumes the perspective of constructivist theories, and is influenced by models of knowledge structures and models of conceptual change.

Refutation Text

The process of facilitating conceptual change is complex and involves a number of factors, as discussed above. However, if the critical requirement of conceptual change is dissatisfaction with current schemata (Hewson, 1992), then it seems reasonable to look for ways to create that dissatisfaction. Furthermore, while print texts, especially textbooks, are often viewed negatively by both teachers and students, they are the dominant method of science instruction (Freeman & Person, 1998; Newton et al., 2002; Yore et al., 1998). However, expository text, the text type most often found in textbooks may not be the most effective text type for promoting conceptual change (Guzzetti et al., 1993). Thus, researchers and educators have developed a

number of text-based strategies.

One text-based strategy for causing readers to become dissatisfied with their prior knowledge is conceptual change text. According to Chambers and Andre (1997), conceptual change text presents a scenario, asks for predictions to be made based on that scenario, describes common misconceptions about the scenario, and then provides the scientific explanation for the scenario. Another text-based strategy designed to promote conceptual change is refutation text.

Refutation text is a specialized form of text that arose from the conceptual change model proposed by Posner et al. (1982). Refutation text, sometimes called refutational text, is text that directly refers to a misconception, explicitly contradicts—refutes—that misconception by explaining why it is not scientifically acceptable, and supplies the current scientific explanation. Table 3 shows a refutation text passage that was developed for use in a research project involving students in Grades 5 and 6 (Maria & MacGinitie, 1987, p. 227).

Table 3

Sample Refutation Text Passage

The lion is often called the "King of the Jungle." Many stories have been written in which the lion is one of the main characters. Pictures that accompany these stories may show the lion hiding among the trees and stalking his prey in the deep forest. However, most lions really live on grassy plains where their tawny coats blend into the background.

Both conceptual change text and refutation text are constructivist strategies, as they attempt to improve reader-text interaction by explicitly addressing readers' misconceptions and current understandings (Hynd, 2001). The difference between conceptual change text and refutation text is that students are asked to make predictions while reading conceptual change text (Chambers & Andre, 1997, p. 109).

The Evolution of Refutation Text Research

Research that has examined the role of refutation text in conceptual change in science has its roots in prior knowledge research. The importance of the relationship between reading comprehension and prior knowledge was well-documented by extensive research conducted during the 1970s (Valencia & Stallman, 1989). In the early 1980s, however, findings began to indicate that the accuracy of prior knowledge might also be an important factor in comprehension. Lipson (1984) noted that readers in Grades 3 to 6 experienced difficulty when they were given a passage that contradicted their beliefs. She concluded that "it was actually an advantage to know nothing about the passage, if the alternative was inaccurate knowledge" (p. 761). She further explained, "The problem appears to be less the lack of prior knowledge than the failure to resolve conflicts between existing knowledge and new information" (p. 763).

Maria and MacGinitie (1980, 1981) also investigated the effect of inaccurate prior knowledge on reading comprehension. They found that students with learning disabilities in Grades 4 to 6 reinterpreted information

contained in text to make it congruent with their prior knowledge (Maria & MacGinitie, 1980) and that students in Grades 4 to 7 found incongruent information more difficult to comprehend (Maria & MacGinitie, 1981).

Alvermann, Smith, and Readence (1985), building on the work of both Lipson (1984) and Maria and MacGinitie (1980, 1981), designed a study to examine the effect of prior knowledge activation on reading comprehension of compatible and incompatible texts. Text was described as incompatible if it contained information that conflicted with the Grade 6 participants' current conceptions, conceptions that were identified by a multiple-choice pretest. Results from the study indicated that even if prior knowledge was not purposely activated, inaccurate prior knowledge could interfere with reading comprehension, as readers allowed their misconceptions to override incompatible, but correct, information.

Maria and MacGinitie (1987), continuing their investigations into the interaction of inaccurate prior knowledge and reading comprehension, designed a study based upon several different text structures, including refutation text. Working with students in Grades 5 and 6, the researchers concluded that text that contained direct reference to the incorrect information was more effective than text which simply stated the correct information.

Results of the Research on Refutation Text

The research on refutation text is organized in three sections: an overview of the results of a meta-analysis that indicated the superiority of refutation text as a method for promoting conceptual change; summaries of

the results of research that focused on specific aspects of refutation text; and a grade level analysis that includes many of the studies mentioned in the first two sections.

Efficacy of Refutation Text in Promoting Conceptual Change

A comprehensive meta-analysis of instructional interventions designed to promote conceptual change resulted in a number of interesting findings (Guzzetti et al., 1993). The 23 interventions included in the meta-analysis encompassed a range of grade levels from Grade 5 to university undergraduates. Think Sheets, concept mapping, semantic mapping, summary writing, demonstrations, and prior knowledge monitoring and activation (PKMI) were among the teaching techniques used in the studies included in the meta-analysis (Guzzetti et al., 1993). Findings indicated that augmented activation activities, activities that consisted of prior knowledge activation augmented by a refutation of common misconceptions, were the most effective strategies for promoting conceptual change. Refutational expository text was more effective than nonrefutational expository text, and in fact, any form of refutation text was more effective than any form of nonrefutational expository text when used as an isolated strategy. Nonrefutational expository text, the type of text most prevalent in science textbooks, was the least effective of all strategies.

The studies included in Guzzetti et al.'s (1993) meta-analysis were mainly quantitative, or nomothetic, in nature. Since then, a number of qualitative, or idiographic, studies have been conducted in the area of conceptual change in science. Both types of refutation text studies are

included in the remainder of the literature review, with no differentiation made between the two types.

Focus: Refutation Text Structure

By definition, refutation text contains three elements: (a) the presentation of a misconception; (b) an explicit refutation of that misconception; and (c) the scientifically accepted conception. However, these three elements can be present in any order, and in a number of different formats, including the narrative genre. The relationship of the various text formats is shown in Figure 2.

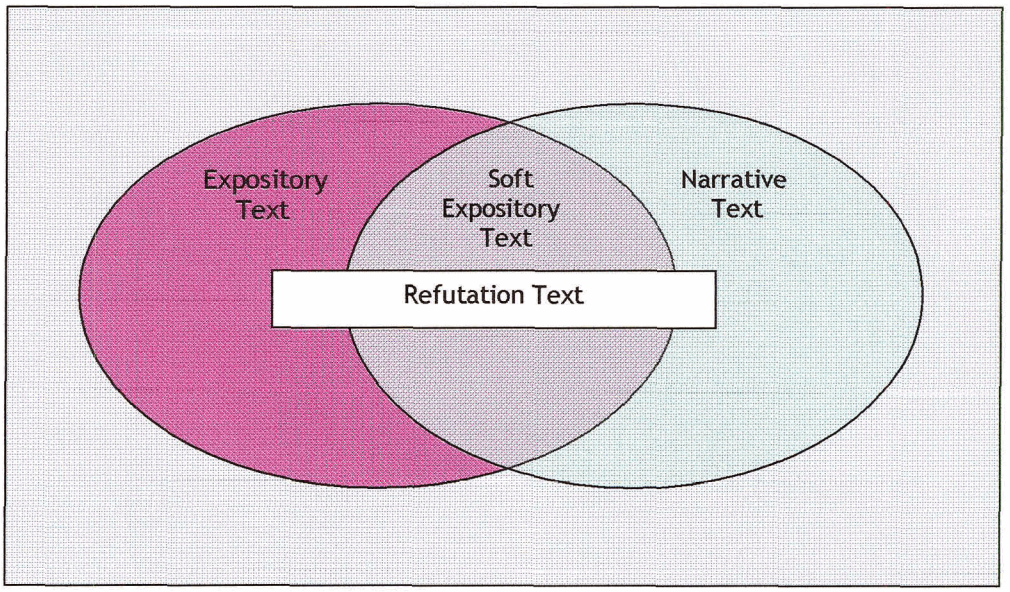

Figure 2. Relationship of text formats.

Soft expository is a genre of text that combines elements of both narrative and informational text. This genre has also been called combined text (Chapman & Sopko, 2003). The study that I designed and implemented focused on expository text and refutation text structures, shown at the left in Figure 2.

Format of the refutation text.

Gordon and Rennie (1987) suggest that when the same information is embedded in both expository and narrative formats, Grade 5 students may not give the information in the narrative format as much consideration as that in the expository format. This suggestion is supported by Alvermann, Hynd, and Qian (1995), who found that for Grade 9 students, concepts included in expository refutation text were more likely to be learned than those included in a narrative refutation text. The authors postulated that students might have been distracted by the story in the narrative refutation text.

A study by Maria and Johnson (1989) attempted to differentiate between three text formats: inconsiderate nonrefutational expository text, considerate refutational expository text, and considerate refutational soft expository text. The soft expository text contained the same concepts as the other two texts, but the concepts were embedded in a narrative, resulting in a combined text format. Working with gifted students in Grades 5 and 7, the researchers found that reading the considerate soft expository text resulted in higher scores and that these higher scores were maintained in a delayed posttest given a month later. The results from this study are limited by the fact that the readability levels of the inconsiderate nonrefutational expository text and the considerate soft expository refutational text were two grade levels lower than the readability of the considerate refutational text.

It is clear that more research is needed to determine which refutation text format is most effective. The inconclusive results to-date may be due to

the grade levels of the study participants, or to the researchers' definitions of narrative and soft expository text. Regardless, the current body of research on the most effective refutation text structure is limited by the lack of replication studies.

Placement of the refutation.

The refutation may be placed at the beginning or the end of the text, although it is more commonly located at the beginning. Maria and MacGinitie (1987) found that the location of the refutation had no effect on comprehension, although when Grades 5 and 6 students were asked to retell what they had read, they usually began with the refutation, regardless of its original placement in the text. This finding may indicate a preference for text passages in which the refuting element is located at the beginning of the passage, or it may be that students began their retelling with the most salient information contained in the passage.

Student preference for text structure and format.

The lack of replication studies is also evident in the area of student preference for text structure. However, a small number of studies have attempted to answer various questions about text preference. As described above, results from the study by Maria and MacGinitie (1987) suggested that readers in Grades 5 and 6 had a preference for refutation text with the refutation located at the beginning. A comparison of narrative, expository and cartoon forms of refutation text indicated that students in Grades 11 and 12 preferred the expository format (Guzzetti et al., 1997). Hynd (2001) found that

high school students preferred refutational texts to other kinds of text, and that they preferred an expository format over a narrative format.

Focus: Refutation Text in Combination with Other Activities

Strategies that combine any kind of print text with another teaching technique, such as a demonstration, have been shown to be more effective than strategies that do not include text (Guzzetti, et al., 1993). Paivio's (1991) dual coding theory states that concept learning is more effective when information is presented in verbal and non-verbal formats. Thus, it is reasonable to expect that combining refutation text with demonstrations, pictures, or other activities will be even more likely to produce conceptual change.

Marshall (1989), working with college students, found that the use of refutation text followed by a demonstration, which included the same information, was not as effective at producing conceptual change as was the demonstration followed by reading the refutation text. The difference in effectiveness may be because prior knowledge was activated or perhaps even developed during the demonstration, although Marshall did not address this issue in her discussion of the results. However, she suggested that further research be undertaken to clarify and confirm the importance of the order of the combined activities.

Focus: Commitment to Prior Knowledge

Dole and Niederhauser (1990) conducted a study to determine whether the degree of commitment to naïve conceptions would affect the likelihood of

conceptual change for Grade 6 students. Using traditional, considerate, and refutation text, they found that the level of commitment, determined by asking students how sure they were of their answers, had little effect on conceptual change learning from text. However, they noted that students who read refutation text were more likely to experience conceptual change than students who read traditional text.

Focus: Delayed Effect of Refutation Text

A number of studies have indicated that the effects of reading refutation text are maintained over time. Hynd, McWhorter, Phares, and Suttles (1994) found that two weeks after reading refutation text, students in Grades 9 and 10 continued to demonstrate changed conceptions. Maria and Johnson (1989) found delayed effects a month after gifted students in Grades 5 and 7 had read both expository and soft expository refutation text. These findings are reflected in the results of the meta-analysis by Guzzetti et al. (1993), which showed that refutation text was the only strategy that was effective at producing long-term conceptual change.

Focus: Grade Level Analysis

Several meta-analyses have been conducted in the area of conceptual change, at least two of which focused on studies using text as a means to effect that change (Guzzetti et al., 1992; Guzzetti et al., 1993). However, neither of these two meta-analyses focused on the use of refutation text or compared the results of the research according to the grade levels of the participants. I compiled the results of the refutation text research to

determine if there was evidence of any trends.

Criteria for inclusion in grade level analysis.

Studies were not included in the grade level analysis if the use of refutation text was only compared to the use of another form of refutation text; the results of a study had to clearly show that the use of refutation text either was or was not effective compared to traditional nonrefutational text. The latter criterion eliminated several studies claiming positive results for refutation text, including studies by Hynd, Alvermann, and Qian (1997) and Qian (1995), neither of which included a control group for comparison purposes.

One study (Palmer & Flanagan, 1997), which claimed to be based on refutation text, was in fact based on an innovative form of non-refutation text. The authors even stated that the text used in their study was different from other refutation texts because it was designed only to present the scientifically accepted concepts. This study was not included in the grade level analysis.

If refutation text was used in combination with another technique, such as the Discussion Web (Alvermann et al., 1995), it was not included in the grade level analysis unless the results were compared with the results obtained from using that technique in conjunction with nonrefutation text.

Results of grade level analysis.

Studies of refutation text used with college or university students have produced mixed results, as shown in Table 4 (Alvermann & Hague, 1989; Hynd & Alvermann, 1986a, 1986b). Alvermann and Hague (1989) compared the

effects of refutation text and expository text, in conjunction with three levels of prior knowledge activation, and found that students preferred refutation text. Additionally, the researchers found that activation of prior knowledge followed by alerting students to the possibility of misconceptions (augmented activation) was more effective than activation of prior knowledge without a warning, which in turn was more effective than no activation of prior knowledge. Hynd and Alvermann (1986a, 1986b) examined the effects of the activation of incorrect prior knowledge with refutation and non-refutation text with two different student populations and obtained mixed results.

Table 4

The Effectiveness of Refutation Text for University and College Students

Study	Level	Findings	Refutation Text More Effective?
Hynd & Alvermann (1986b) Prior knowledge activation in refutation and non-refutation text.	University (physics undergrads)	There was little difference between refutation and non-refutation texts.	no
Hynd & Alvermann (1986a) The role of refutation text in overcoming difficulty with science concepts.	College	Refutation text was more effective at changing prior misconceptions.	yes
Alvermann & Hague (1989) Comprehension of counterintuitive science text: Effects of prior knowledge and text structure.	College	Refutation text was superior to non-refutation text.	yes

Note. Entries are listed in descending order of education level of participants.

The variability of the results shown in Table 4 may be because conceptual change has already occurred for a greater number of students of university age, resulting in fewer students who possess incorrect prior knowledge. The inaccurate conceptions held by those few students are likely to be highly resistant to change. It is also possible that students at the university or college level are already in the midst of conceptual change, and that very little new information is required to effect the change.

Most studies that have been conducted with high school students have indicated that refutation text is more effective than expository text at promoting conceptual change for students at this level (Chiu & Wong, 1995; Guzzetti et al., 1997; Hynd et al., 1994; Stahl et al., 1997; Yuruk & Geban, 2001). Studies have investigated the use of different text formats (Guzzetti et al., 1997), the use of refutation text in conjunction with other activities (Chiu & Wong, 1995), the efficacy of refutation text compared with traditional expository text (Hynd et al., 1994; Stahl et al., 1997; Yuruk & Geban, 2001), and the delayed effects of refutation text (Hynd et al., 1994). Two studies found that while refutation text was not more effective than expository text, it was still an effective way to correct misconceptions (Guzzetti, 1990; Palmer, 2003). Table 5 shows the results of refutation text studies that have been conducted with participants from Grades 8 to 12.

Table 5

The Effectiveness of Refutation Text for Students in Grades 8 to 12

Study	Grade Level	Findings	Refutation Text More Effective?
Guzzetti (1990) Effects of textual and instructional manipulations on concept acquisition.	11 and 12	No statistically significant differences after reading refutational or nonrefutational text, with or without a prereading activity.	no
Guzzetti, Williams, Skeels & Wu (1997) Influence of text structure on learning counterintuitive physics concepts.	10, 11, and 12	All forms of refutation text, expository, narrative, and cartoon, were effective. Most students preferred the expository format.	yes
Yuruk & Geban (2001) Conceptual change text: A supplementary material to facilitate conceptual change in electrochemical cell concepts.	11	Refutation text (conceptual change text) was more effective than traditional instruction.	yes
Hynd, McWhorter, Phares & Suttles (1994) The role of instructional variables in conceptual change in high school physics topics.	9 and 10	Refutation text had the strongest overall effect, showing significant effects in all posttests (including delayed).	yes
Palmer (2003) Investigating the relationship between refutational text and conceptual change.	9	Both the innovative refutation text and the expository text were effective.	no
Stahl, Hynd, Montgomery & McClain (1997) "In fourteen hundred and ninety two, Columbus sailed the ocean blue": Effects of multiple document readings on student attitudes and misconceptions.	9	Refutation text proved most effective at changing attitudes, because of its perceived fairness.	yes
Chiu & Wong (1995) Ninth graders' mental models and processes of generating inferences of four seasons.	9	The use of refutation text and augmented activation activities improved student achievement.	yes

Note. Entries are listed in descending order of grade level of participants.

Results of studies conducted with students at the intermediate level, shown in Table 6, indicate that refutation text is an effective method of producing conceptual change in students from Grades 4 to 7 (Diakidoy et al., 2002; Dole, 2000; Dole & Niederhauser, 1990; Maria & Johnson, 1989; Maria & MacGinitie, 1987). Studies have investigated the use of different text formats with gifted Grades 5 and 7 students (Maria & Johnson, 1989) and have compared the use of refutation text with the use of traditional expository text with students in Grades 5 and 6 (Diakidoy et al., 2002; Dole, 2000; Dole & Niederhauser, 1990; Maria & MacGinitie, 1987).

Only one study has focused on the use of refutation text with students in primary grades and the results of this study indicated that refutation text was not particularly effective at the primary level, as shown in Table 7 (Mayer, 1995). However, the text used in this study was a narrative text containing scientifically inaccurate illustrations, and other studies have shown differences in conceptual change depending on the format of the text and the inclusion of illustrations (Alvermann et al., 1995; Kearsley, 2003; Maria & Johnson, 1989). Additionally, Mayer's study had only 16 participants, ranging from Kindergarten to Grade 3, and generated a limited amount of data. The lack of research on refutation text and conceptual change learning of younger students indicates a need for further investigation.

Table 6

The Effectiveness of Refutation Text for Students in Grades 4 to 7

Study	Grade Level	Findings	Refutation Text More Effective?
Maria & Johnson (1989) Correcting misconceptions: Effect of text type.	5 and 7 (Gifted)	Soft expository refutation text was more effective than non-refutation text. In some cases expository refutation text was also more effective.	yes
Maria & MacGinitie (1987) Learning from texts that refute the reader's prior knowledge.	5 and 6	Refutation texts were better than non-refutation.	yes
Dole (2000) Readers, texts and conceptual change learning.	6	Students who read refutation texts made significant improvements over other students.	yes
Dole & Niederhauser (1990) Students' level of commitment to their naïve conceptions and their conceptual change learning from texts.	6	Refutation text was more effective than traditional text or considerate non-refutation text in changing naïve conceptions.	yes
Diakidoy, Kenedou, & Ionnides (2002) Reading about energy: The effects of text structure in science learning and conceptual change.	6	Students who read refutation texts outperformed students who read expository text or who received standard instruction.	yes

Note. Entries are listed in descending order of grade level of participants.

Table 7

The Effectiveness of Refutation Text for Students in Kindergarten to Grade 3

Study	Grade	Findings	Refutation Text More Effective?
Mayer (1995) How can we best use literature in teaching.	K to 3	Children acquired an insignificant amount of new information. Misrepresentations in the text and illustrations may have interfered with science learning.	no

Current Trends in Refutation Text Research

Recently, refutation text has been described as a form of persuasion. Noting that persuasion and conceptual change are closely related as they both involve the changing of beliefs, Vosniadou (2001) suggests that text can be used to persuade, and identifies refutation text as a particular type of persuasive text. Hynd (2001) concurs, and expands upon the factors that make refutation text persuasive. These factors include text characteristics, such as the length of the argument and the presentation of a two-sided argument; and reader-text interactions, such as the perceived credibility of the text and the reader's discrepant prior knowledge.

A number of recent studies examining the use of conceptual change text indicate the continued interest in using a text-based strategy to facilitate conceptual change. The use of conceptual change text in conjunction with concept mapping has been compared with traditional instruction for high school students, with results showing a statistically significant improvement in

achievement for the students who received the conceptual change text (Sungur, Tekkaya, & Geban, 2001; Tekkaya, 2003). Mikkilä-Erdmann (2001) compared conceptual change text and traditional expository text in a study with Grade 5 students and found that students who read the conceptual change text had statistically higher achievement on the posttest.

Other Issues Relating to this Study

Two other issues that pertain to the thesis study are gender and readability. Gender was one of three factors that I identified as a possible influence upon the effectiveness of traditional and refutation text passages in facilitating conceptual change. Readability is a pertinent issue because, according to Lysynchuk, Pressley, d'Ailly, Smith, and Cake (1989), a valid reading study will include information about the readability levels of the text passages used in the study.

Gender

As I analyzed the data from the pilot study upon which the present thesis study was based, I identified several factors, including gender, which I wanted to investigate as having a possible influence upon the effectiveness of the text passages in facilitating conceptual change. It is widely believed that boys read less than girls, that boys experience less success with reading activities than girls, and that boys tend to prefer nonfiction texts while girls prefer fiction texts (Coles & Hall, 2002; Gambell & Hunter, 2000; Simpson, 1996). The literature on gender preferences and reading generally supports these beliefs: for example, Gambell and Hunter (2000) surveyed nearly 20,000 Canadian

students aged 13 and 16 and found significant gender differences in reading attitudes and practices: boys read less frequently and for shorter periods; boys enjoyed reading less, and rated themselves as less capable readers; and girls preferred bestsellers and popular fiction while boys preferred cartoons, comic books, and sports reports. Additionally, almost twice as many boys as girls at both age levels reported an interest in science books. Coles and Hall (2002) conducted a survey of nearly 8,000 English students aged 10, 12, and 14 and found that there were significant gender differences in choices of reading material: girls tended to read more romance/relationship books, while boys read more science fiction/fantasy books. They also found that while very few boys read nonfiction books exclusively, boys did tend to select reading material that was information rich, and that "boys' vernacular literacies give greater emphasis to taking from the text and to analyzing *information* rather than analyzing *motivation* or characterization" (p. 105). Gendered preferences for reading material may contribute to motivation to read a particular text, and motivation, in turn, may contribute to comprehension (Duke & Pearson, 2002; Harp & Mayer, 1997).

Readability Levels

A second issue pertaining to the thesis study is readability level of text. In much of the refutation text literature, the readability levels of the texts used in the studies are not provided. The findings of such studies are difficult to generalize, since the readability level of text is a factor in reading comprehension. In the thesis study, I calculated the readability levels of all the

text passages that I used to compare the effectiveness of refutation text and expository text. Therefore, the literature review concludes with a brief overview of the ways in which readability can be assessed.

The readability of a book or a text passage can be assessed either qualitatively or quantitatively. A qualitative measure of readability can be obtained by following a procedure such as that described by Chall, Bissex, Conard, and Harris-Sharples (1996). This procedure requires that samples of the text under consideration be matched to grade-level exemplars in one of six scales: literature, popular fiction, life sciences, physical sciences, narrative social studies, or expository social studies. The exemplars demonstrate typical vocabulary, sentence length and complexity, density of ideas, and cognitive difficulty. A qualitative method can provide a quick and relatively accurate assessment of readability. However, the results are not as easily replicated as the results obtained by a quantitative measure, as the assessment is subjective, rather than objective.

The cloze procedure can also be used to assess the readability of a text for a specific reader. The reader is given a copy of the text passage that has every fifth word deleted. The reader fills in the blanks and the readability of the text is related to the percentage of words that are predicted correctly. However, the cloze procedure is less useful for predicting the readability of a text for a wider audience (Rush, 1984).

A quantitative measure of readability can be obtained by using one of numerous formulae (e.g., Anderson, 1983; Dale & Chall, 1948a; Flesch, 1948;

McLaughlin, 1969; Spache, 1953), or by using the Fry Readability Graph (Fry, 2002). Typically these formulae are based on the syntactic and semantic characteristics of the text, such as sentence length, number of sentences in a sample passage, number of syllables in a sample passage, and number of widely-used words in a passage. Readability formulae are static measures of readability, as they do not account for the influences of text style and presentation or for the interactive nature of reading. They involve textual factors only, with the exception of the Flesch Human Interest Formula (Flesch, 1948), which contained a human interest component that was determined by the number of personal words and personal sentences that appeared in a text. According to Flesch, personal words would include pronouns referring to people; words that imply a gender, such as actress or policeman; and group words, such as people, while personal sentences would include conversation as well as any statements addressed to the reader.

Despite the limitations of readability formulae, however, they do provide a replicable, objective measure of the textual characteristics of a book or a text passage, and in the thesis study I used the Dale-Chall formula and the Fry Readability Graph to calculate the readability of the 16 text passages. These two quantitative methods for determining readability are described in more detail in Chapter 3, as is the process by which I selected the methods.

Conclusion

The body of literature on refutation text research is clear: refutation text promotes conceptual change more effectively than regular expository text

does when read by students in Grades 5 to 12. Whether refutation text is also more effective for readers who are either older or younger is less clear, as indicated by the mixed results for readers at the college and university level as well as by the lack of research conducted with readers below the Grade 5 level. The following chapter describes a study that I designed and implemented in an attempt to explore whether reading refutation text is an effective conceptual change strategy for readers in Grades 3 and 4, and to investigate some of the factors which influence the effectiveness of both refutation text and regular expository text passages.

CHAPTER 3

METHODOLOGY

In this chapter, I describe the methodology of the thesis study. The chapter begins with a brief description of the research design, and continues with a summary of the pilot study upon which the thesis study was based. A detailed discussion of the development and implementation of the methodology of the thesis study itself follows, and the chapter concludes with a description of the statistical procedures used to analyze the data.

Design

This study was based in a constructivist framework, as is most refutation text research (Guzzetti et al., 1993), and was grounded in conceptual change theory. The research design for the study was mixed methods in which qualitative approaches were embedded in a quasi-experimental approach. Quasi-experimental designs usually lack a random sample population (Best, 1981; Neuman, 1997), and that was the case with my design as the study participants were not randomly selected, but were recruited from the entire Grades 3 and 4 populations at a school in Victoria. Frequently, quasi-experimental designs lack a control group. However, in this study, the participants acted as their own control group, because each student received both types of text. This design is similar to a design described by Best (p. 79), in which the experimental group acts as the control group during a second cycle of the treatment. In my design both treatments, the refutation text and the expository text, occurred at the same time.

To enable a comprehensive analysis of the results of this study, I collected qualitative data to supplement the quantitative data. The qualitative data included results from individual interviews, as well as comments from teachers regarding the readability and the format of the text passages I developed.

Pilot Study

The current study was based on a pilot study that I completed in the spring of 2003. My purposes in conducting the pilot study were to determine the suitability of the materials I planned to use in the current study and the appropriateness of the methods, as well as to obtain a preliminary indication of the effectiveness of refutation text for students in Grades 3 and 4.

Since the only published study conducted with students younger than Grade 5 was based on a single soft expository tradebook (Mayer, 1995), I needed to prepare a set of text passages at an appropriate reading level. I wrote eight refutation text passages first. Six of these passages, deserts, camels, octopuses, gorillas, ostriches, and bats, were adapted from material received from Kate Maria, who has published several studies in the field of refutation text (Maria, 2000; Maria & Johnson, 1989; Maria & MacGinitie, 1980, 1981, 1987). In an initial attempt to achieve consistency of text passage characteristics such as sentence length and number of words, I rewrote the six passages to contain between 60 and 65 words. Then, drawing upon my review of the literature and my classroom experience, I selected two more commonly held misconceptions and wrote the final refutation passages about spiders and

seasons in a similar style. The eight target misconceptions upon which the text passages were based are shown in Table 8.

Table 8

The Eight Target Misconceptions

Deserts are flat and covered with sand.
Ostriches bury their heads in the sand.
It is summer in Canada when the Earth is closer to the sun.
Camels store water in their humps.
Octopuses will attack divers.
Gorillas are omnivores.
Spiders are insects.
Bats try to nest in peoples' hair.

I checked all facts using the Encyclopædia Britannica (2003). Finally, I wrote the expository text passages for each topic using similar vocabulary and a similar number of words, so that the readability levels of pairs of text passages were consistent. The passages ranged in readability levels from Grade 4.1 for the desert and camel expository text passages, as calculated by the Dale-Chall formula, to Grade 11 for the gorilla refutation text, as determined by Fry's Readability Graph. The differences between pairs of passages on a particular topic ranged from 0.0 to 2.1 grade levels. The text passages were revised slightly for the thesis study so that the average readability levels were

lower and more consistent; I discuss the process of revising the texts and the process of calculating readability in more detail in a later section. Table 9 shows an original refutation text passage, received from Kate Maria, as well as the refutation text passage and the matching expository text passage that were used in the pilot study.

Table 9

Example of the Development of Text Passages

Original refutation text passage - Grades 5 to 7

The male gorilla is very big. He has very strong arms. He looks like he could pick you up and throw you a mile. It is easy to think of him hunting and eating other animals. But gorillas really eat only plants. If you met a gorilla in the jungle, he would be as frightened as you. Does that sound like the King Kong sort of monster you see in the movies? (72 words) (Maria, personal communication, February, 2003)

Revised refutation text passage - Grade 3/4

Gorillas live in tropical forests in Africa. The male gorilla is big and powerful. He may weigh up to 220 kilograms (485 pounds). The gorilla's strong arms are longer than its legs. It is easy to imagine a gorilla hunting and eating other animals. However, gorillas really eat the leaves, stems, and shoots of plants. In fact, gorillas are quite timid. (61 words)

Table 9 (continued)

Example of the Development of Text Passages

Expository text passage - Grade 3/4

Gorillas are the largest members of the ape family. They live in tropical forests in Africa. Gorillas have black skin and hair, and their arms are longer than their legs. Male gorillas may weigh up to 220 kilograms (485 pounds). Gorillas are herbivores - they eat fruit as well as the leaves, stems, and shoots of plants. Although gorillas are very powerful, they are quite timid. (65 words)

For the pilot study, I also developed a pretest and a posttest that were designed to determine which, if any, of the target misconceptions were held by individual students. These two data collection instruments yielded the data that I required, and so I used both the original pretest and the original posttest in the thesis study, without revisions.

Results from the pilot study indicated that refutation text might be an effective strategy for correcting misconceptions held by students in Grades 3 and 4, and that it might be more effective than expository text. However, as I analyzed the pilot study data, I had questions about the factors that might contribute to that effectiveness. Additionally, I decided that the pilot study procedure required some improvements with respect to the type and the quantity of data that I collected. Although the pretest and the posttest yielded appropriate data, the thesis study needed a delayed posttest to provide information about the long term effects of refutation text. The thesis study

also required a measure of participants' reading abilities, and at least one of the measures used in the thesis study needed to be a standardized measure. These modifications are described in the upcoming section on external validity.

The Thesis Study: A Description

In this section I begin with a discussion of the criteria for external validity of a study, and I include an evaluation of the thesis study based on those criteria. Subsequently, I provide a description of the sample population, and discuss the development of the text passages, including the readability calculations that were required. I describe the data collection instruments, both standardized and researcher-developed, and explain the steps I took during the implementation of the thesis study.

External Validity

The pilot study procedures consisted of three steps: pretest, text passages, and posttest. However, I made some changes to the methods used in the pilot study so that the thesis study would meet more of the criteria for external validity. According to Lysynchuk et al. (1989), there are six criteria for external validity that a good comprehension strategy study should meet, as shown in Table 10. The use of refutation text can be considered a highly specific comprehension strategy: instruction about text structure is described by Duke and Pearson (2002) as one of six important elements of a reading comprehension curriculum. They include both narrative and informational text structure in their discussion of the research that supports the explicit instruction of text structure as a comprehension strategy.

Table 10

Criteria for External Validity of a Study

1. Research questions have a theoretical basis.
2. The sample characteristics are described.
3. The measures are standardized.
4. Information about reading ability and text readability are provided.
5. Delayed effects are measured.
6. There is a measure of the transfer of the strategy to other subject areas.

Note. Adapted from Lysynchuk, Pressley, d'Ailly, Smith, and Cake (1989, p. 466)

The pilot study met only two criteria: the research was grounded in theory, and I described my sample population. I partially met a third criterion because I calculated the readability of the text passages. The procedures that I followed for the thesis study were altered from that of the pilot study to include a delayed posttest and a standardized measure of the participants' reading ability. This study therefore met five criteria: (a) the research questions arose from constructivist and conceptual change theories and were supported by research as described in the literature review; (b) I provided a detailed description of the sample population; (c) I used a combination of standardized and researcher-developed measures to collect data; (d) I assessed and reported the reading ability of the participants and I calculated and reported the readability levels of the text; and (e) I administered a delayed

posttest to measure the long-term effects of the intervention. The thesis study did not meet the final criterion, as there was no measure of transfer to other subject areas, although the study was conducted in a science context.

Description of Participants

All students in Grades 3 and 4 at the research site (a K-5 school in Victoria) were invited to participate in the study. The catchment area of the school has a combination of single-family dwellings and low-cost tenement housing, resulting in economic and multiethnic diversity at the school. At the time of the study, the school had an enrollment of 206 students, with 66 students in Grades 3 and 4. Those 66 students were in one of four classrooms: a Grade 4/5 class, a Grade 3/4 class, a Grade 3 class, and a Grade 2/3 class. Forty of the 66 students (61%) returned signed student and parental consent forms. Appendix A contains sample consent forms.

The 40 participants consisted of 22 girls (55%) and 18 boys (45%) as compared to the entire population of 28 girls (42%) and 38 boys (58%) in Grades 3 and 4. Participants included 18 Grade 3 students (45%) and 22 Grade 4 students (55%) as compared to the entire population of 38 Grade 3 students (58%) and 28 Grade 4 students (42%). Two of the study participants (5%) were designated ESL (English as a Second Language) learners as compared to six students (9%) in the entire population. Another six students (15%) were receiving Learning Assistance support in Language Arts as compared to 11 students (17%) in the entire population. The thesis study participant group, therefore, had slightly higher proportions of girls and of Grade 4 students than

the entire population of Grades 3 and 4 students at the research site; a lower proportion of ESL students; and an equivalent proportion of students requiring support with Language Arts.

Text Passages

The text passages used in the current study were based on the passages that I developed for the pilot study. However, as stated previously, I revised the text passages so that the average readability levels would be lower and so that the readability of the pairs of passages would be more consistent. I made minor changes such as altering the number of sentences and substituting words of fewer syllables so that the readability levels for a pair of passages were within 0.5 grade levels of each other, and less than Grade 7 in all cases. Table 11 contains a refutation text passage that was used in the pilot study and the revised refutation text passage that was used in the thesis study; the eight target misconceptions, the pairs of text passages based on those misconceptions, and the calculated readability levels for each passage are shown in Appendix B.

Table 11

Comparison of Text Passages used in the Pilot Study and the Thesis Study

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Pilot study refutation text passage - Grade 3/4

Adventure movies often show octopuses attacking divers and squeezing them to death with their powerful tentacles. However, if an octopus really saw a diver close to it, it would quickly swim away. Octopuses are actually timid animals. They do not usually hunt their prey. They hide and wait for their food to come near. They eat crabs, clams, and shrimp - not people! (62 words, 98 syllables, 6 sentences, readability grade levels: Dale-Chall: 5.7, Fry: 7)

Thesis study refutation text passage - Grade 3/4

Movies sometimes show octopuses attacking divers and squeezing them to death. However, if an octopus really saw a diver nearby, it would quickly swim away. Octopuses are actually quite timid. They do not often hunt for their food. They hide in holes or cracks and wait for their food to come near. They eat crabs, clams, and shrimp - not people! (60 words, 90 syllables, 6 sentences, readability grade levels: Dale-Chall: 5.4, Fry: 6)

Readability Levels of Text Passages

One criterion for external validity of a study is that information about the text readability is provided (Lysynchuk et al., 1989). Readability of a particular text or text passage can be determined qualitatively or quantitatively, as discussed in the previous chapter. To obtain a measure of

readability in the context of the classroom, a qualitative assessment is recommended. Results of such an assessment will be obtained more quickly than by using a quantitative measure, and will be precise enough to assist students in choosing books at an appropriate reading level (Chall et al., 1996). However, the readability levels of texts that are used in research should be determined quantitatively to ensure ease of comparison, both with other texts in the same study and with other studies. While readability formulae may not be considered constructivist measures, since they typically focus on text variables and exclude reader variables, they do provide an easily replicated means of obtaining information about the static textual characteristics of a book or a text passage. In the context of this study, I selected quantitative measures as the most appropriate methods of assessing the readability levels of the 16 text passages, and I focused on the Dale-Chall formula and Fry's readability graph. However, I also included a brief qualitative assessment in the form of a member check.

Selection of readability formulae.

Most readability formulae are not suitable for calculating a readability level of less than Grade 4, which was not an insurmountable obstacle, as the text passages that were written for use with the thesis study were written at approximately a Grade 5 level. However, the scarcity of formulae available for short passages was more problematic. A thorough review of readability literature revealed two published formulae for calculating the readability of text passages containing fewer than 100 words. The Homan-Hewitt Readability

Formula was developed for use with single-sentence test items (Homan, Hewitt, & Linder, 1994) and Fry's (1989) Short Passage Readability Formula was developed for use with passages of 40 to 99 words. Both of these readability formulae are based on *The Living Word Vocabulary* (Dale & O'Rourke, 1976), a book that contains familiarity ratings for over 40,000 words. Because the text passages used in the thesis study were an average of six sentences in length, the Homan-Hewitt Readability Formula (Homan et al.) was not appropriate for calculating the readability of those passages, so I used Fry's Short Passage Readability Formula.

According to the Short Passage Readability Formula (Fry, 1989), three or more key words from the short passage are identified and the grade level of those key words as indicated by *The Living Word Vocabulary* is averaged, yielding a word difficulty rating for the passage. Key words are defined as words needed to understand a passage. Then, the average number of words per sentence is converted to a sentence difficulty rating using a table. The readability of the short passage is the value obtained by averaging the word difficulty rating and the sentence difficulty rating. Following this procedure, I identified four key words in each of the 16 text passages. For example, in the refutation text passage about octopuses, I selected *divers*, *octopus*, *people*, and *timid* as the four key words. In each case, three of the four words were indicated as having a reading level of Grade 4, while the fourth word had a reading level of Grade 4 or Grade 6 or Grade 8. The sentence difficulty rating ranged from Grade 3 to Grade 5. Thus, the 16 passages that I developed for use

in the thesis study had readability grade levels ranging from 3.5 to 5.2. However, the differences between the readability levels of the various passages were too small to offer a valid internal comparison, and there was no other formula against which these results could be compared to check for external validity.

I decided to use quantitative methods developed for use with passages of 100 words. For the pilot study, I had calculated the readability level of each of the 16 text passages using three widely accepted methods: Fry's Readability Graph (Fry, 2002); the Dale-Chall readability formula (Dale & Chall, 1948a; 1948b); and the SMOG readability formula (McLaughlin, 1969). However, because the SMOG formula typically yields readabilities that are approximately two grades higher than other formulae, including the Dale-Chall (McLaughlin), I did not use the SMOG formula for the thesis study.

Readability calculations.

Fry's Readability Graph (Fry, 2002), shown in Figure 3, provides a grade level readability based upon the number of syllables and the number of sentences contained in a 100 word excerpt. Because the text passages used in the thesis study were less than 100 words, I calculated those values using the following equations:

$$\text{number of syllables in 100 words} = \frac{100 \text{ X (number of syllables in passage)}}{\text{(number of words in passage)}}$$

and

$$\text{number of sentences in 100 words} = \frac{100 \text{ X (number of sentences in passage)}}{\text{(number of words in passage)}}$$

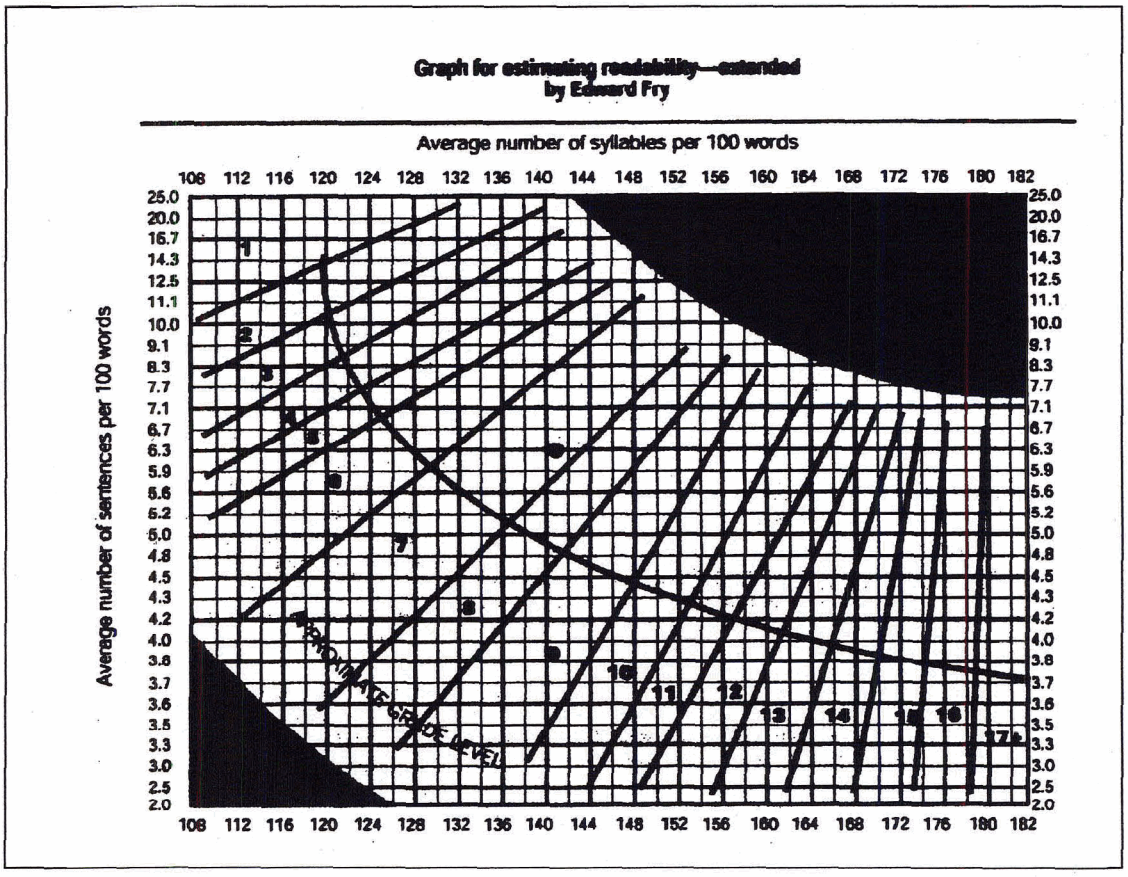

Figure 3. Fry's Readability Graph from "Readability versus Leveling," by E. Fry, 2002, *The Reading Teacher, 56*(3), p. 288.

For example, in the refutation text passage on deserts, there are 92 syllables, 64 words, and 6 sentences. The number of syllables that would be in an equivalent passage of 100 words would be (100 X 92)/64, or 144 syllables. In the same manner, the number of sentences in an equivalent passage of 100 words would be (100 X 6)/64, or 9.4 sentences per 100 words. I then used these calculated values to obtain readability grade levels from the graph. Although it can be argued that by calculating equivalent values for 100 word passages, I introduced an element of error into the readability levels, I argue that the 100

word passages upon which the two methods are based are supposed to be selected at random from a more lengthy text passage, which also introduces the possibility of error in the resulting readability levels. Figure 4 shows the readability level for each passage as determined by Fry's Readability Graph.

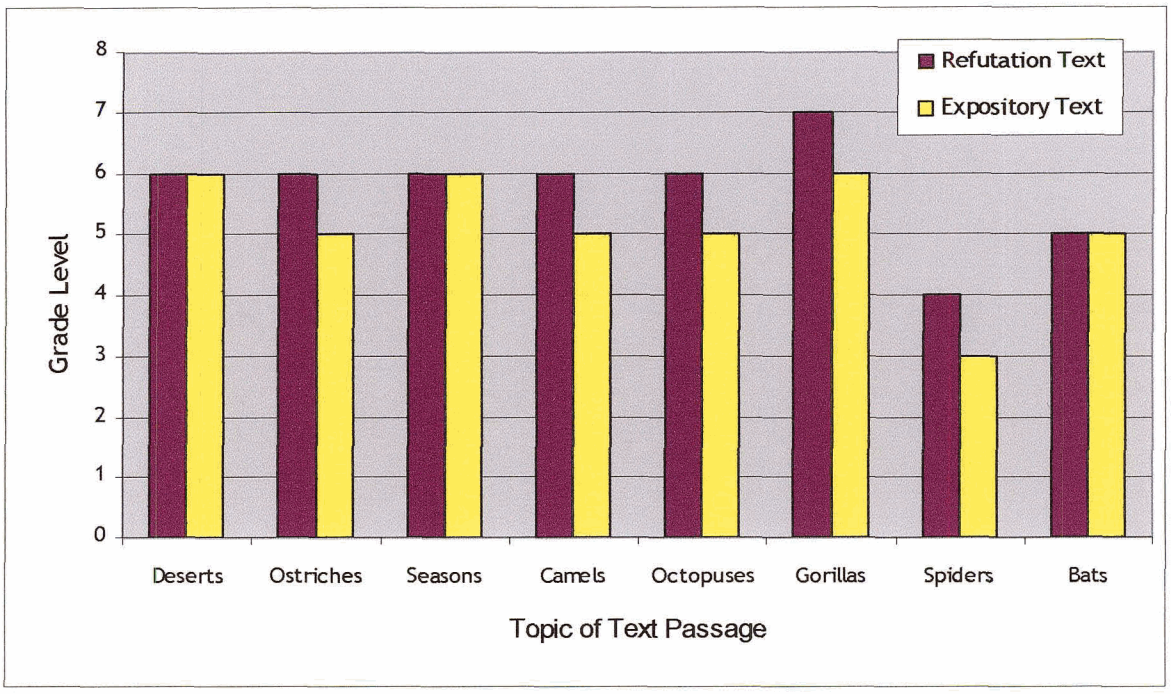

Figure 4. Fry's Readability Graph results.

The Dale-Chall formula is also based on excerpts of 100 words but uses average sentence length rather than number of sentences, and so I followed the steps shown in Table 12 without any adjustments. My justification for this decision is the same as my justification for calculating the 100-word equivalents for the use of Fry's Readability Graph (2002). Figure 5 shows the readability level for each passage as calculated by the Dale-Chall formula.

Table 12

Calculating Readability Using the Dale-Chall Formula

1. Select several excerpts of approximately 100 words.
2. Count the total number of words.
3. Count the number of sentences, and calculate the average sentence length.
4. Count the number of words which are not on the Dale-Chall List of 3,000 Familiar Words, and calculate the percentage of unfamiliar words. This is the Dale score.
5. Reading grade score =

(0.1579 X Dale score) + (0.0496 X average sentence length) + 3.6365

Note. Adapted from Dale and Chall, 1948b.

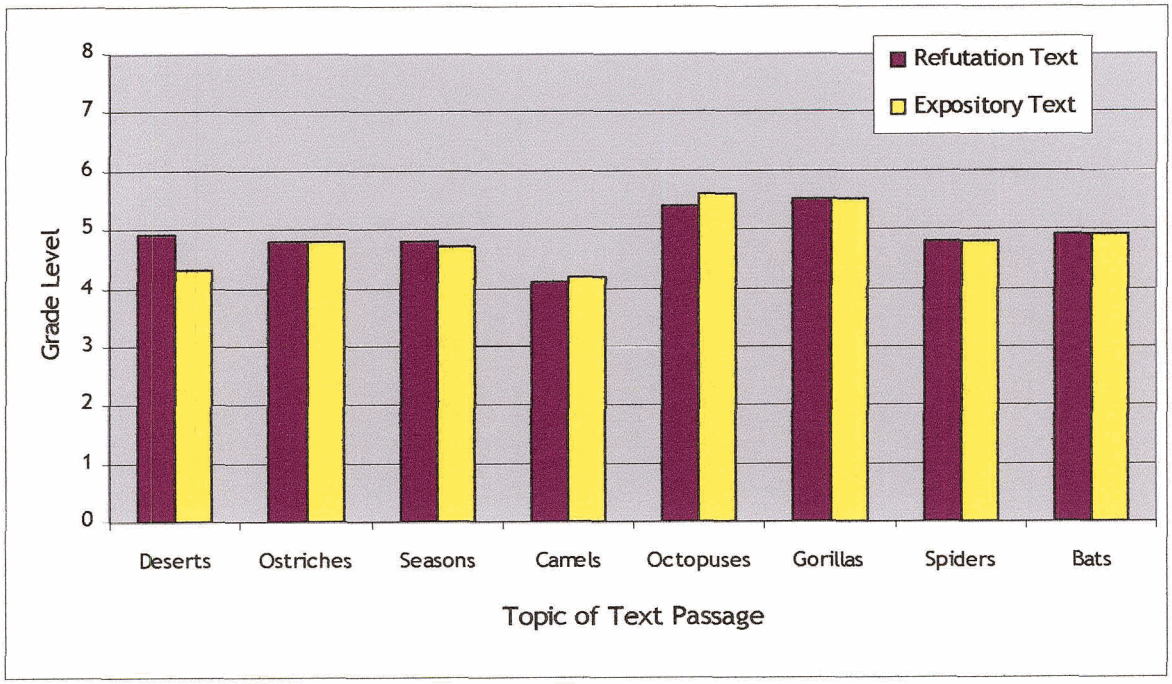

Figure 5. Dale-Chall formula readability results.

Although there was some variation in the results between the two methods of calculating readability, as might be expected due to the underlying assumptions and procedures, in general the calculated readability levels of pairs of passages were similar when using the same method (i.e., as shown in Figures 4 and 5). I made an effort to ensure that if there was a difference in readability levels, it would be the refutation text passage that was more difficult, since I predicted that the refutation text would be more effective than the expository text. I did not want a lower readability level to contribute to the increased effectiveness of the refutation text, as that would make the findings less credible. However, in two pairs of passages (camels and octopuses) the expository text passage had a slightly higher readability than the refutation text passage as calculated by the Dale-Chall formula.

I calculated an average readability level for each text passage using the results from the Dale-Chall formula and Fry's Readability Graph. Figure 6 shows the readability levels of the refutation text passages, while Figure 7 shows the readability levels of the expository text passages.

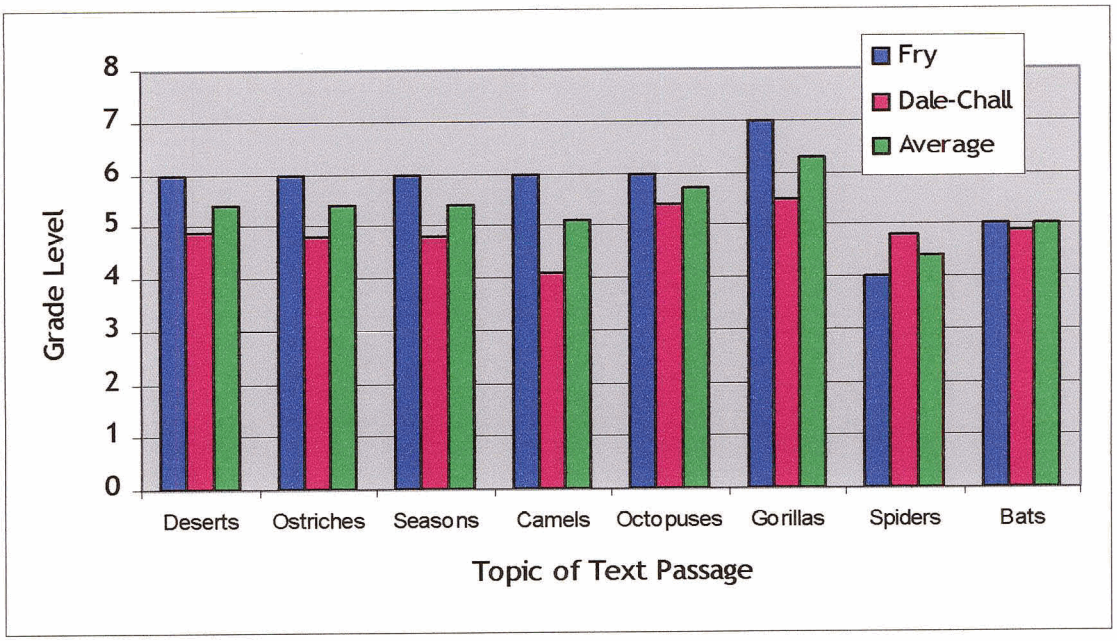

Figure 6. Readability levels of refutation text passages.

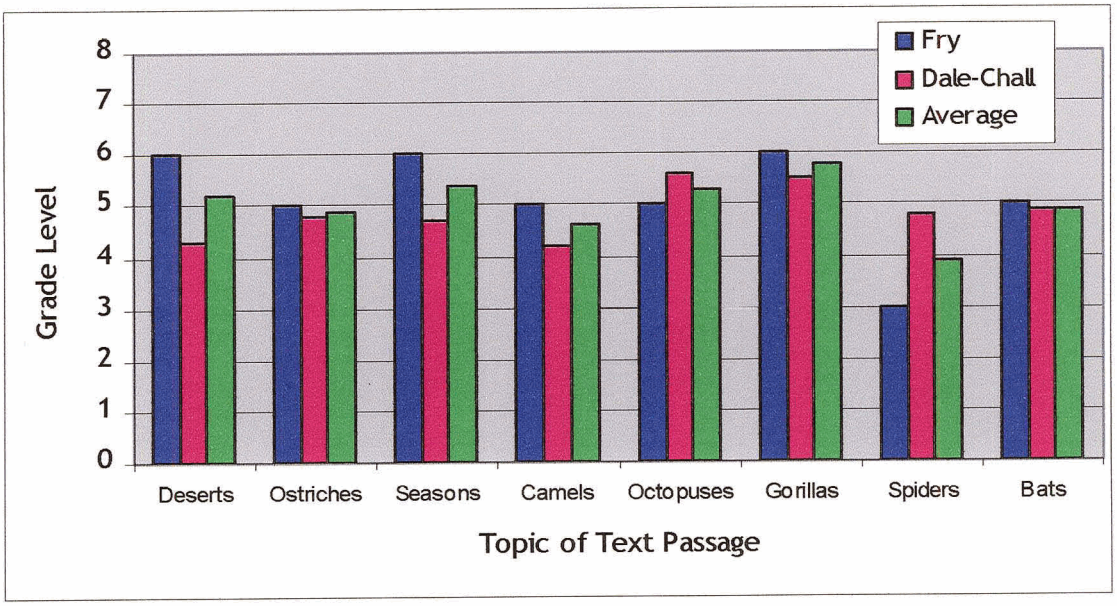

Figure 7. Readability levels of expository text passages.

Member check: Readability levels as perceived by teachers.

Since I wanted a qualitative assessment of the readability levels of the text passages as well as a quantitative assessment, I asked two teachers, each with more than 10 years experience teaching either Grade 3 or Grade 4, to read the 16 text passages and make comments. Mrs. Allen (all names are pseudonyms), the Grade 3 teacher, stated that the passages were "suitable for [my] average Grade 3 readers." Mrs. Bishop, the Grade 4 teacher, also indicated that the passages were appropriate for her students. The comments from these two teachers served as a member check.

Member check: Validity of text passage format

I read the description of refutation text shown in Table 13 to three different teachers, each with more than 10 years experience teaching elementary grades. I then asked those teachers to sort the 16 text passages into two piles, one of refutation text and one of expository text. In all three cases, sorting took less than three minutes and was completed with 100% accuracy.

Table 13

A Description of Refutation Text

Refutation text consists of three parts: the presentation of a misconception; an explicit refutation of that misconception; and the scientifically accepted conception. These three elements may be present in any order.

Data Collection Instruments

The data collection instruments for this project included several researcher-developed measures. However, a standardized measure was required to meet the criteria for external validity (Lysynchuk et al., 1989). Since one of the goals of this study was to explore the relationship of reading ability and the effectiveness of refutation text and expository text, I elected to use a standardized measure of reading comprehension. I also developed an interview guide to enable the collection of supplemental qualitative data regarding students' perceptions of the text passages.

Standardized Reading Assessment

I selected the *Canadian Tests of Basic Skills* (King, 1982) as the standardized measure to assess reading comprehension. The *Canadian Tests of Basic Skills (CTBS)* is an assessment package which is used by several teachers at the school where this study was conducted. The *CTBS* are based on Canadian curriculum and are norm-referenced. The *CTBS* reliabilities vary depending on the subtest and grade: the internal consistency reliability coefficients range from .87 to .96, while the composite reliability is .97 to .98. The *CTBS* package was developed to ensure validity: (a) specifications are based on more than 40 years of research; (b) test items were selected with the assistance of experts in a number of related fields; and (c) empirical and judgmental procedures included evaluation by representatives of diverse cultural groups. The *CTBS* is available in a number of different Forms, and I used Form 6, the Form that the school owned. The Reading Comprehension subtest of the *CTBS* consists of a

series of progressively more difficult text passages. Each passage is followed by several multiple choice questions. The number of questions to be answered during the subtest is determined by the grade of the student; students in Grade 3 read and answer 44 questions based on 8 passages, while students in Grade 4 read and answer 49 questions based on 8 passages.

Pretest, Posttest, and Delayed Posttest

The pretest, posttest, and delayed posttest were researcher-developed measures. Once the eight target misconceptions were selected, I designed the pretest shown in Appendix C to determine which, if any, of the focus misconceptions were held by individual participants. The eight questions about the target misconceptions were embedded within a total of 15 questions, so that when students subsequently read their individualized sets of text passages, they would be less likely to make connections between the pretest and the text passages. The pretest was identical to the pretest used in the pilot study.

The posttest and the delayed posttest, shown in Appendix C, were designed to resemble the style of the pretest. Table 14 provides a comparison of the question format for each of the data collection instruments, using the target misconception that the earth is closer to the sun when it is summer in Canada. The eight focus questions in both the posttest and the delayed posttest were again embedded within a total of 14 or 15 questions. The differences in the answer formats were intended to minimize the reactivity between the three tests. When I administered the tests, I instructed

participants that they needed to be very sure of their answers. If they were unsure, they were to answer *?* or *maybe*.

Table 14

A Comparison of Data Collection Instruments.

Pretest: It is summer in Canada when the earth is closer to the sun. T F ?

Posttest: Is it winter in Canada when the Earth is closer to the sun?

yes no maybe

Delayed Posttest: It is winter in Canada when the Earth is closer to the sun.

True False ?

The posttest was intended to provide an immediate measure of the effectiveness of the text passages. The delayed posttest was intended to indicate whether the effect of reading a refutation text passage was maintained, and whether that effect was more likely to be maintained than the effect of reading an expository text passage. Although the posttest was used in the pilot study, the delayed posttest was developed for use with the thesis study.

Although I had previously used the pretest and the posttest in the pilot study with satisfactory results, I consulted two experienced teachers and sought their opinions of all three measures. Mrs. Allen, with more than 15 years experience teaching Grade 3, felt that the wording and the questions were suitable for Grade 3 students. Mrs. Bishop, with more than 10 years experience

teaching Grade 4, stated, "I would use these with my [Grade 4] students." These two expert opinions confirmed the validity of these three researcher-developed data collection instruments.

Semi-structured Interview

An interview guide, consisting of the questions shown in Table 15, was designed to provide a starting point for a brief interview with a representative cross-section of the participants. Further questions, framed to encourage participants to elaborate upon their answers, were based on individual participant's responses to the initial questions.

The purpose of the interview was to determine if students had a preference for a particular text type, and if students were able to indicate sections of the passages that were effective at changing their ideas. The interview was also meant to be a means of eliciting students' thoughts regarding the content and format of the text passages. Student interviews were not a part of the pilot study.

Table 15

Questions from the Semi-structured Interview Guide.

Which paragraph did you enjoy reading the most? Why?
Did any of these paragraphs teach you something new?
Did any of these paragraphs change your thoughts about a topic? Why?

The Thesis Study: Implementation

Once I received approval from the university and from the school district in which I conducted my thesis research (see Appendix D), I distributed student and parental consent forms to all students in Grades 3 and 4 in an initial visit to the school. During each subsequent visit, I worked with all of the students in three separate implementation groups, and I worked with each of the groups in turn. Two of the implementation groups were entire classes: the Grade 3, and the Grade 3/4 class. The third implementation group was composed of the Grade 4s from the Grade 4/5 class and the Grade 3s from the Grade 2/3 class. The nonparticipants in each of the three implementation groups were provided with activities that resembled the study materials, so that neither teachers nor students would be able to distinguish participants from nonparticipants. I worked with students in one of two locations: the Fine Arts room or their own classroom. The teachers were not present during any part of the implementation of the study.

The classroom teachers decided when I would work with their students, and they chose times that were convenient for them, with all students in the room, and that did not conflict with another session that I was conducting. Teachers attempted to select times during their regularly scheduled Language Arts and Science periods, but on occasion I worked with students during other subject periods.

The steps in the study implementation consisted of collecting baseline data; facilitating the intervention, including interviews; and conducting follow-up activities. Figure 8 shows the timeline for the project.

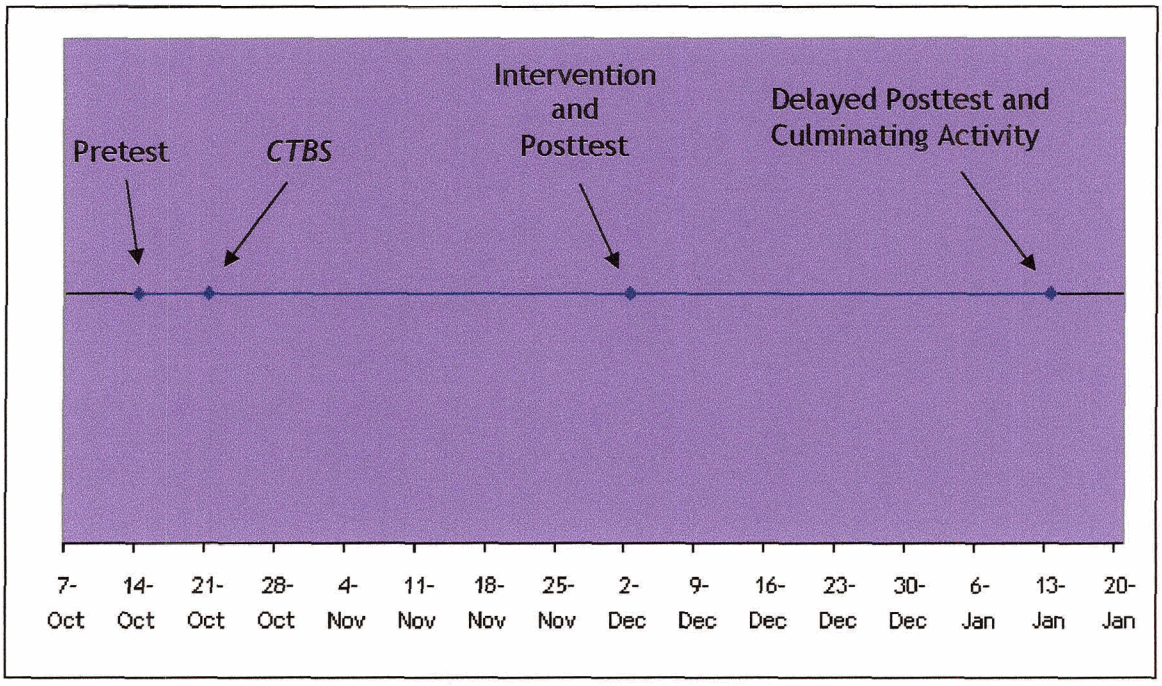

Figure 8. Timeline of the thesis study.

Collecting Baseline Information

Baseline information for this project included whether or not specific misconceptions were held by individual participants. It also included a measure of the reading comprehension of the participants.

Identifying misconceptions: The pretest.

The pretest was the first data collection measure that I administered. I explained the format of the test, and instructed students that they needed to be very sure of their answers. If they were unsure, students were to circle the

question mark. I read the questions aloud, to each of the three implementation groups, so that any students who might have difficulty reading would still be able to answer the questions. The pretest and the delayed posttest were the only occasions during the study when students received support with reading, since in all other instances, students were working independently (during the *CTBS*) or were working at varying rates (while reading the text passages and completing the posttest). To maintain anonymity of the participants, nonparticipants also completed the pretest. In all three implementation groups, students completed the pretest in less than 15 minutes. Students who finished before their peers were asked to draw a picture on the back of the pretest paper. When everyone in the implementation group was finished the pretest, the students returned to their classrooms or I asked their teacher to return to the classroom.

***Assessing reading ability: The* CTBS.**

One week after the pretest, I administered the reading comprehension subtest of the *CTBS* to all students in each of the three study groups. The teachers' guide for administering the *CTBS* is very detailed and I followed the instructions for the reading comprehension subtest exactly as they were listed in the guide. This assessment measure was the only measure in the study that was timed, and it lasted for precisely 42 minutes. Before the assessment began, students were able to ask questions, but for the duration of the reading comprehension subtest, students did not receive any assistance. To obtain the participants' reading comprehension grade levels, I marked the answer sheets,

and converted the raw scores to grade level equivalents using the tables contained in the teachers' guide.

Facilitating the Intervention

The intervention phase of the project consisted of text passage selection, the actual reading of selected text passages, and the completion of the immediate posttest. For some participants, the intervention phase also included a brief interview.

Text passage selection.

I marked the pretests, noting which of the eight target misconceptions were held by each participant. Based on the results of the pilot study, I anticipated that there might be partial corrections of misconceptions, so I also noted cases where students were unsure about a topic. As in the pilot study, each student received four text passages, one on each of four misconceptions. Four passages fit on a single page and reading four passages was manageable for most students. I assigned two refutation text passages and two expository text passages to each student, basing my selections on the results of the student's pretest. I recorded the text passages assigned to each student, so that I would have an equal number of refutation text passages and expository text passages for each target misconception. Since several of the target misconceptions were held by only a small number of students, as shown in Figure 9, I began by assigning those students text passages on those topics. This assignment order was essential to obtain data regarding the bat and spider misconceptions.

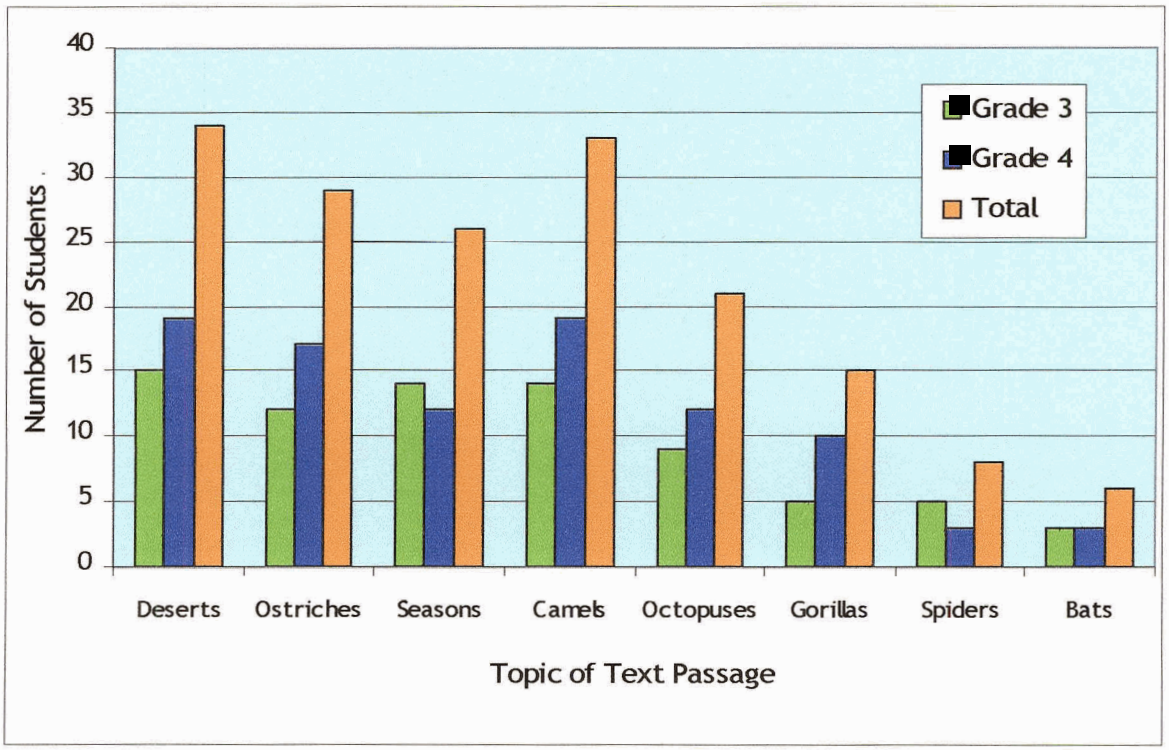

Figure 9. Misconceptions held by students in the sample.

If a student's pretest showed that fewer than four misconceptions were held, I first selected text passages on the topics about which the student did have misconceptions, and then selected text passages on the topics about which the student was unsure. In two cases, individual students did not hold four misconceptions even if I included partial misconceptions, so I randomly selected text passages to act as 'fillers.' I believed it was important for all students to receive pages that looked nearly identical. I selected a total of 160 text passages to be read by the 40 participants. One hundred forty-seven passages were read by students who held misconceptions about the passage topic; 10 passages were read by students who were unsure about the passage

topic; and 3 passages were read by students who did not hold misconceptions about the passage topic.

Reading the text passages.

Seven weeks after the pretest had been administered I presented the students with their individualized sets of four text passages. In all three groups, I instructed the students to read the passages carefully, as they would be answering questions when they were finished. I did not make any mention of the pretest, as I wanted to minimize the connections between the pretest and the text passages. Since my instructions were brief, I did not prepare a script to follow. To maintain the anonymity of participants, I presented all nonparticipants with a page containing four text passages. Each nonparticipant received the same set of text passages consisting of two expository passages and two refutation passages. I selected the four passages about camels, deserts, ostriches, and seasons simply because those target misconceptions were the most widely held by the study participants.

Posttest.

As soon as a student finished reading the four text passages, I collected the text passage page and then distributed the posttest. I did not want the students to have access to the text passages while completing the posttest. Rereading is a technique which, as a teacher, I usually encourage, but in this case I believed that the effectiveness of the text passages could not be as clearly determined if students simply reread the passages as they answered the questions on the posttest. Because students were reading individualized

passages at their own paces, the amount of time required to complete the intervention step of the study varied. However, all students completed the 14 questions on the posttest within 30 minutes of receiving their text passages. I distributed a coloring sheet with a seasonal theme to each student, including nonparticipants, once the posttest was collected.

Semi-structured interview.

I selected 1 or 2 students representing each of the 12 possible combinations of a) gender; b) reading comprehension ability (high, medium, or low as determined by categorizing the results of the *CTBS*, a process described in detail in Chapter 4); and c) grade (3 or 4). A total of 21 students participated in a brief interview that, while lasting less than five minutes, provided some interesting insights about student preferences for text passages. I conducted the interviews after the students completed the posttest and before they returned to their classrooms, or before I asked teachers to return to the classrooms, so that teachers would not be able to identify study participants. While I conducted the individual interview, all other students, including the nonparticipants, worked on their coloring sheets. In each of the three groups, I completed all of the interviews within 20 minutes.

I made a copy of the interview guide (Table 14) for each interview that I conducted. The data collected during each interview consisted of handwritten notes that I made on the interview guide.

Follow-up Activities

The follow-up activities consisted of a delayed posttest and a

culminating activity. These activities took place six weeks after the intervention phase of the project. In previous refutation text studies, delayed posttests were administered two weeks after the intervention (Hynd et al., 1994) and one month after the intervention (Maria & Johnson, 1989), so I selected six weeks as an appropriate delay.

Delayed posttest.

The 14 true or false questions on the delayed posttest were completed by the participants, in their three groups, in less than 10 minutes. As with the pretest, I read the questions out loud so that any students who might have difficulty reading would still be able to answer the delayed posttest questions. The culminating activity began immediately upon the completion of the delayed posttest.

Culminating activity.

I created a booklet, shown in Appendix E, which consisted of eight pages, one for each of the target misconceptions. Each page included the pair of text passages relating to the misconception topic as well as an illustration to support the scientific information contained in the passages. Immediately following the delayed posttest, I read the booklet out loud to each of the three study groups, so that all students, participants and nonparticipants, would have access to the information contained in all 16 text passages, and not just the 4 passages that were presented during the intervention. After I read each pair of text passages, I asked students to write a few words on a lined piece of paper about the similarities ("things that were the same") and the differences

("things that were not the same") they noticed about the pairs of text passages. Once I had read all eight pairs of text passages, I facilitated a discussion about the similarities and differences that students had noted. During the discussion, I recorded, in writing, the participants' comments that I deemed relevant to the exploration of the use of refutation text with Grades 3 and 4 students. I collected the lined paper before students returned to their classrooms, or before I asked teachers to return. The culminating activity was completed in less than 40 minutes for each of the three groups.

Data Analysis Procedures

As the thesis study generated quantitative and qualitative data, I needed to select appropriate methods for analyzing both types of data. The quantitative data could often be displayed graphically, but I also carried out a statistical analysis of selected data. The qualitative data, generated by interviews and discussion, was coded and categorized.

Quantitative Data: Statistical Analysis

The quantitative data gathered during this study yielded frequencies that corresponded to the number of students whose misconceptions were either corrected or not corrected. Individual responses were independent of one another since no response on the pretest was linked to any other, and no response on the posttest was linked to any other. A Chi-square analysis is suitable for use with this type of data, and can be used to determine whether the resulting frequencies are significantly different from the theoretical or

expected frequencies (Isaac & Michael, 1997). A Chi-square, or X^2, is calculated using the formula

$$X^2 = \Sigma \frac{(O-E)^2}{E}$$

where O is the observed frequency and E is the expected frequency for each cell in a tabular arrangement of data. A more detailed example of the 2 X 3 X^2 calculation that I carried out is provided in the following chapter. If the data can be arranged in a 2 X 2 table, which was the case for most of the analyses I performed, then X^2 is obtained using the computing guide shown in Table 16.

Table 16

Computing Guide for X^2, 2 X 2 Table

$$X^2 = \frac{N(AD - BC)^2}{(A + B)(C + D)(A + C)(B + D)}$$

The values of A, B, C, D, and N are the frequencies arranged as shown:

	Outcome 1	**Outcome 2**	
Variable 1	B	A	→ A + B
Variable 2	D	C	→ C + D
	↓	↓	↓
	B + D	A + C	→ N

Note. Adapted from Isaac and Michael, 1997, p. 185.

Regardless of the method used to calculate X^2, the resulting value is then compared to a standard X^2 table, to check for significance and to obtain a p value. Altogether, I performed five separate X^2 analyses to determine whether the original data set should be revised, and if so, how it should be revised. I describe this process in detail in the following chapter.

Qualitative Data: Coding and Categorizing

The qualitative data generated by individual interviews, as well as by the large group discussions, were analyzed following an open coding procedure (Flick, 2002). After an initial reading of the responses, I reread the responses to specific questions and gave each response a descriptive label. I then developed response categories containing labels that were similar. The result was a variety of response types into which all responses could be categorized. For example, Edward's response, when asked why he preferred a particular passage was, *It tells me stuff I don't know.* I labeled his response *learned something new.* The final category to which Edward's response belonged was *new information.*

Summary

I visited the research site on five occasions: to distribute consent forms; to administer the pretest; to administer the *CTBS* reading comprehension subtest; to implement the intervention, which also included the posttest and the interview; and to conduct the delayed posttest and culminating activity. Students spent approximately 2 hours and 45 minutes engaged in the study activities. The data I collected consisted of both quantitative data (*CTBS,*

pretest, posttest, and delayed posttest results) and qualitative data (interview notes and discussion notes). In the following chapter, I present the results of the thesis study and interpret those results using graphs, statistics, and direct quotes from participants.

CHAPTER 4

RESULTS

In this chapter, I present and interpret the data that I collected during the thesis study. First, I describe the initial data set, discuss the process of revising the data set, and present the revised data set. Next, I examine the overall effectiveness of refutation text passages as compared to expository text passages in correcting the target misconceptions held by students in Grades 3 and 4. This examination includes the immediate effectiveness, as indicated by the results of the posttest, and the long-term effectiveness, as indicated by the results of the delayed posttest. I also discuss the issue of partial correction of misconceptions. Finally, I explore some of the factors that may contribute to the effectiveness of the text passages, including text characteristics such as readability as well as reader characteristics such as reading comprehension ability, gender, and preference for text passages.

The Original Data Set

The focus of the thesis study was to explore the effectiveness of refutation text and expository text in correcting science misconceptions held by students in Grades 3 and 4, and I conducted my initial analysis with the aim of producing some general statements about the efficacy of each text type. However, I first needed to organize the data in a manner that would yield clear results, yet neither inflate nor minimize the effectiveness of either the refutation or expository text passages.

My first step in the initial analysis was to compile the data on the immediate effects of the text passage types, which I determined by comparing the pretest and posttest results for each participant. A total of 160 text passages were read by the 40 participants during the intervention phase of the thesis study. Of those 160 passages, 147 passages were read by students who held misconceptions about the passage topics; 10 passages were read by students who were unsure about the passage topics; and 3 passages were read by students who did not hold misconceptions about the passage topics. These last three passages were treated as filler passages, and therefore, my initial analysis was based on the results of 40 students reading 157 text passages.

Because each student received only four text passages during the intervention phase, only four of the eight target questions on the posttest and the delayed posttest were related to those text passages. Thus, I marked only the four relevant questions for each participant, except for the three cases mentioned above, in which students did not hold a total of four misconceptions. The results of the pretest and the posttest were compared for each participant and the data were tallied, according to whether or not a misconception had been corrected. The students whose posttests indicated that the previously held misconception was corrected were counted as a 'yes'. The students whose posttests indicated that the previously held misconception was still held were counted as a 'no'. The students whose pretests indicated uncertainty about a misconception topic, and whose posttests indicated that the misconception was no longer held, were counted as a 'partial', as were the

students whose pretests indicated that they held a target misconception and whose posttests showed that they were unsure. The partial corrections are discussed in detail in the section on revision of the initial data set, as well as in the section focusing on partial corrections. There were no instances in which a misconception appeared to be strengthened: no student's pretest indicated uncertainty about a misconception topic while the posttest indicated that the misconception was held. For ease of interpretation, the data generated by the pretest/posttest comparison were tabulated as shown in Tables 17 and 18.

Table 17

Refutation Text Results

	Correction of Misconception?											
	yes			no			partial			passages read		
Topic	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**
Deserts	0	5	**5**	5	4	**9**	1	0	**1**	6	9	**15**
Ostriches	6	4	**10**	1	1	**2**	1	0	**1**	8	5	**13**
Seasons	0	1	**1**	2	5	**7**	0	0	**0**	2	6	**8**
Camels	5	6	**11**	2	3	**5**	0	0	**0**	7	9	**16**
Octopuses	2	6	**8**	0	0	**0**	1	0	**1**	3	6	**9**
Gorillas	2	1	**3**	2	3	**5**	1	0	**1**	5	4	**9**
Spiders	2	2	**4**	0	0	**0**	1	0	**1**	3	2	**5**
Bats	1	1	**2**	0	1	**1**	1	0	**1**	2	2	**4**
Total:	18	26	**44**	12	17	**29**	5	1	**6**	36	43	**79**

Note. A partial correction was noted when a response changed from *incorrect* to *unsure* or from *unsure* to *correct* after reading a particular passage.

Table 18

Expository Text Results

	Correction of Misconception?											
	yes			no			partial			passages read		
Topic	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**
Deserts	2	0	**2**	6	8	**14**	0	0	**0**	8	8	**16**
Ostriches	0	3	**3**	4	5	**9**	1	1	**2**	5	9	**14**
Seasons	5	4	**9**	1	0	**1**	0	0	**0**	6	4	**10**
Camels	1	2	**3**	6	5	**11**	0	0	**0**	7	7	**14**
Octopuses	0	1	**1**	1	2	**3**	4	2	**6**	5	5	**10**
Gorillas	0	4	**4**	0	2	**2**	0	0	**0**	0	6	**6**
Spiders	1	1	**2**	2	0	**2**	0	0	**0**	3	1	**4**
Bats	1	1	**2**	0	1	**1**	1	0	**1**	2	2	**4**
Total:	10	16	**26**	20	23	**43**	6	3	**9**	36	42	**78**

Note. A partial correction was noted when a response changed from *incorrect* to *unsure* or from *unsure* to *correct* after reading a particular passage.

Figure 10 shows the number of passages of each text type (i.e., the figures contained in the bottom rows of Tables 17 and 18) that resulted in correction, lack of correction, or partial correction of a target misconception for students in Grades 3 and 4.

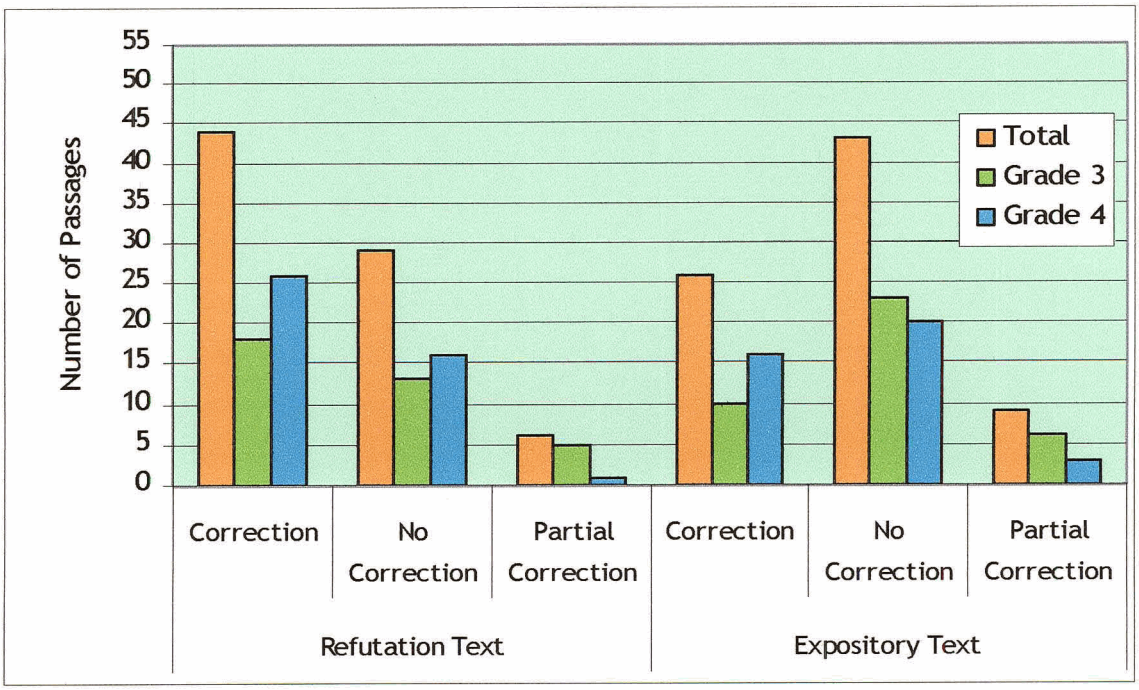

Figure 10. Correction of misconceptions by text passage type.

Revision of the Data Set

In the pilot study, many students indicated that they were unsure about a topic on both the pretest and the posttest. In the thesis study, however, the pretest results meant that only 10 of the 157 text passages were assigned to students who partially held the target misconception that was the topic of the passage. The results of the posttest indicated that seven of those partially held misconceptions appeared to be corrected after reading a text passage on the topic. Of the remaining 147 text passages, there were only eight cases in which a text passage appeared to cause a partial correction of the target misconception.

The small number of partial corrections, although unexpected, prompted me to consider a revision of the data set. Based on my review of the literature on conceptual change and refutation text, I believe that the conceptual change that occurs during partial correction of a misconception might be quite different from the conceptual change that occurs during complete correction. I also believe that it is difficult to quantify the degree of conceptual change, as conceptual change does not occur in precise increments: the amount of conceptual change required for one student's answers to reflect a partial correction would be different than the amount required for another student, depending on many factors, including the strength of the misconception.

Taking into account the complexity of conceptual change and the difficulty of determining the amount of conceptual change that occurs, I decided to revise the data set in a way that would minimize the impact of the partial corrections without affecting the significance of any differences between the refutation and expository text passages. I selected the Chi-square as an appropriate statistic to use as I determined the best way to treat the partial corrections.

Chi-Square Analyses of the Original Data Set

As explained in the previous chapter, a Chi-square (X^2) analysis is appropriate when data exist in the form of frequencies. I performed five separate chi-square analyses in order to determine how the partial corrections of misconceptions should be treated in further analyses of the results of the thesis study. The first X^2 was based on a 2 X 3 table that treated the partial

correction of misconceptions as a separate category (i.e., as shown in Tables 17 and 18). Next, I calculated three different 2 X 2 tables: (a) treating each partial correction as a half of a correction; (b) treating partial corrections as 'no' corrections; and (c) excluding all of the data relating to partial corrections (i.e., the 18 instances when a student's answers indicated uncertainty on the pretest or the posttest). After completing these calculations, I revised the data set and performed a final X^2 analysis. Each of these five X^2 analyses is described in more detail in the remainder of this section.

The first X^2 analysis was based on the totals (frequencies) shown in Tables 17 and 18. The tabular arrangement of the observed frequencies and the calculated expected frequencies for the 2 X 3 X^2 is shown in Figure 11.

Frequencies

		Misconception Corrected?			
		yes	no	partially	**Total**
Text Type	Refutation	**44** (35.2)	**29** (36.2)	**6** (7.5)	**79**
	Expository	**26** (34.8)	**43** (35.8)	**9** (7.5)	**78**
	Total	**70**	**72**	**15**	**157**

Notes: 1. The observed frequencies, O, were obtained from Tables 17 and 18.

2. The numbers in brackets are the expected frequencies, E, calculated by multiplying the row total and the column total and dividing by 157.

3. $X^2 = \Sigma (O-E)^2/E$

Figure 11. The 2 X 3 table for the initial X^2 calculation.

The results of the 2 X 3 X^2 calculation were X^2 (2, N = 157) = 7.905, p<.02, indicating that the differences in the frequency of misconception correction were not due to chance, and that the frequencies were indeed statistically significant. However, because I wanted to revise the data set to minimize the effect of the partial corrections of misconceptions, I proceeded to perform three separate 2 X 2 X^2 analyses to determine the most appropriate treatment of the partial corrections data. These three X^2 analyses, as well as the final analysis of the revised data set, were all based on 2 X 2 tables, and followed the computing guide shown in Table 19.

Table 19

Computing Guide for X^2, 2 X 2 Table

$$X^2 = \frac{N(AD - BC)^2}{(A + B)(C + D)(A + C)(B + D)}$$

The values of A, B, C, D, and N are the frequencies from Tables 17 and 18 arranged as shown:

		Text Type		
		Refutation	Expository	
Misconception	Corrected	B	A →	A + B
	Not corrected	D	C →	C + D
		↓	↓	↓
		B + D	A + C →	N

Note. Adapted from Isaac and Michael, 1997, p. 185.

Because the expository text passages appeared to cause a higher number of partial corrections than the refutation text passages, I wanted to determine if including those partial corrections with the corrections would cause the differences between the text passage types to become insignificant. I performed a second X^2 analysis, counting each partial correction as a half correction, as shown in Figure 12. The results were X^2 (1, N = 149.5) = 6.195, $p<.01$, indicating that the differences between the frequencies observed for correction of misconceptions based on text type were still statistically significant when partial corrections were counted as half of a correction.

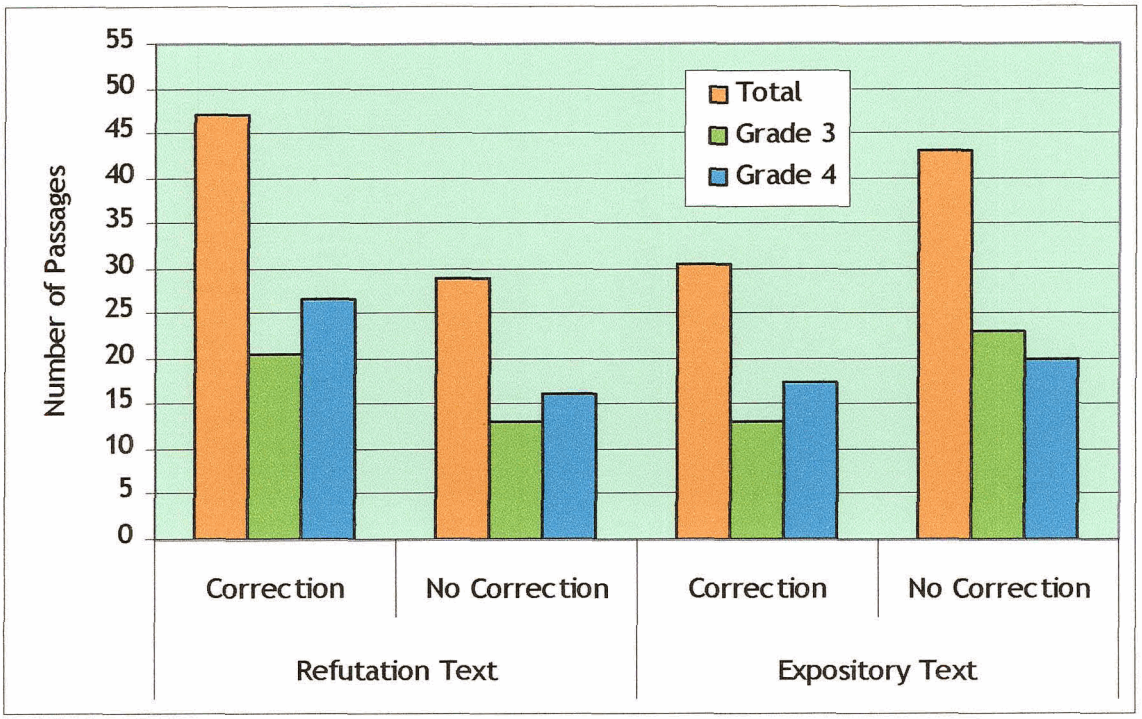

Figure 12. Correction of misconceptions by text passage type with partial corrections counted as half corrections.

Next, as another check, I added the partial corrections of misconceptions to the no correction total, as shown in Figure 13, and found X^2 (1, N = 157) = 7.944, p<.005, indicating that the differences between the frequencies of misconception correction based on text type were still significant.

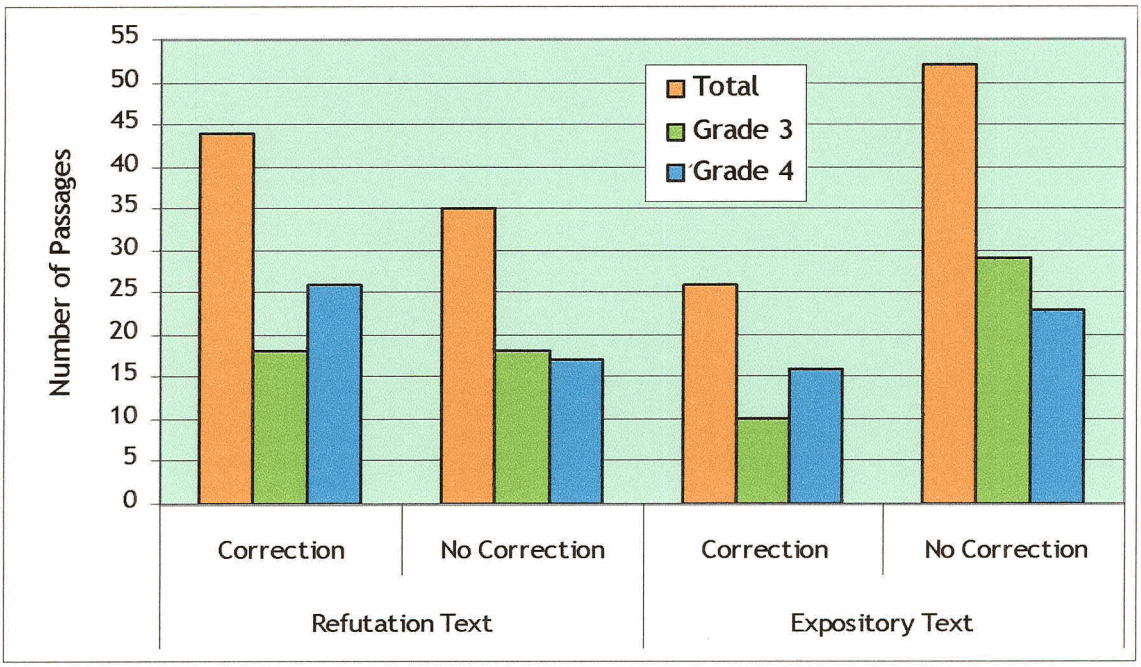

Figure 13. Correction of misconceptions by text type with partial corrections counted as no correction.

As a further statistical check on the overall effectiveness of text type, I calculated a X^2 that was based on only complete correction or lack of correction (i.e., all partial corrections were removed from the data set, as shown in Figure 14). I found that X^2 (1, N = 139) = 6.907, p<.005, indicating that these results were still statistically significant.

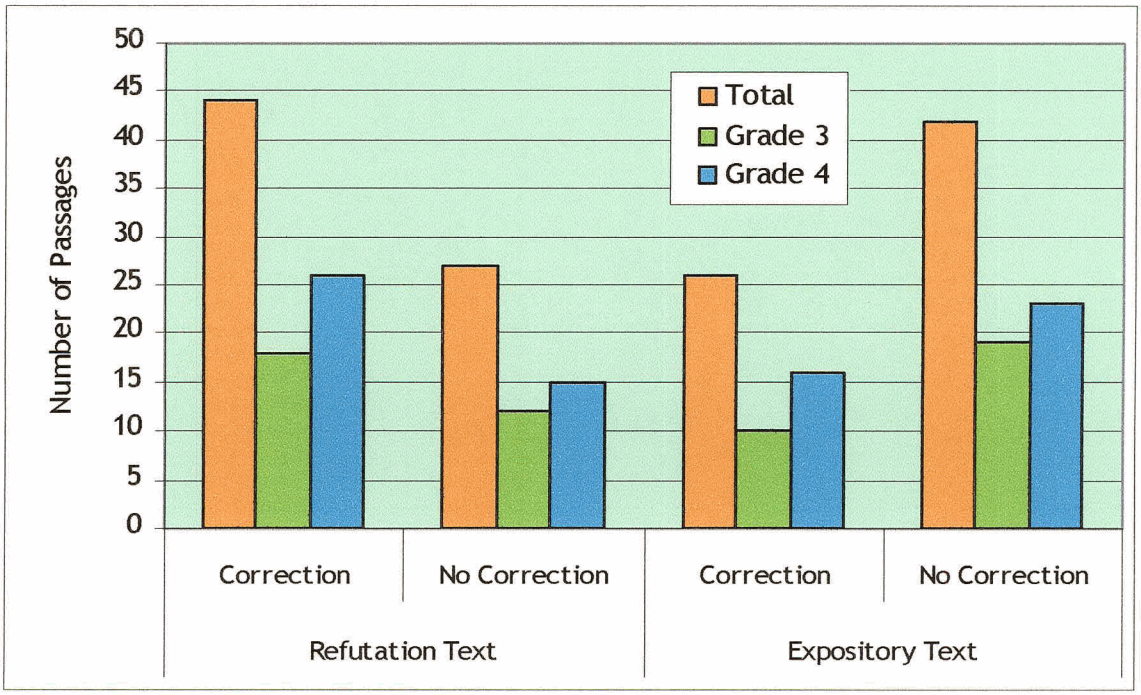

Figure 14. Correction of misconceptions by text type with all partial corrections removed from the data set.

Based on the four X^2 analyses conducted using the original data set, I decided that the data set could be appropriately revised: I removed the data generated by students who were initially unsure about target misconceptions (n = 10) from the data set; and I then treated the results showing partial correction of a previously held misconception (n= 8) as results showing no correction of the misconception. By revising the data in this manner, I minimized the effectiveness of both the refutation text passages and the expository text passages. However, I believed that the results obtained from further analyses would be more powerful if the refutation text passages proved to be more effective even when partial correction of misconceptions were not

counted as conceptual change. I performed a focused analysis of those instances in which partial corrections of misconceptions occurred, and that analysis is described later in this chapter. The revised data set, the basis for all further analyses, is shown in Tables 20 and 21.

Table 20

Revised Refutation Text Results

	Correction of Misconception?								
	yes			no			passages read		
Topic	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**
Deserts	0	5	**5**	6	4	**10**	6	9	**15**
Ostriches	6	4	**10**	1	1	**2**	7	5	**12**
Seasons	0	1	**1**	2	5	**7**	2	6	**8**
Camels	5	6	**11**	1	3	**4**	6	9	**15**
Octopuses	2	6	**8**	0	0	**0**	2	6	**8**
Gorillas	2	1	**3**	2	3	**5**	4	4	**8**
Spiders	2	2	**4**	0	0	**0**	2	2	**4**
Bats	1	1	**2**	1	0	**1**	2	1	**3**
Total:	18	26	**44**	13	16	**29**	31	42	**73**

Note. Data generated from initial *unsure* responses removed from the data set; partial corrections of misconceptions counted as no correction.

Table 21

Revised Expository Text Results

	Correction of Misconception?								
	yes			no			passages read		
Topic	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**	Gr.3	Gr.4	**total**
Deserts	2	0	**2**	5	8	**13**	7	8	**15**
Ostriches	0	3	**3**	5	5	**10**	5	8	**13**
Seasons	5	4	**9**	1	0	**1**	6	4	**10**
Camels	1	2	**3**	6	5	**11**	7	7	**14**
Octopuses	0	1	**1**	4	4	**8**	4	5	**9**
Gorillas	0	4	**4**	0	2	**2**	0	6	**6**
Spiders	1	1	**2**	2	0	**2**	3	1	**4**
Bats	1	1	**2**	0	1	**1**	1	2	**3**
Total:	10	16	**26**	23	25	**48**	33	41	**74**

Note. Data generated from initial *unsure* responses removed from the data set; partial corrections of misconceptions counted as no correction.

I calculated a final 2 X 2 X^2 based on the revised data set (i.e., Tables 20 and 21) and found that $X^2(1, N = 147) = 9.052$, $p < .005$, indicating that the differences between the frequencies of misconception correction based on text type were still significant, even with initial partial corrections removed from the data set and subsequent partial corrections treated the same as no correction.

The Effectiveness of Text Type

The thesis study was designed to explore the effectiveness of refutation text for students in Grades 3 and 4 and to compare the effectiveness of refutation text and expository text for students at these grade levels, as well as to investigate some of the factors which may contribute to the effectiveness of both text types. In this section, I interpret the revised data set and discuss the immediate effectiveness of text type. Next, I present the data generated by the delayed posttest, which took place six weeks after the intervention phase of the study, and I discuss the delayed effectiveness of text type.

In my analysis of the immediate and delayed effectiveness of the text types, I first discuss the results for the participants as a whole, then for the Grade 3 participants, and finally for the Grade 4 participants. I elected to present the results in this order because I had initially intended to consider the study participants as a heterogeneous group of readers. However, as I proceeded to analyze the data, it appeared that further information could be obtained by examining the results by grade level.

Immediate Effectiveness of Text Type

To investigate the use of refutation text as an effective and appropriate strategy for correcting the misconceptions held by students in Grades 3 and 4, I compared the effectiveness of refutation text and expository text for students at these grade levels. In this section, I discuss the immediate effectiveness of the two text types, as revealed by the results of the posttest. The immediate effectiveness of the text passages at correcting the target misconceptions held

by participants was determined by the answers to the four target questions on the posttest which corresponded to the four text passages read by the participants. Immediately after reading four text passages that were each based on a different target misconception, the participants completed a posttest. The results of the posttest were tabulated and revised as I explained in an earlier section. Figure 15 is based on the revised data set, which was previously presented in Tables 20 and 21.

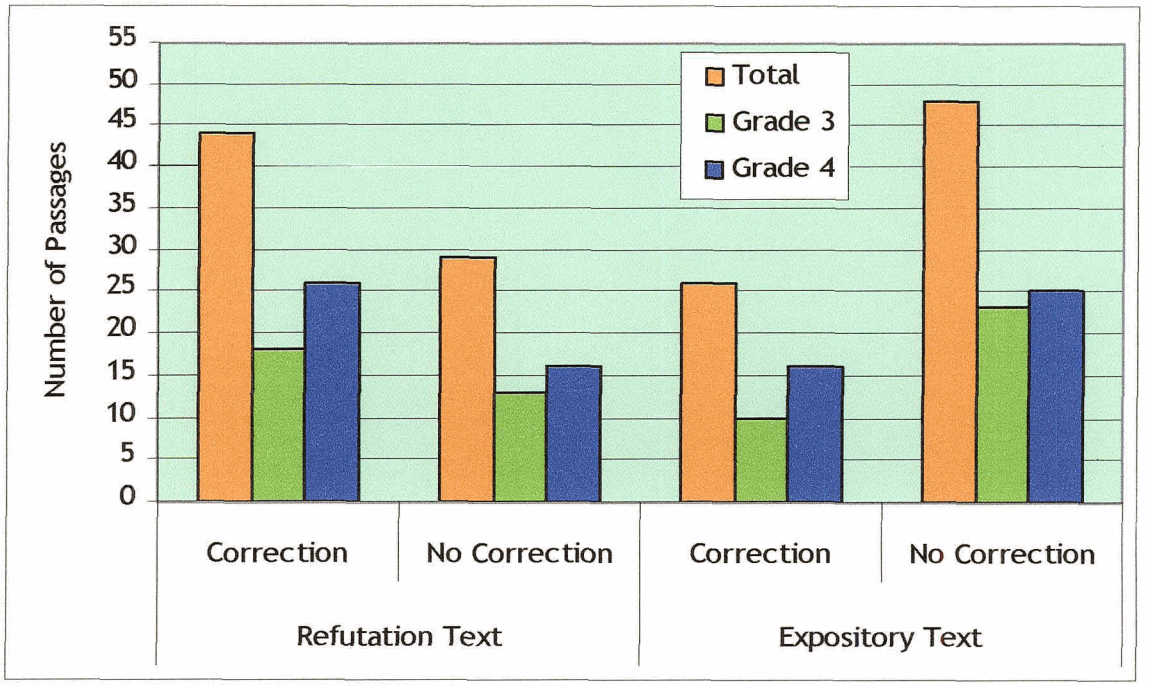

Figure 15. The revised data set of misconception correction as a function of text type.

To facilitate the comparison of the effectiveness of the two text types in correcting misconceptions for Grades 3 and 4 students, I calculated percentages for each of the categories shown in Figure 15 by dividing the

number of passages that did or did not result in corrections of the target misconceptions when read by participants with the total number of passages of that text type that were read by participants. Figure 16 shows the effectiveness of the text passages.

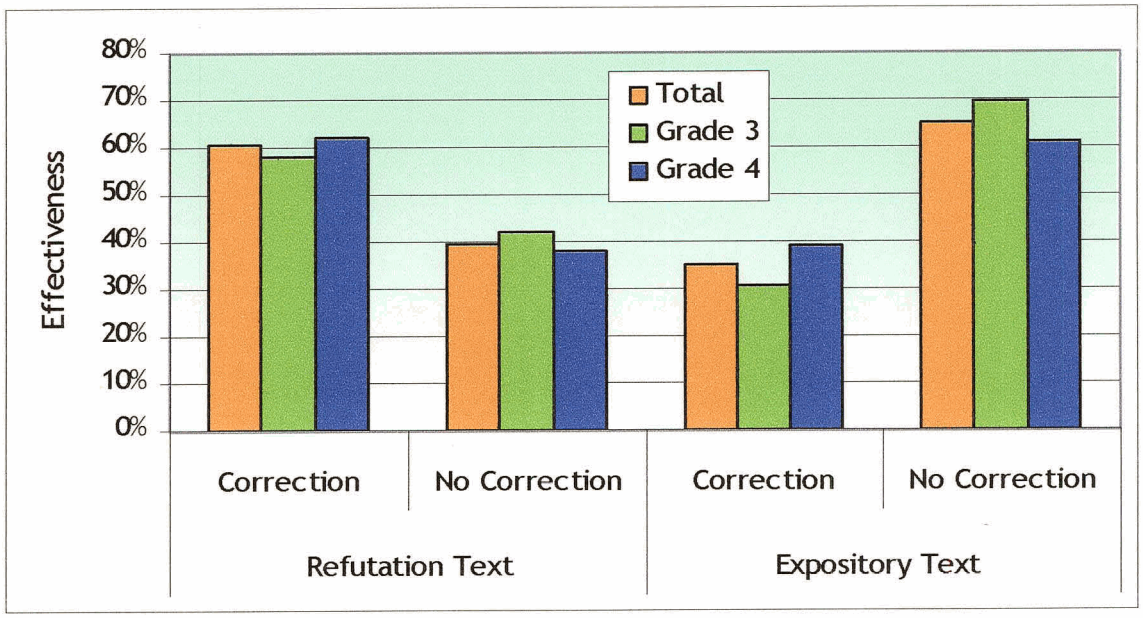

Figure 16. The effectiveness of text passage type by grade level of reader.

All Participants

As Figure 16 clearly shows, students who read refutation text passages were more likely than students who read traditional expository text passages to have their misconceptions corrected. For the participants as a whole, refutation text passages were effective 60% of the time; that is, 44 of the 73 refutation text passages that were read led to a correction of the target misconception, according to the participants' posttest answers. Expository text passages, however, were effective only 35% of the time, with 26 of the 74

passages that were read leading to a correction of the target misconception. As noted previously, these differences are significant: X^2 (1, N = 147) = 9.052, p < .005. Therefore, based on the results of the thesis study, it appears that for students in Grades 3 and 4, the use of refutation text can be an appropriate and effective strategy for correcting misconceptions. In fact, refutation text appears to be even more effective than traditional expository text.

Grade 3 Participants

While refutation text appeared to be effective for the group as a whole, I wondered whether that effectiveness might vary depending upon the grade level of the individual participants. Therefore, I analyzed the results as a function of the grade level of the participants. As shown in Figure 16, for participants in Grade 3, reading refutation text passages led to a correction of the target misconception 58% of the time. Traditional expository text passages were effective in 30% of the cases. This difference is significant: X^2 (1, N = 64) = 5.006, p<.025. For Grade 3 students, therefore, it appears that the use of refutation text is an appropriate strategy for correcting misconceptions, and that refutation text passages are even more effective than traditional expository text passages.

Grade 4 Participants

For participants in Grade 4, reading refutation text passages led to a correction of the target misconception 62% of the time, while reading traditional expository text passages led to corrections 39% of the time. Again, this difference is significant: X^2 (1, N = 83) = 4.345, p<.025. It appears that the

use of refutation text is an appropriate and effective strategy for Grade 4 students, and that reading refutation text may be even more likely than reading traditional expository text to result in the correction of misconceptions.

Summary: Immediate Effectiveness

When used as a strategy for correcting the misconceptions held by students in Grades 3 and 4, refutation text passages were significantly more effective than traditional expository text passages, as indicated by the results of the Chi-square analyses discussed earlier. Additionally, the effectiveness of the refutation text passages did not appear to be a function of the grade level of the reader, as there was little difference between the effectiveness for Grade 3 students (58%) and the effectiveness for Grade 4 students (62%). Although the expository text passages appeared slightly more effective for Grade 4 students (39%) than for Grade 3 students (30%), this difference is not significant: X^2 (1, N = 74) = 0.610.

Maintained Effectiveness of Text Type

In a second analysis of the overall effect of text type, I focused on the delayed effectiveness of the text passages. Although the refutation text passages appeared initially more effective than the expository text passages in correcting the misconceptions of students in Grades 3 and 4, those corrections might not be maintained. To explore the delayed effects of text type on correcting misconceptions, I administered a delayed posttest six weeks after the intervention. Figure 17 shows the five possibilities for the outcome of the

delayed posttest: (a) a correction that was indicated by the results of the immediate posttest was maintained; (b) a correction indicated by the posttest was partially maintained; (c) a correction that was indicated by the immediate posttest was not maintained; (d) a partial correction was indicated by the delayed posttest but NOT by the immediate posttest; and (e) a correction was indicated by the delayed posttest but NOT by the immediate posttest.

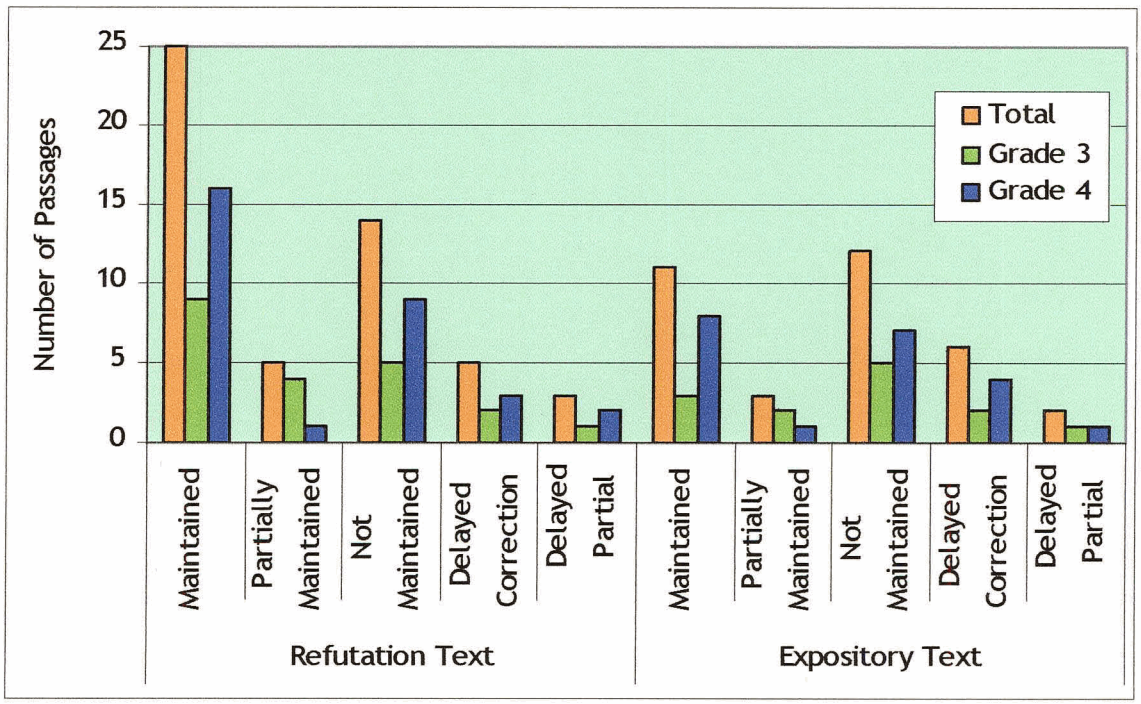

Figure 17. The maintained correction of misconceptions as a function of text type.

The thesis study was not designed to investigate the factors that may have led to delayed corrections or delayed partial corrections, and an in-depth examination of the delayed corrections is not possible. Therefore, I did not include the delayed corrections in my comparison of the delayed effectiveness of the two text types, although I do discuss them briefly as a separate

subsection. Figure 18 shows the effectiveness of refutation text and expository text, as a percent of the total number of passages of each text type that were initially assigned.

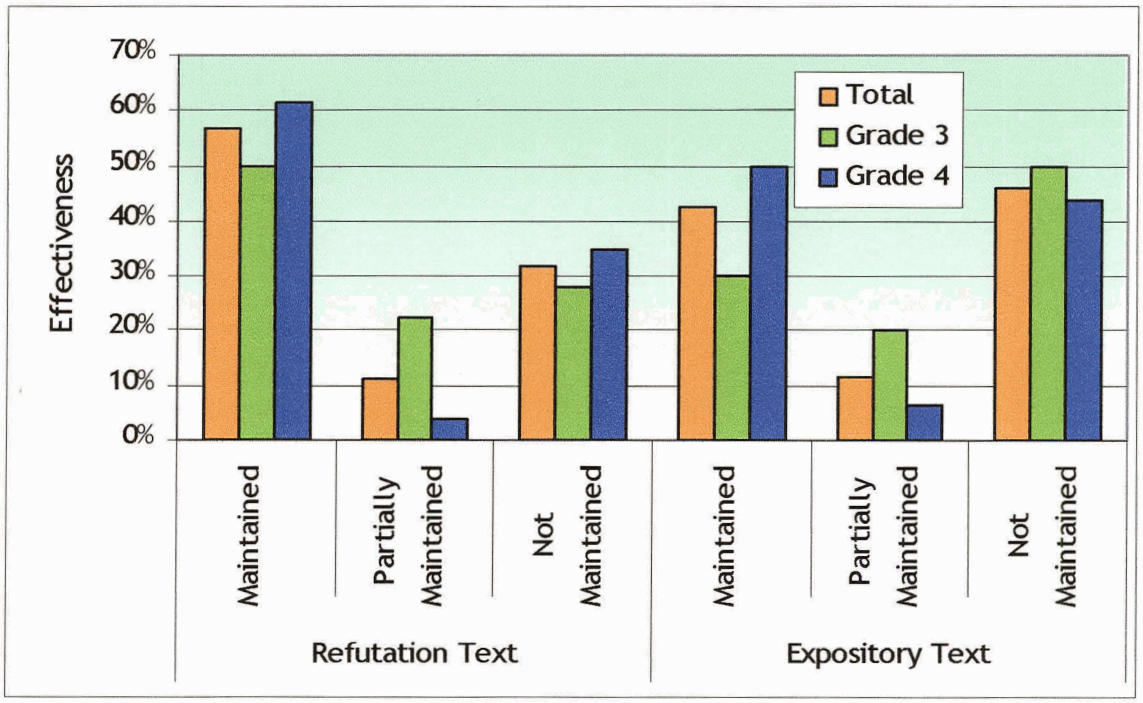

Figure 18. The maintained correction of misconceptions as a percent of the total initial corrections.

All Participants

The delayed posttest indicated that of the initial 44 corrections that were attributed to the reading of refutation text passages, 25 corrections (57%) were maintained six weeks later. In comparison, 11 of the 26 corrections (42%) attributed to the reading of expository text passages were maintained after six weeks. Although these figures would appear to indicate that corrections that occur after reading a refutation text passage are more likely to be maintained

than corrections that occur as a result of reading an expository text passage, a Chi-square analysis showed that the differences are not significant: X^2 (1, N = 70) = 1.378. Comparing the maintained corrections to the number of passages initially assigned to participants, I found that the original 73 refutation text passages resulted in 25 corrections (34%) that were maintained six weeks after reading those passages. Only 11 out of the 74 (15%) expository text passages resulted in the delayed maintenance of misconception correction. The differences are significant, X^2 (1, N = 147) = 7.465, $p<.005$, and indicate that refutation text is more effective than expository text when used as an isolated strategy for correcting misconceptions held by students in Grades 3 and 4, but that the corrections due to reading refutation text passages are no more likely to be maintained than the corrections that result from reading expository text passages.

Grade 3 Participants

As with my previous analysis of the immediate effectiveness of text type, I wanted to further explore the delayed effectiveness of text type as a function of grade level. As shown in Figures 17 and 18, the results of the delayed posttest indicated that for students in Grade 3, 9 of the 18 corrections (50%) that appeared to be caused by reading refutation text passages were maintained six weeks later. Only 3 of the 10 corrections (30%) that occurred after an expository text passage were maintained. In this instance, a Chi-square analysis is inappropriate, since the frequencies are too small. It appears from the results of the thesis study that Grade 3 students whose

misconceptions were corrected as a consequence of reading refutation text passages were more likely to have those corrections maintained.

For students in Grade 3, the percentage of corrections that were partially maintained, that is, students who had answered correctly on the immediate pretest and answered 'unsure' on the delayed posttest did not appear to depend on text type. Of the 18 original corrections attributed to reading refutation text passages, 4 (22%) were partially maintained, while 2 of the 10 corrections (20%) caused by reading expository text passages were partially maintained. These differences are not significant.

Grade 4 Participants

Figures 17 and 18 indicate that, for Grade 4 students, corrections that occurred after reading a refutation text passage were more likely to be maintained after six weeks. Of the 26 corrections attributed to reading refutation text passages, 16 corrections (62%) were maintained, while 8 of the 16 corrections (50%) that occurred after reading traditional expository text passages were maintained.

Neither refutation text nor expository text passages, when read by the Grade 4 students, were likely to result in partially maintained corrections as revealed by the results of the delayed posttest. For each text type, there was only one instance where a correction was partially maintained: only 4% of the corrections that occurred after reading refutation text passages were partially maintained, while only 6% of the corrections that occurred after reading traditional expository text passages were partially maintained.

Delayed Corrections

One of the interesting aspects revealed by the delayed posttest was the occurrence of delayed corrections. In other words, students who maintained a misconception, as indicated by the immediate posttest, were found to have had that misconception corrected, as indicated by the results of the delayed posttest. Figure 19 shows the percent of text passages which resulted in delayed corrections or delayed partial corrections.

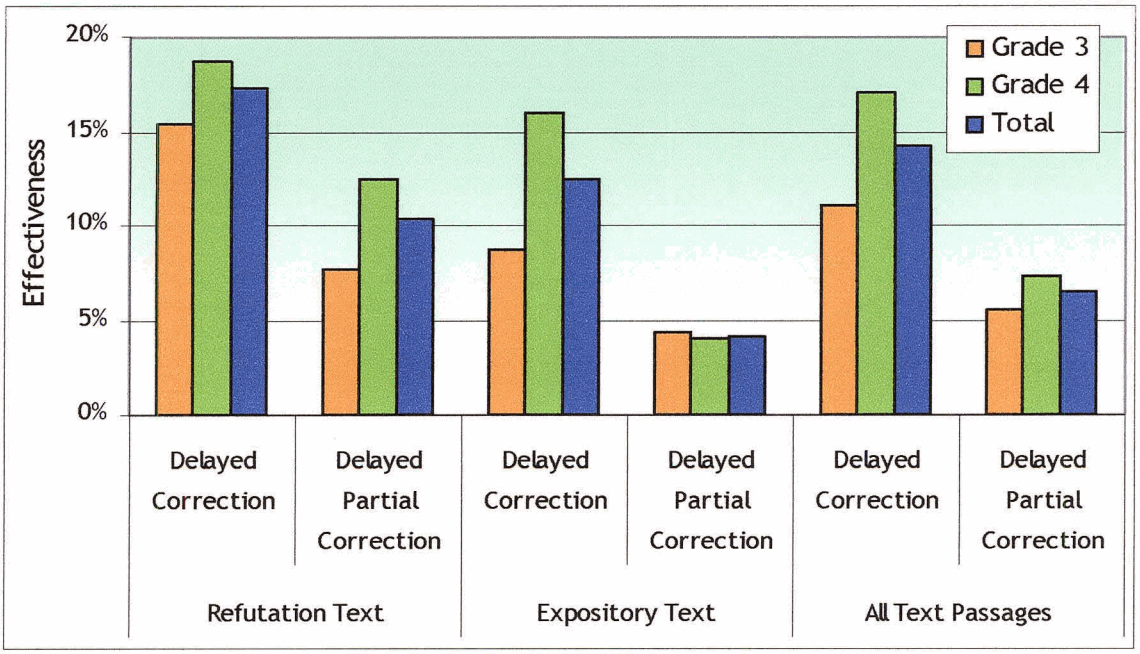

Figure 19. Percent of passages that resulted in the delayed correction of a misconception.

Students who read refutation text passages were somewhat more likely than students who read expository text passages to experience the delayed correction of a misconception: 5 students (17%) who maintained a target misconception after reading a refutation text passage responded correctly on

the delayed pretest, while 6 students (13%) who read expository text passages experienced a delayed correction. Further, students who read refutation text passages were more likely than students who read expository passages to experience a delayed partial correction, i.e., a student who still maintained a misconception as indicated by the immediate posttest was unsure about the target concept on the delayed posttest. Overall, Grade 4 students (27%) were more likely than Grade 3 students (17%) to experience delayed or delayed partial corrections independent of which text passage type they initially read, although these differences are not significant.

The delayed and delayed partial corrections may have been caused by students encountering further information about the target misconception on their own in the six weeks between the immediate and the delayed posttest. Perhaps as a result of reading the text passages during the intervention, students were more aware of the topic, and more able to accept the previously incompatible information regarding the target misconception.

Summary: Maintained Effectiveness

The results of the thesis study indicate that refutation text is more effective than expository text for correcting misconceptions held by students in Grades 3 and 4, and that the correction of a misconception is more likely to be maintained if it results from reading refutation text than if it results from reading expository text. Grade 3 students were less likely to have their misconceptions corrected after reading an expository text passage, and the corrections that did occur were less likely to be maintained after six weeks.

Additionally, Grade 3 students were more likely than Grade 4 students to have the corrections only partially maintained, whether they read refutation text passages or expository text passages. Grade 4 students were more likely than Grade 3 students to experience delayed and delayed partial corrections after reading either expository text or refutation text passages. As discussed previously, it is difficult to quantify delayed partial corrections and partial maintenance of corrections, since a response of 'unsure' could indicate a wide range of positions in the continuum of uncertainty. Finally, refutation text passages were somewhat more likely than expository text passages to yield delayed corrections and partial delayed corrections of the target misconceptions.

Partial Corrections of Misconceptions

My initial analyses were conducted to investigate the overall effectiveness of text type, both immediate and delayed. Then, in order to more fully explore a number of aspects including partial corrections and factors that might influence text passage effectiveness, I proceeded to perform several focused analyses. In this section I discuss my first focused analysis, which was an examination of the partial corrections that occurred during the thesis study.

The issue of how firmly the partial beliefs were held was not explored during the thesis study. My inability to quantify the information about partially held misconceptions and partial corrections was the impetus for the revision of the initial data set (i.e., Tables 17 and 18). Since students who were unsure about the target topics could possess varying levels of uncertainty, a statistical

comparison of results was neither meaningful nor appropriate. However, in this section I present the data relating to partial corrections and make a few general statements based upon those data.

As previously noted, there were very few instances of partial corrections of misconceptions. Of the 157 text passages assigned to the students, only 10 were assigned to students who were initially unsure about the target misconception, and 8 of the 10 passages were assigned to Grade 3 students. Figure 20 shows the number of students who were initially unsure about the target misconception but who answered the posttest correctly after reading a text passage, as well as the number of students who had their initial misconception partially corrected.

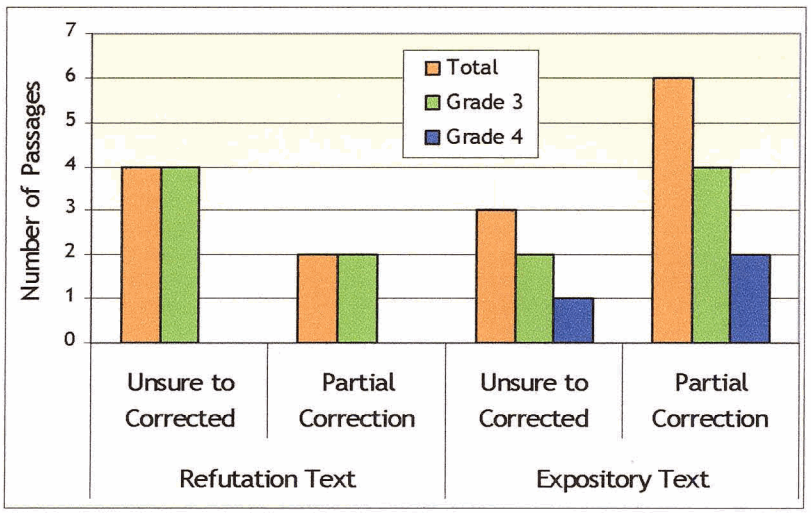

Figure 20. Partial correction of misconceptions as a function of text type.

First I examined the cases in which students who were initially unsure about a target topic were able to answer correctly on the posttest after reading a text passage based on the topic. Of the 10 students who initially had

partially held misconceptions, 7 students no longer held the misconception after reading a text passage based on the target misconception, while 3 remained unsure about the topic. There was little difference between the two text types: four students who answered 'unsure' on the pretest responded correctly on the posttest after reading a refutation text passage, while three students who answered 'unsure' on the pretest responded correctly after reading an expository text passage.

Next, I examined the cases in which students answered incorrectly on the pretest and indicated uncertainty on the posttest. There were eight instances in which a student's misconception appeared to be partially corrected after reading a text passage based on the topic, and six of those instances were as a result of reading an expository text passage. Reading the expository text passage about octopuses seemed especially likely to result in the partial correction of a misconception: five of the eight partial corrections occurred for students who read this passage.

The persuasive power of refutation text is indicated by the lack of uncertainty shown by students who read refutation text passages. Perhaps because refutation text contains an explicit reference to the misconception, readers may be more willing to accept the correct information that is contained in the text. As Chinn and Brewer (1993) suggest, when new information is anomalous it might be ignored or dismissed as incorrect. Refutation text may discourage these reactions by causing readers to

experience cognitive conflict and become dissatisfied with their current beliefs.

Exploration of Factors that May Contribute to Text Effectiveness

The pilot study raised several questions about the factors that might influence how likely a text passage was to cause readers to experience a correction of a target misconception. These factors included text-based characteristics such as readability level, topic, and number of words; as well as reader characteristics such as reading comprehension ability, grade level, gender, and preference for text passages. The thesis study yielded sufficient quantitative and qualitative data to permit an exploration of some of those factors and in this section I discuss textual characteristics of the passages such as number of syllables, number of words, and readability level. Next, I present and interpret quantitative data regarding the reader characteristics of reading comprehension ability and gender. Finally, I present and interpret the qualitative data gathered during the course of the semi-structured interviews.

Characteristics of the Text Passage

The factors that might influence the effectiveness of a text passage include both reader-based and text-based characteristics. Textual characteristics include the readability level of the passage, which is based on the number and difficulty of the words contained in the passage, as well as the number of sentences and the number of syllables in the passage. In an attempt to identify the text-based characteristics which contributed to a particular text

passage's effectiveness, I generated two graphs based on the revised data set. The number of misconception corrections associated with each of the text passages is shown in Figure 21.

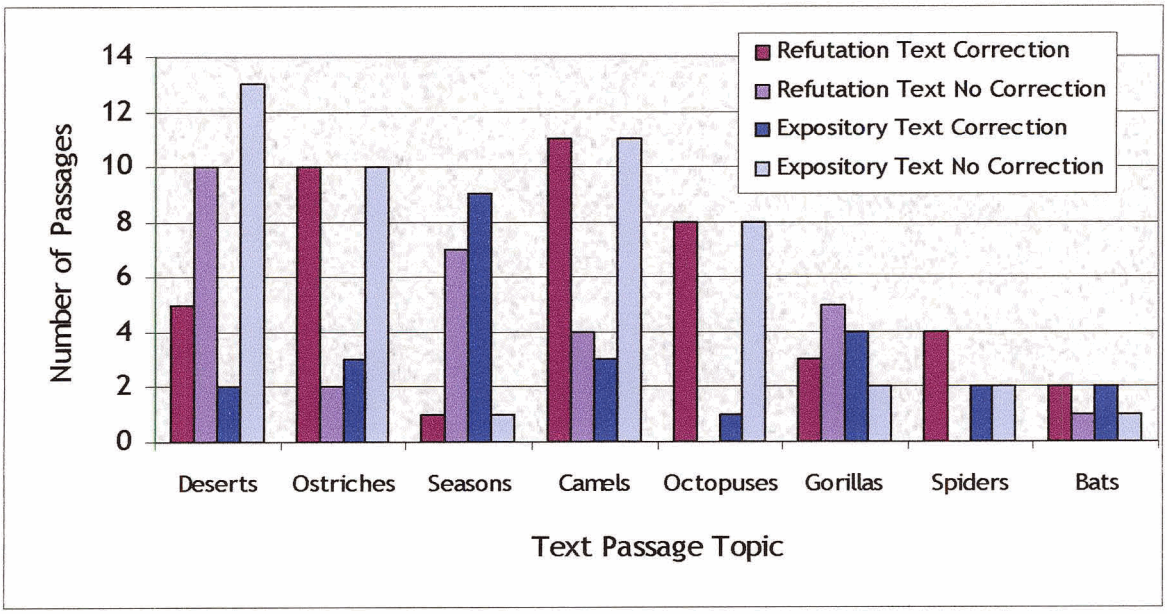

Figure 21. Correction of misconceptions by text passage topic and type.

It appears from Figure 21 that some text passages were more effective that others. However, I believed that the differences in effectiveness would be more apparent if I compared the percentage of students who experienced correction of a misconception after reading a specific text passage. For example, 15 students read the refutation text passage about deserts, and 5 of those students (33%) experienced a correction of the target misconception, while 2 of the 15 students (13%) who read the expository text passage about deserts had their misconceptions corrected. Figure 22 shows the percentage of

students whose posttest results indicated that the correction of a misconception had occurred after reading a particular text passage.

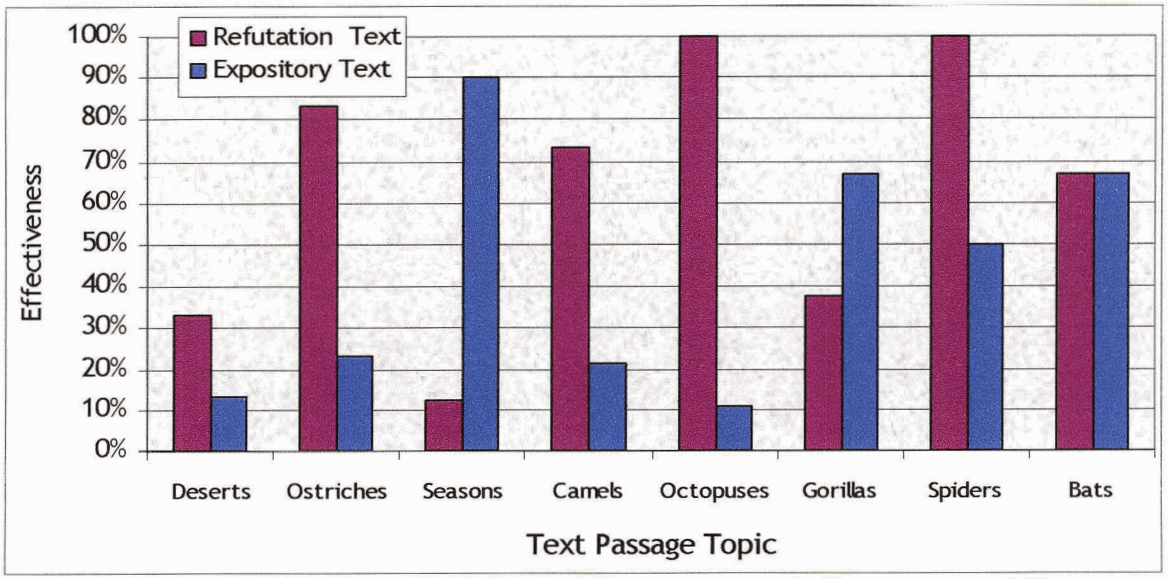

Figure 22. Percent Effectiveness of Individual Passages. Percentages are the number of students whose posttest results indicated correction of a misconception after reading a particular text passage divided by the total number of passages.

It is evident from Figure 22 that some text passages were more effective than others at correcting misconceptions. What is less evident, however, is why particular passages were more effective or less effective than others. I selected the two most effective refutation text passages, as compared to the effectiveness of the corresponding expository text passages, and tabulated a number of textual characteristics (Table 22) for the two passages and the corresponding expository text passages.

Table 22

A Comparison of the Two Most Effective Refutation Text Passages and Their Corresponding Expository Text Passages

Passage Topic	Text Type	Readability Level	# of Words	# of Syllables
ostriches	refutation	5.7	67	87
ostriches	expository	5.3	66	83
octopuses	refutation	5.4	60	88
octopuses	expository	4.9	60	82

A comparison of the readability levels of the four passages reveals that the average readability is at least 0.4 grades higher for the refutation text passage than for the expository text passage on the same topic. The two text passages about octopuses have an equal number of words, while the refutation text passage about ostriches contains one more word than the corresponding expository text passage. The refutation text passages have at least four more syllables than their corresponding expository text passages. Although the two refutation text passages share some characteristics, their commonalities are having a higher readability level and a greater number of syllables than their

corresponding expository text passages. Since these two characteristics would be likely to make the comprehension of the text passage more difficult, based on the comparison of these four passages, it is difficult to identify the textual variables that might have contributed to the higher effectiveness of the refutation text passages about octopuses and ostriches.

I also analyzed the two least effective refutation text passages, as compared to their corresponding expository text passages. The passages about seasons and gorillas were, in fact, the only two refutation text passages that were less effective than their corresponding expository text passages, although the two text passages about bats were equally effective. Table 23 reveals that the two passages about seasons have identical readability levels, while the refutation text passage about gorillas has a readability level 0.5 grades higher than its corresponding expository text passage. The refutation text passage about seasons has three more words than the corresponding expository text passage, while the refutation text passage about gorillas has four fewer words than the expository text passage on the same topic. Even an examination specifically focused on the two expository passages in Table 23 does not reveal a sufficient explanation for their comparative effectiveness. Unfortunately, this second comparison also did not reveal which textual characteristics, if any, might have contributed to the effectiveness of the text passages. The abstract nature of the target concept of seasons may have played a role in the lack of effectiveness of the refutation text passage, as more inferencing is required to

comprehend the information contained in the text, but this abstract quality does not explain the higher effectiveness of the expository text passage.

Table 23

A Comparison of the Two Least Effective Refutation Text Passages and Their Corresponding Expository Text Passages

Passage Topic	Text Type	Readability Level	# of Words	# of Syllables
seasons	refutation	5.4	66	86
seasons	expository	5.4	63	89
gorillas	refutation	6.3	61	94
gorillas	expository	5.8	65	94

A third comparison aimed at identifying textual characteristics that might influence the effectiveness of text passages was based on two refutation text passages about seasons. The first passage was one of the most effective passages in the pilot study. The second passage, a slightly revised version of the first, was one of the least effective passages in the thesis study. Table 24 contains the two passages and a list of some of their textual characteristics.

Table 24

Comparison of Refutation Text Passages about Seasons

Pilot study refutation text passage - Grade 3/4

Some people believe that it is warmer in the summer because the Earth is closer to the sun. This is not true. The Earth is actually closer to the sun in the winter! The Earth's distance from the sun does not cause the seasons. It is the angle of the sun's rays. Summer occurs when the Earth is tilted towards the sun. (62 words, 80 syllables, 6 sentences, readability grade levels: Dale-Chall: 4.9, Fry: 4)

Thesis study refutation text passage - Grade 3/4

Some people believe that it is warmer in the summer because the Earth is closer to the sun, but this is not true. In Canada the Earth is actually closer to the sun when it is winter! The Earth's distance from the sun does not cause the seasons. It is the angle of the sun's rays. Summer occurs when the Earth is tilted towards the sun. (66 words, 86 syllables, 5 sentences, readability grade levels: Dale-Chall: 4.8, Fry: 6)

The revised refutation text passage is four words longer than the passage used in the pilot study, and the Fry's readability level is two grades higher for the revised passage, because the first and second sentences have been combined, resulting in fewer sentences in the revised passage. The revised passage contains the word 'Canada', which should not have presented a

difficulty for the participants in this study, all of whom had been learning about Canada during the school year in which the thesis study was conducted. Once again, the textual characteristics that may have contributed to the effectiveness or lack of effectiveness of a text passage are not clear.

In a final attempt to identify textual characteristics which might contribute to text passage effectiveness, I plotted the effectiveness of each of the 16 text passages used in the thesis study (i.e., as shown in Figure 22) as a function of its average readability level (Figure 23), as a function of the number of words in the passage (Figure 24), and as a function of the number of syllables in the passage (Figure 25). It can be inferred from the randomness of the points in all three graphs that there is little or no correlation between readability level and passage effectiveness, or between the number of words or syllables in a passage and its effectiveness.

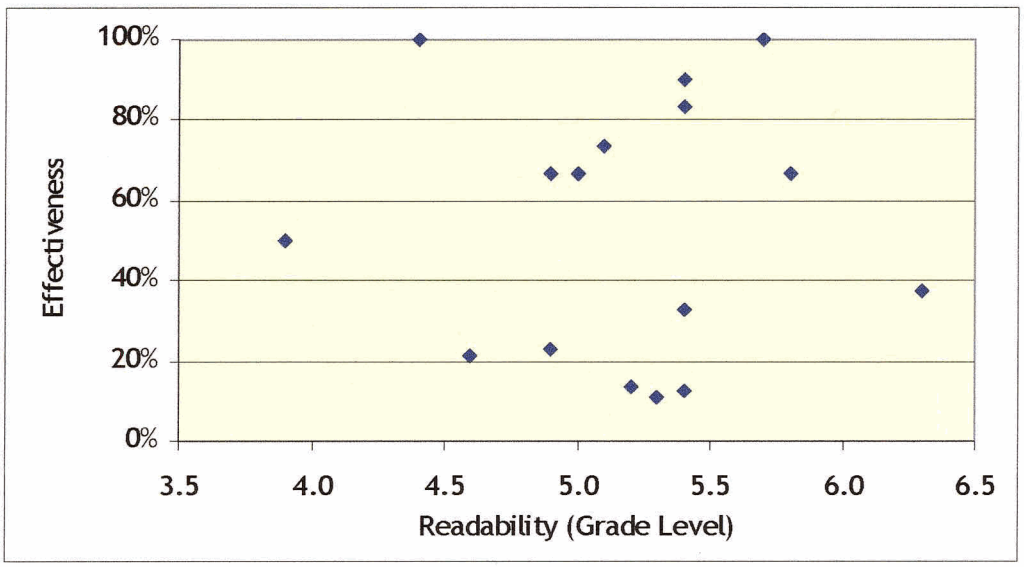

Figure 23. Percent effectiveness of text passages as a function of readability level.

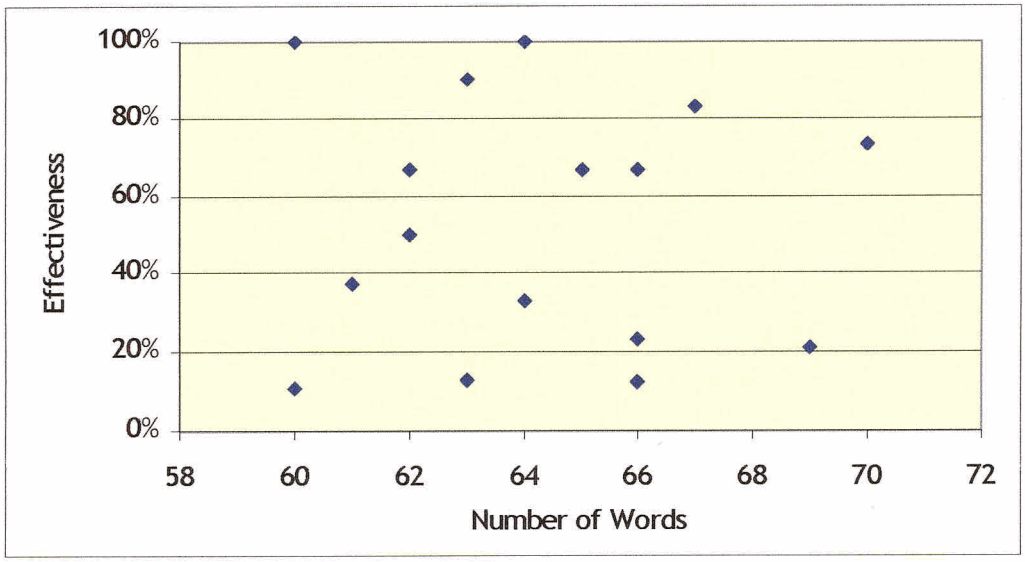

Figure 24. Percent effectiveness of text passages as a function of the number of words in the passage.

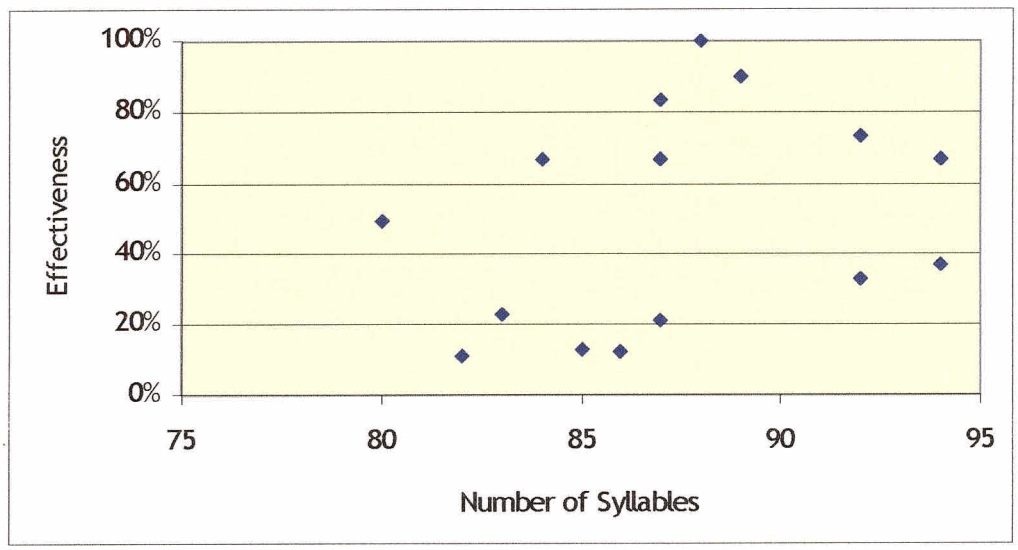

Figure 25. Percent effectiveness of the text passages as a function of the number of syllables in the passage.

Placement of the Refutation

While I was unable to identify textual characteristics that may have influenced the effectiveness of particular text passages, there is the possibility that the location of the refuting element in a refutation text passage may influence its effectiveness. Previous research has indicated that students have a preference for refutation text passages in which the refutation element appears at the beginning, and that preference might influence effectiveness. The thesis study, however, was not designed to explore the relationship between the placement of the refutation element and the effectiveness of the text passage. Of the eight refutation text passages used in the study, seven passages have the refutation element at the beginning of the passage; only the gorilla passage has the refutation element at the end. While the refutation text passage about gorillas was one of the least effective passages (i.e., as shown in Figure 22), its lack of effectiveness cannot be clearly attributed to the location of the refutation, since no other text passage has the refutation element at the end.

Summary: Text Passage Characteristics

Although I conducted a number of comparisons of text passage effectiveness, the thesis study did not generate sufficient data to allow the identification of textual characteristics that may have contributed to the effectiveness of specific text passages. It is important to note, though, that I wrote the text passages that were used in the thesis study with the aim of minimizing the differences between the textual characteristics of readability

level, number of words, and number of syllables. These three characteristics could likely be correlated to the effectiveness of authentic text passages, if those passages were reproduced in their entirety from a tradebook or a textbook. However, I was unable to locate authentic text passages suitable for use in the thesis study.

Characteristics of the Readers

I investigated several textual characteristics that may have influenced the text passage effectiveness, but the effectiveness of the individual text passages might also be influenced by a number of reader-based characteristics including prior knowledge, reading comprehension ability, gender, and motivation. In the thesis study, although I administered a pretest to determine whether participants possessed accurate or inaccurate prior knowledge, I did not further explore the quality or quantity of their prior knowledge and so a focused analysis of the influence of prior knowledge is not possible. As well, although I do discuss the influence of reader preference in a later section, the thesis study was not designed to provide an in-depth exploration of reader motivation. Relying upon the quantitative data that I collected, however, I was able to investigate the influences of reading comprehension ability and gender.

The Effect of Reading Comprehension Ability

In this section, I explore the possible relationship between reading comprehension ability and the effectiveness of refutation and expository text passages. First, I describe the classification of participants into reading grade intervals using the results of the Reading Comprehension subtest of the *CTBS*.

Then, I explain the development of three categories of reading comprehension ability (low, medium, and high) for the Grade 3 participants. I follow with a discussion of the effectiveness of the text passages for the Grade 3 participants at each reading comprehension ability level. Next, I repeat the explanation of category development and the discussion of text passage effectiveness for the Grade 4 participants. Finally, I summarize the effects of reading comprehension that were indicated by the results of the thesis study.

Classification of participants into reading grade interval categories.

I used the Reading Comprehension subtest of the *CTBS* to obtain a snapshot assessment of reading comprehension ability for the participants, and I used the results of that assessment to assign the participants to reading grade level categories, which were based on the *CTBS* grade level equivalent scores. I plotted the *CTBS* reading grade score for each participant and defined four reading grade intervals (RGI), as shown in Figure 26.

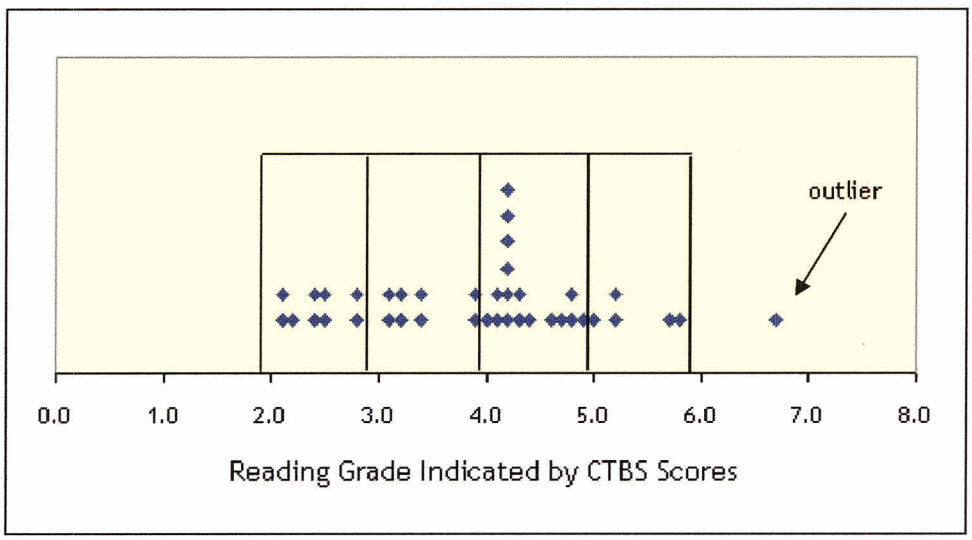

Figure 26. Four reading grade intervals of participants based on *CTBS* scores.

The four reading grade intervals correspond to *CTBS* Reading Comprehension subtest scores from Grade 2 to Grade 2.9 (attained by 9 participants), scores from Grade 3 to Grade 3.9 (attained by 8 participants), scores from Grade 4 to Grade 4.9 (attained by 17 participants), and scores from Grade 5 to Grade 5.9 (attained by 5 participants). They encompass all thesis study participants, with one exception, that of the student with a reading grade level of Grade 6.7, whom I treated as an outlier.

The next step in my exploration of the relationship between reading comprehension ability and the effectiveness of text type was to graph the number of passages that resulted in the correction of a target misconception, as indicated by the results of the posttest, for students in each reading grade interval, as shown in Figure 27.

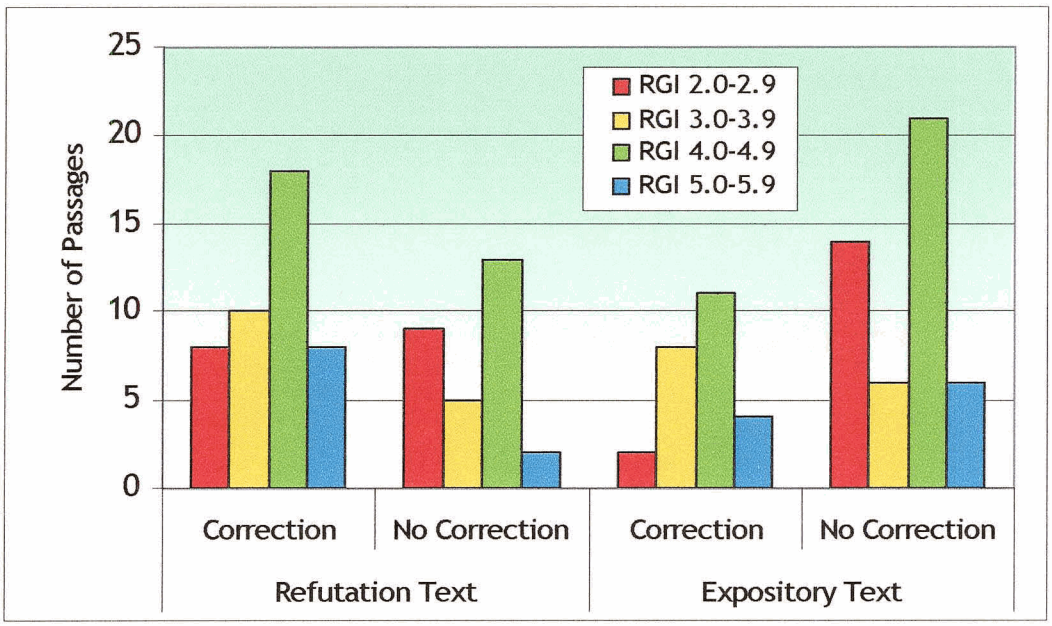

Figure 27. Corrections in participants' previously held misconceptions as a function of reading grade interval (RGI) based on *CTBS* scores.

To facilitate a comparison of the effectiveness of the two text types for each reading grade level, I developed Figure 28, which shows the percent effectiveness of the refutation text and expository text passages as a function of reading grade level for the participants as a whole.

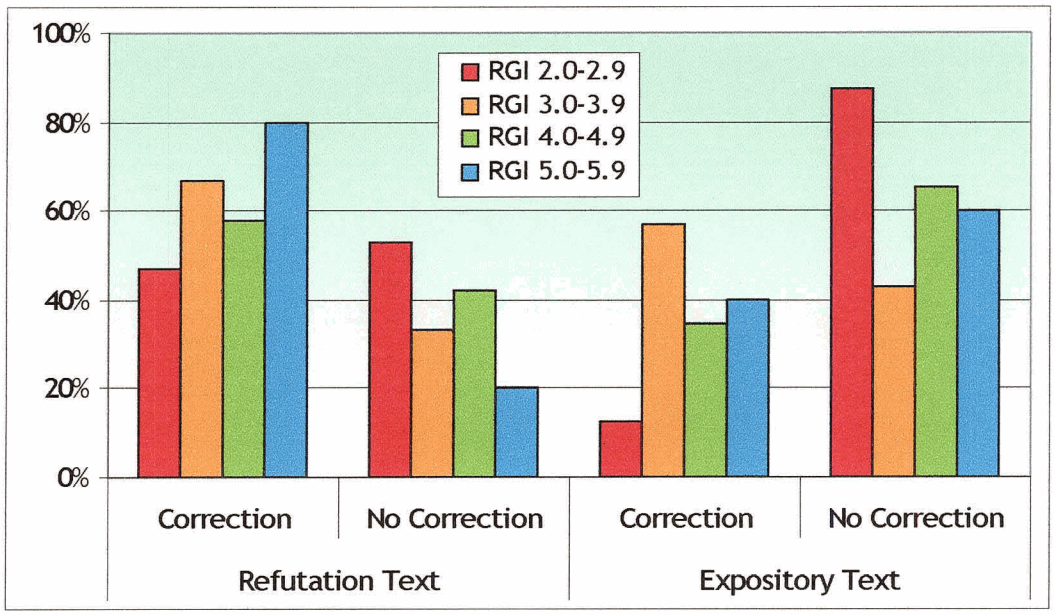

Figure 28. Effectiveness of text type for all participants as a function of reading grade interval (RGI) based on *CTBS* scores.

A general trend is evident in Figure 28. As the reading grade level interval increases, the effectiveness of the text passages also tends to increase, regardless of text passage type. The refutation passage effectiveness increases from 47% for the students in RGI 2.0-2.9 to 67% for students in RGI 3.0-3.9. The effectiveness drops slightly to 58% for students in RGI 4.0-4.9, and then increases again to 80% effectiveness for students in RGI 5.0-5.9. The discrepancy in text passage effectiveness for students in RGI 4.0-4.9 may be

attributable to the number of students (9 out of 17) whose *CTBS* reading comprehension grade level equivalents fall at the low end on the interval (i.e., as shown in Figure 26). Those 9 students had scores between Grade 4.0 and 4.2 in a total range of Grade 4.0 to 4.9. Results for the expository text effectiveness show a similar pattern: as the reading grade interval increases, expository text effectiveness also tends to increase. In this case, however, the expository text passages were most effective (57%) for students in RGI 3.0-3.9.

A second trend is also clear. Regardless of the reading grade interval, refutation text passages were more effective than expository text passages. While individual students may have had results that do not reflect this trend, for each group of participants at a particular interval, refutation text was more effective than expository text, indicating the power of refutation text as a tool for promoting conceptual change. However, for participants in RGI 2.0-2.9, refutation text was less effective than would be suggested by the results of the general analysis (47% as compared to 60% for all participants). For participants in RGI 3.0-3.9, refutation text was even more effective (67%) than would be suggested by the general analysis. For participants in RGI 4.0-4.9, refutation text was almost equally effective (58%), which is not surprising, since it is the interval with the greatest number of students, and the results for those students would contribute to a large proportion of the general effectiveness of refutation text passages. For participants in RGI 5.0-5.9, the refutation text passages were more effective (80%) than for the participants as a whole.

For participants in two reading grade intervals, expository text passages were as effective as would be suggested by the general analysis. For participants in RGI 4.0-4.9 and RGI 5.0-5.9, expository text passages had an effectiveness of 34% and 40% respectively, as compared to 35% for the participants as a whole. However, for participants in RGI 2.0-2.9, the expository text passage effectiveness was much lower than would be expected (13%), while for participants in RGI 3.0-3.9, the expository text passage effectiveness was much higher than expected (57%). It appeared that for the students with lower reading comprehension ability, reading an expository text was even less likely than for students with higher reading comprehension ability to produce the conditions required for conceptual change. While this lower effectiveness may be due to lower reading comprehension ability, it may also be due to the fact that the text passages were too challenging and that if they were less difficult, the participants in the lowest RGI may have been more likely to experience conceptual change.

Classification into reading comprehension ability categories.

As with previous analyses of the immediate effect and the delayed effect of text type, I wanted to explore the relationship between the effectiveness of the text passage types and reading comprehension for students in each grade as well as for the participants as a whole. Therefore, I used the results of the Reading Comprehension subtest of the *CTBS* to develop three categories of reading comprehension ability (low, medium, and high) for each grade level and then I compared the effectiveness of the text passages for the

Grade 3 participants in each category and the Grade 4 participants in each category.

Grade 3 participants.

I graphed the results of the *CTBS* Reading Comprehension subtest for the Grade 3 participants and created three reading comprehension ability categories, as shown in Figure 29. Logically, students in Grade 3 who were classified as having medium reading comprehension ability should be reading at the Grade 3 level. In fact, when the three categories (low, medium, and high ability) were defined on the graph, the six participants with medium reading comprehension ability were reading at a grade level equivalent of 3.0 to 4.0. The five students in Grade 3 who scored a grade level equivalent of less than 3.0 were classified as having low reading comprehension ability. The seven students in Grade 3 who scored a grade level equivalent of greater than 4.0 were classified as having high reading comprehension ability.

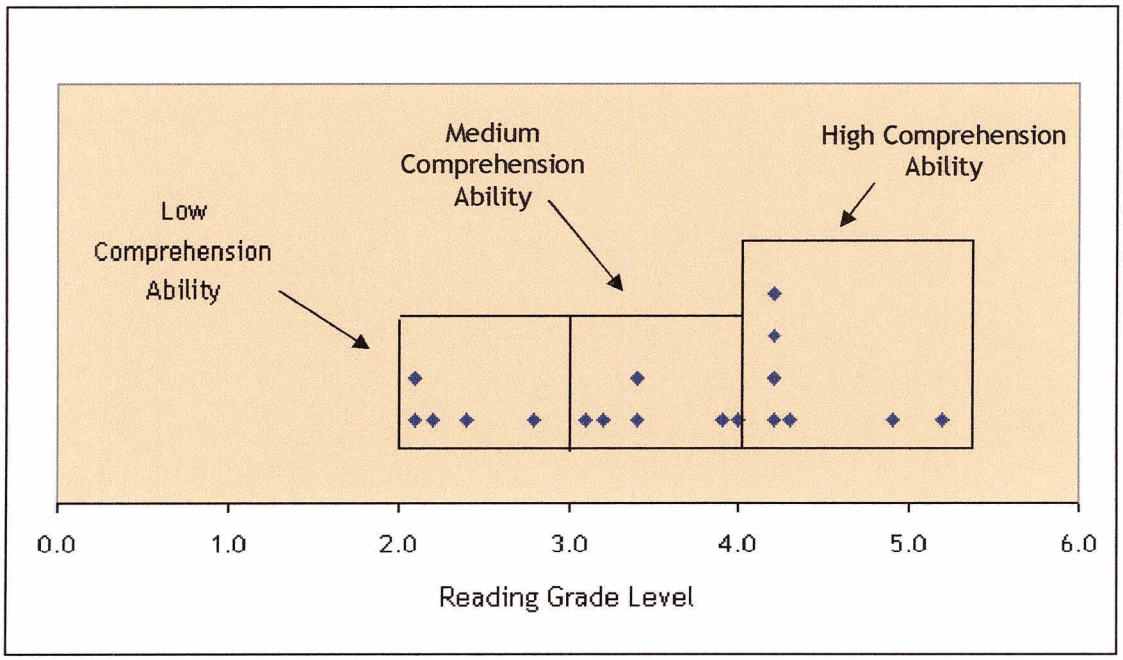

Figure 29. Reading comprehension ability of Grade 3 participants as determined by the *CTBS*.

Although the *CTBS* is a standardized measure, I recognize that the development of these ability categories is somewhat arbitrary, as is the placement of participants into the categories. For this reason, I performed a member check. I showed three of my colleagues (Mr. Cole, Ms. Davis, and Mrs. Edwards) the Grade 3 participants' reading comprehension grade level results from the *CTBS* that I had plotted on a graph that was identical to Figure 29, but without the lines indicating ability categories. I asked my colleagues to examine the graphs and to draw lines indicating three ability levels of low, medium, and high. One of my colleagues, Ms. Davis, created categories that were the same as the ones that I had developed, while the other two teachers developed categories that differed by one or two students. I conferred with all

three colleagues, and we were able to reach consensus: the categories of high, medium, and low reading comprehension ability as shown in Figure 29 were reasonable.

I used the Grade 3 reading comprehension ability groups developed and shown in Figure 29 to produce a graph of the number of passages that resulted in the correction of a target misconception, as indicated by the results of the posttest, for Grade 3 students at each of the three levels of reading comprehension ability (Figure 30). I then created a second graph showing the percent effectiveness of the text types as a function of the reading comprehension ability of the Grade 3 students (Figure 31).

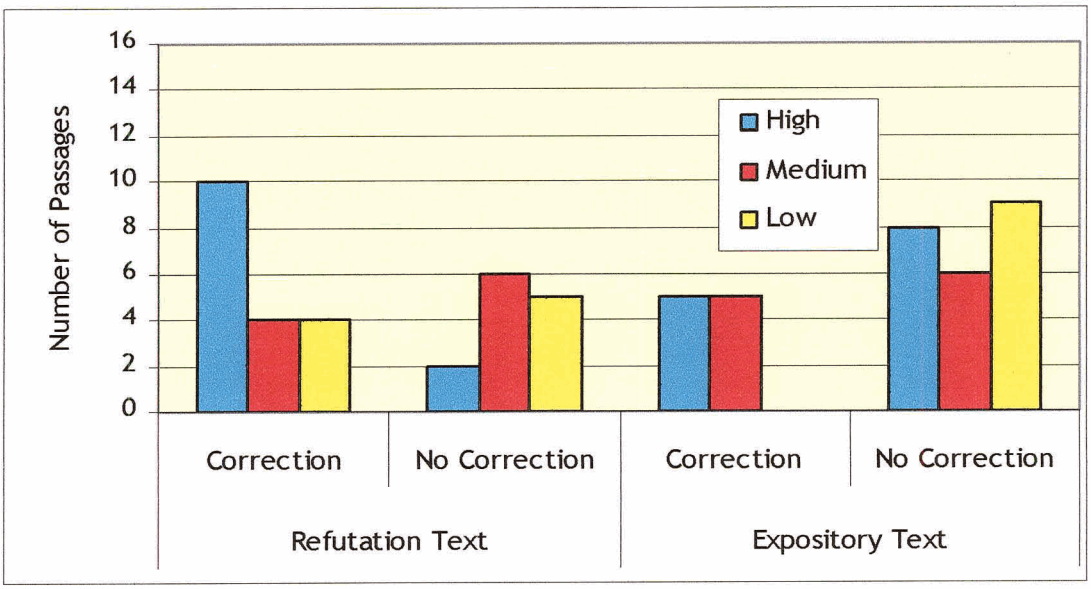

Figure 30. Corrections in Grade 3 students' previously held misconceptions as a function of reading comprehension ability as determined by the *CTBS*.

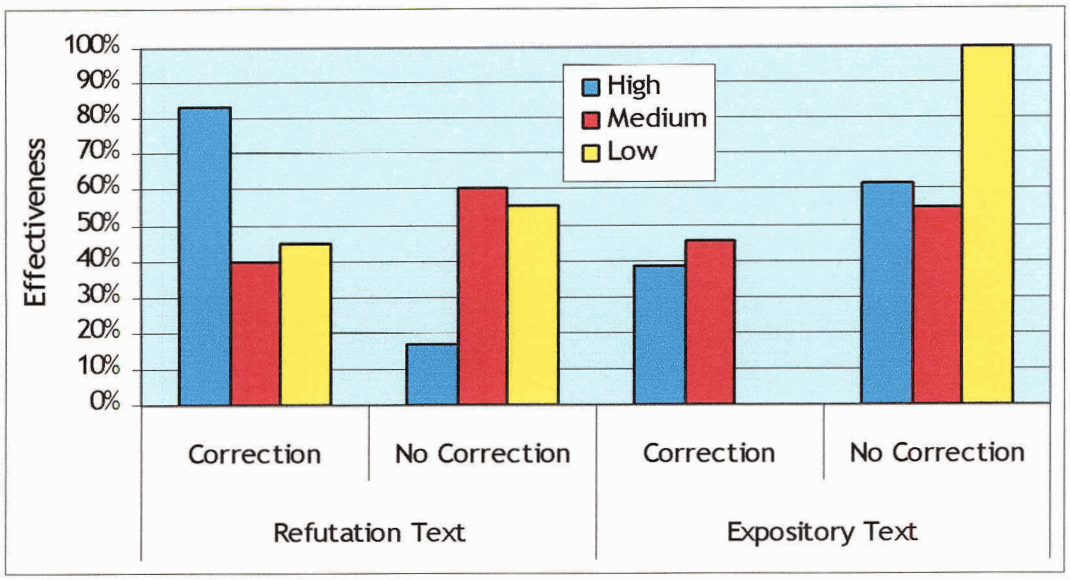

Figure 31. Effectiveness of text type for Grade 3 students as a function of reading comprehension ability as determined by the *CTBS*.

For the seven Grade 3 students in the high reading comprehension ability group, that is, students whose Reading Comprehension subtest scores were equivalent to greater than Grade 4.0, refutation text passages were effective in 10 out of 12 cases (83%), while expository text passages were effective in 5 out of 13 cases (38%). However, for the six Grade 3 students in the medium reading comprehension ability group, that is, whose Reading Comprehension subtest scores were equivalent to between Grade 3.0 and Grade 4.0, the two text types appear equally effective: refutation text passages were effective in 4 out of 10 cases (40%) while expository text passages were effective in 5 out of 11 cases (45%). For the five Grade 3 students in the low reading comprehension ability group, that is, whose Reading Comprehension subtest scores were equivalent to less than Grade 3.0, refutation text passages were

effective in 4 out of 9 cases (44%) while expository text passages were not effective at all (i.e., 0 out of 9 cases). This difference in effectiveness for participants with lower reading comprehension ability speaks to the power of refutation text, since the readability levels of the text passages were grater than the comprehension ability of the students. Unfortunately, for all three reading comprehension ability levels, the frequencies were too small to permit a Chi-square analysis. Interestingly, however, for students with either medium or low reading comprehension ability, that is, students whose Reading Comprehension subtest scores were equivalent to less than Grade 4.0, the refutation passages led to a much smaller percentage of corrections of misconceptions than for students with higher reading comprehension ability. Perhaps students who were reading at less than a Grade 4 level were focusing on identifying words rather than focusing on comprehending or remembering information contained in the text passages. It is also possible that the text passages were too challenging, as the average readability level of each text passage is Grade 3.9 or higher.

Grade 4 participants.

Next, I graphed and categorized the Reading Comprehension subtest scores for the Grade 4 participants, with the results shown in Figure 32. Logically, students in Grade 4 who were classified as having medium reading comprehension ability should be reading at approximately a Grade 4 level. In fact, when the three categories (low, medium, and high ability) were defined on the graph, the 11 participants with medium reading comprehension ability

were reading at a grade level equivalent of 3.9 to 4.9. The six students in Grade 4 who scored a grade level equivalent of less than 3.9 were classified as having low reading comprehension ability. The five students in Grade 4 who scored a grade level equivalent of greater than 4.9 were classified as having high reading comprehension ability.

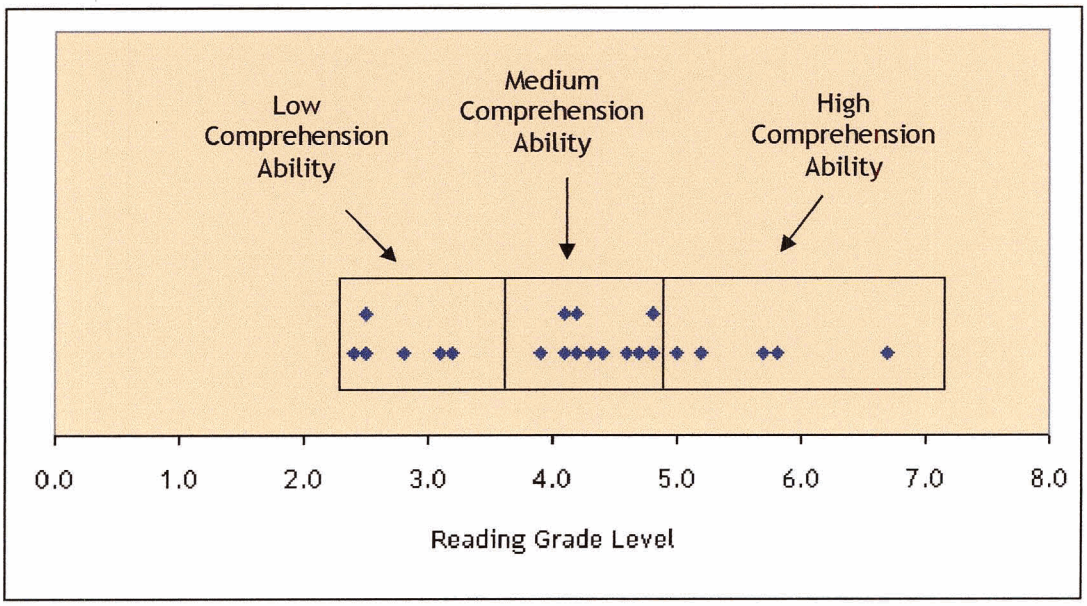

Figure 32. Reading comprehension ability of Grade 4 participants as determined by the *CTBS*.

Again, during the member check for this second graph, one of my colleagues (Mrs. Edwards) created categories that were the same as the ones that I had developed, while the other two teachers developed slightly different categories. I conferred with all three colleagues and we were able to reach consensus a second time: the categories of high, medium, and low reading comprehension ability as shown in Figure 32 were reasonable.

To explore the relationship between text type effectiveness and reading comprehension ability for students in Grade 4, I developed two more graphs, following the same steps outlined in the previous section about the Grade 3 participants. Figure 33 shows the number of corrections for each of the two text types as a function of the reading comprehension ability of the Grade 4 students, while Figure 34 shows the effectiveness of the text types as a percent of the total number of passages of each type that were assigned to the Grade 4 students.

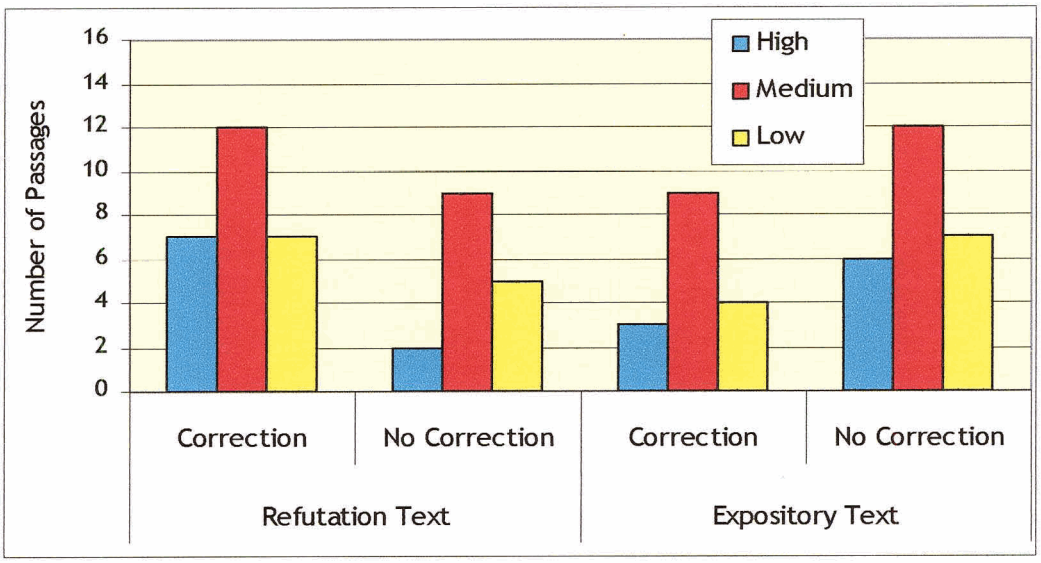

Figure 33. Corrections in Grade 4 students' previously held misconceptions as a function of reading comprehension ability as determined by the *CTBS*.

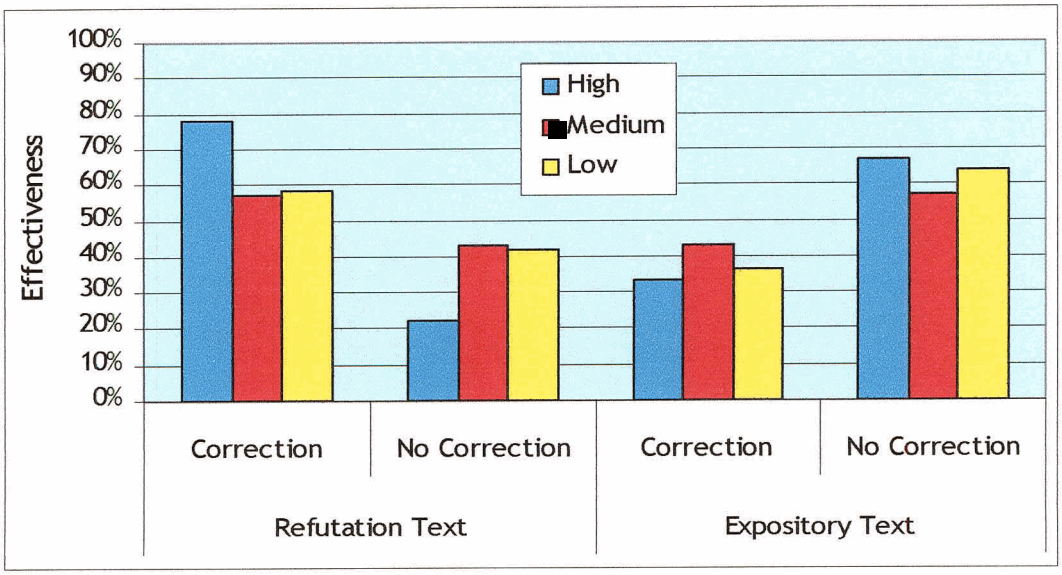

Figure 34. Effectiveness of text type for Grade 4 students as a function of reading comprehension ability as determined by the *CTBS*.

It appears that the refutation text passages were more likely to correct misconceptions than the expository text passages for Grade 4 students at all three levels of reading comprehension ability. For the five Grade 4 students in the high reading comprehension ability group, that is, students whose Reading Comprehension subtest scores were equivalent to greater than Grade 4.9, refutation text passages were effective in 7 out of 9 cases (78%), while expository text passages were effective in 3 out of 9 cases (33%). For the 11 Grade 4 students in the medium reading comprehension ability group, that is, whose Reading Comprehension subtest scores were equivalent to between Grade 3.9 and Grade 4.9, refutation text passages were effective in 12 out of 21 cases (57%) while expository text passages were effective in 9 out of 21 cases (43%). For the six Grade 4 students in the low reading comprehension

ability group, that is, whose Reading Comprehension subtest scores were equivalent to less than Grade 3.9, refutation text passages were effective in 7 out of 12 cases (58%) while expository text passages were effective in 4 out of 11 cases (36%). Unfortunately, for all three reading comprehension ability levels, the frequencies were too small to permit a Chi-square analysis. Interestingly, however, more than 50% of the refutation text passages resulted in the correction of a target misconception for Grade 4 students at each of the three reading comprehension ability levels. Expository text passages were effective less than 50% of the time for Grade 4 students regardless of their reading comprehension ability level.

Summary: The effect of reading comprehension ability.

In 9 out of 10 comparisons, refutation text passages were more effective than expository text passages when used as a strategy to correct misconceptions for students at all levels of reading comprehension ability. The one exception occurred for the six Grade 3 students with medium reading comprehension ability, and in this case the two text types were almost equally effective: refutation text was effective in 40% of cases, while traditional expository text was effective 45% of the time. In general, however, it appears that for students with lower reading comprehension ability, refutation text was less effective than it was for students with higher reading comprehension ability. However, refutation text passages were still more effective than the expository text passages for students with low reading comprehension ability. Unfortunately, an analysis of the possible significance of the results could not

be conducted because of the small number of study participants.

Gender Effects

It appears that for the Grades 3 and 4 students who participated in the thesis study, reading comprehension ability, as indicated by *CTBS* scores, influenced the effectiveness of text passages. Another reader characteristic that may influence the effectiveness of text passages is gender. Studies have shown that there are gender preferences for reading material, and that males typically prefer informational or expository text (Coles & Hall, 2002; Gambell & Hunter, 2000; Langerman, 1990; Simpson, 1996). Boys' preference for, or familiarity with, expository text structures might have influenced how effectively the text types corrected misconceptions. I predicted that both the expository and the refutation text passages would be more effective for boys than for girls, and I conducted a focused analysis in an effort to examine possible gender influences in the effectiveness of refutation text and expository text. Figure 35 shows the correction of misconceptions, as indicated by the posttest results, as a function of gender.

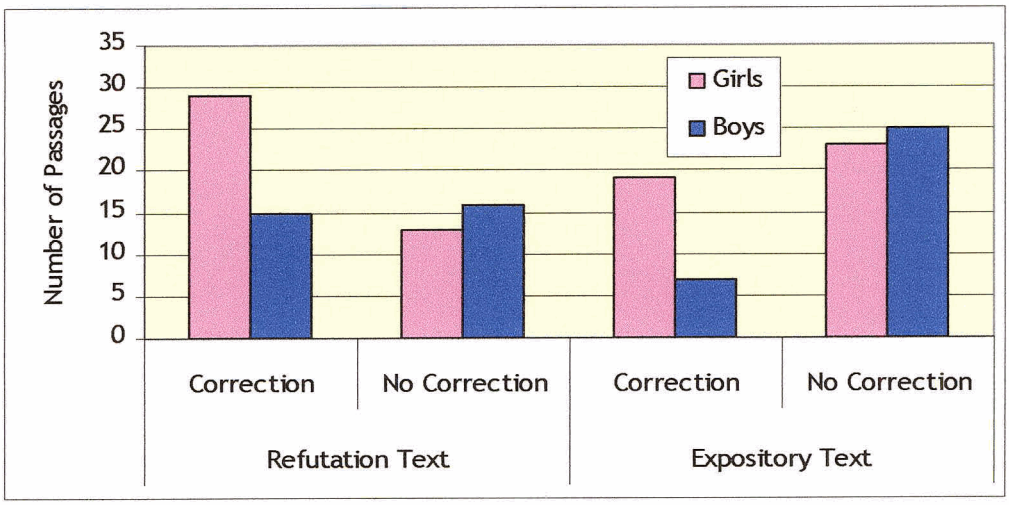

Figure 35. Changes in previously held misconceptions as a function of gender.

The participant group was not representative of the entire population of Grades 3 and 4 students at the focus school, as more girls than boys chose to participate in the thesis study. Therefore, it was more meaningful to compare percent effectiveness of the two text types as a function of gender, as shown in Figure 36.

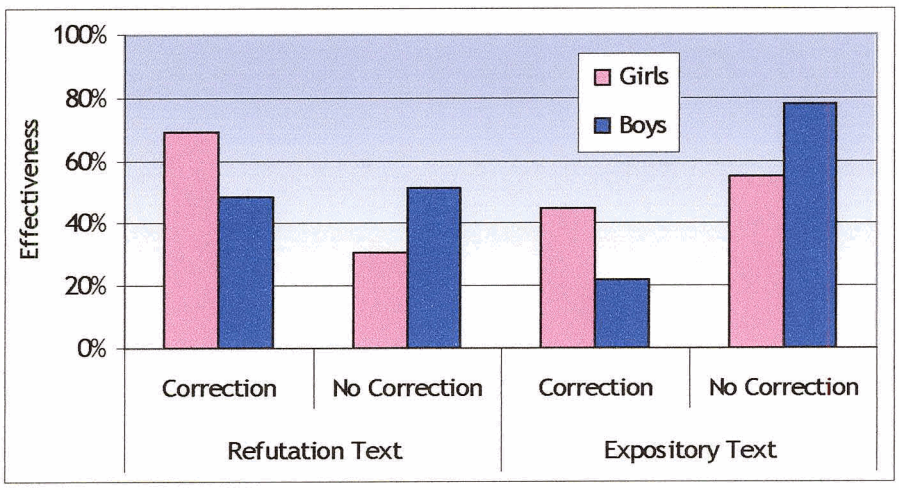

Figure 36. The percent of students experiencing corrections of misconceptions as a function of gender.

It is clear from Figure 36 that the refutation passages were more effective than the expository passages for both girls and boys. The percent effectiveness of the refutation passages was 69% for girls and 48% for boys, compared to the expository text passages effectiveness, which was 45% for girls and only 22% for boys.

Further, both refutation text passages and expository text passages were more effective for girls than for boys. For girls, refutation text passages were effective in 69% of the cases, while for boys, refutation text passages were effective 48% of the time. Girls who read expository text passages had the target misconception corrected 45% of the time, while boys who read expository text passages had the target misconception corrected in only 22% of the cases. I hypothesized that this lack of efficacy for boys could be related to an overall lower reading comprehension score for the boys in this study, since studies have shown that boys tend to be less proficient readers than girls (e.g., Coles & Hall, 2002; Gambell & Hunter, 2000), and the analysis of the effect of reading comprehension ability indicated that refutation text was not as effective for students with a low reading comprehension ability as it was for students with medium or high reading ability.

To test this hypothesis, I calculated the gender composition of the four reading grade intervals that were based on the results of the Reading Comprehension subtest of the *CTBS* (i.e., as shown in Figure 26). Figure 37 shows the number of boys and girls at each of the four reading grade intervals that were developed for the participants as a whole. Regrettably, the total

number of participants was too small to allow an examination of the data by grade level.

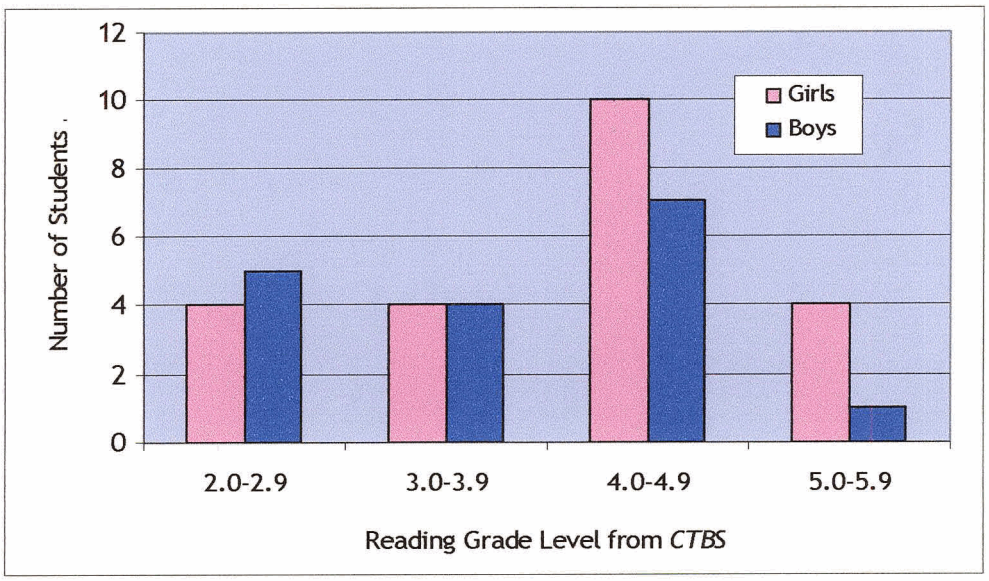

Figure 37. Distribution of girls and boys in reading grade intervals (RGI) based on *CTBS* scores.

The gender distribution is slightly skewed: there are three more girls than boys in reading grade interval Grade 5.0 to 5.9; three more girls in RGI 4.0 to 4.9; an equal number of boys and girls in RGI 3.0 to 3.9; and one less girl in RGI 2.0 to 2.9. However, the numbers of participants in each of the four groups are too small to make a meaningful comparison. Unfortunately, the thesis study did not provide enough information to speculate on the lack of efficacy of both refutation text and expository text passages for boys in Grades 3 and 4.

Qualitative Data

All of the previous analyses in this chapter have been based on quantitative data. However, I also collected qualitative data during the thesis

study: the qualitative data were generated by member checks, as described in Chapter 3; semi-structured interviews with individual participants; and large group discussions that took place during the culminating activity. I followed the open coding procedure previously described in Chapter 3 to analyze the data generated during the semi-structured interviews, and in the following sections, I present and interpret the interview data.

Results of the Semi-Structured Interviews

The semi-structured interviews that I conducted with 21 participants yielded some interesting insights about refutation text. Student responses about preference for text passage format and content allowed an exploration of these two textual characteristics, as well as an exploration of the impact of reader preference on text passage effectiveness. The semi-structured interviews also yielded some more general comments from the students about refutation and expository text passages.

Preference for Text Passages

During the semi-structured interviews, students were asked which text passage they enjoyed reading the most. The responses to this question provided the data for an analysis of student preference for text passage structure and content. The data also permitted an exploration of the impact of student preference for a particular text passage on the effectiveness of that passage in correcting the misconception held by the student.

Structure of preferred passages.

In other refutation text studies, students have indicated a preference for

the refutation text structure. Guzzetti et al. (1997) and Hynd (2001) found that high school students preferred refutation texts to other kinds of text such as traditional expository text. Figure 38 shows the text structure preferences of the 21 students who participated in individual interviews during the thesis study.

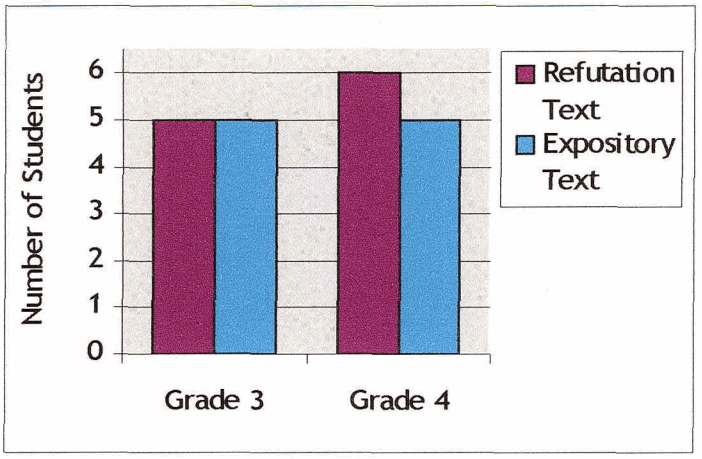

Figure 38. Student preference for text type.

In contrast to the earlier studies cited above, the interviewees in this study showed no marked preference for format, with almost equal numbers of students selecting an expository text passage or a refutation text passage as their preferred passage. The lack of preference for a particular format may be related to the difference in participant grade level, because the earlier studies were focused on high school students. The lack of preference may also be related to reader interest in the content of particular passage topics, which I discuss in the following section.

Content of preferred passages.

As I conducted the semi-structured interviews, I noted that several

students indicated that they preferred a text passage that contained information about a topic that they liked or in which they were interested. During my analysis of the interview data, I decided to code student responses as to why they liked particular passages, as the results would provide the basis for an exploration of the participants' reading preferences.

Of the 21 students who participated in a brief individual interview, 18 students gave reasons for selecting their favorite passages that could be described by two distinct categories of responses. Students chose particular paragraphs as their favorites either because the passage contained new information or because the passage topic was likeable. One student selected her favorite passage because it was funny, while two students were unable to articulate the reasons for their preferences. The number of responses in each category is shown in Figure 39.

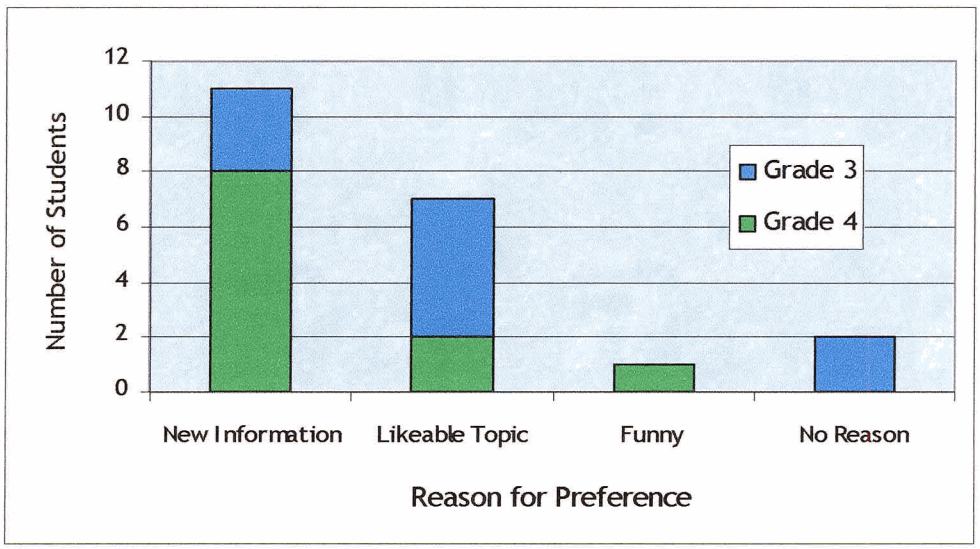

Figure 39. Student reasons for selecting a passage as their favorite.

The 11 responses that were coded as *new information* included:

Carl (Gr. 3): *I didn't know very much about it.*

Debbie (Gr. 4): *I thought they* [ostriches] *would stick their heads underneath the sand but they don't.*

Edward (Gr. 4): *It tells me stuff I don't know.*

Felicity (Gr. 4): *Not many people think that deserts have mountains and water and rocks and stuff.*

The 7 responses that were coded as *likeable topic* included:

Graham (Gr. 3): *I've always liked spiders a lot.*

Helen (Gr. 3): *The ostrich is one of my favorite animals.*

Based on my observations during the interviews, I anticipated that many students would prefer a passage because it was written about a likeable topic. However, I had not foreseen that the majority of students would prefer passages because the passages contained new information. I found this insight into student preference for reading material rather unexpected. As a classroom teacher, I do not always have the opportunity to discover the reasons for my students' selection of their own reading material, with the exception of their interest in a topic or character, or their familiarity with an author or series.

Relationship between student preference and effectiveness.

During the coding process, I began to question the effectiveness of preferred text passages. Would the particular passage, regardless of text type, that was preferred by a student be more effective at correcting the student's misconceptions than other passages that were not as well-liked? In an attempt

to identify and examine a possible relationship between a passage being preferred and its effectiveness, I created the graph shown in Figure 40.

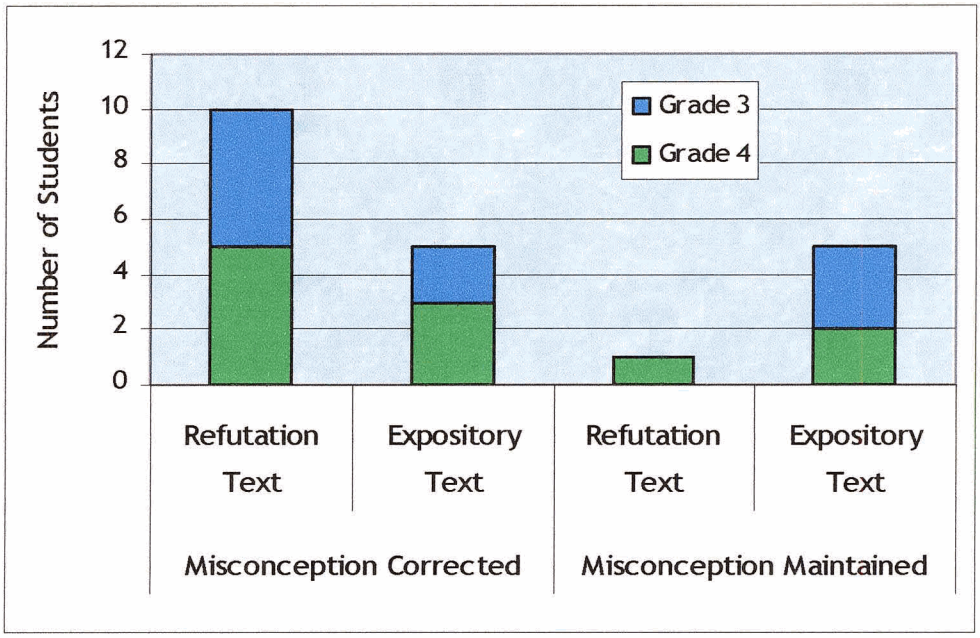

Figure 40. The effectiveness of students' preferred text passages.

Preferred refutation text passages and preferred expository text passages both resulted in a higher percentage of misconception corrections than would be predicted by the overall analysis of text type. The preferred refutation text passages were effective in 10 out of 11 cases (91%), compared to 44 out of 73 cases (60%) in the overall analysis, while the preferred expository text passages were effective in 5 out of 10 cases (50%), compared to 26 out of 74 cases (35%) in the overall analysis. It appears that if a student preferred a particular text passage, whether because they liked the topic or because they found the new information interesting, that passage was more likely to result in the correction of a misconception.

Student Comments about Text Passages

Students were often quite articulate when asked if they had learned anything new from the passages that they had read, and during the 21 individual interviews, there were 33 occasions when students described new information that they had acquired. There were 26 instances (79%) when students referred to learning information about the target misconceptions, and 7 instances (21%) when students learned information unrelated to the target misconception. Nineteen of the 26 instances when students referred to information relating to a target misconception (74%) involved a refutation text passage that the student had read, while 7 of the instances (26%) involved an expository text passage. Although the results are limited by the small number of participants, they indicate that the interviewees were more likely to be aware of learning from a refutation text passage than of learning from an expository text passage.

When describing what they had learned from the text passages, 12 of the 19 students who referred to a refutation text (63%) mentioned their previous belief, and compared it with the new information provided by the text passage. These responses included:

Ian (Gr. 3): *I used to think when ostriches were afraid they put their heads in the ground, but they don't.*

Jenny (Gr. 3): *I used to think they stored water in their humps.*

Kevin (Gr. 3): *I thought they put their heads in the sand. They stretch their heads out.*

Lily (Gr. 4): *I used to think the sun was closer in the summer.*

It's amazing because the sun is further away.

Michael (Gr. 4): *I learned that octopuses don't attack divers. I always thought they did, but I was wrong.*

Another seven students (37%) said that they had learned something from a refutation text passage, but merely stated the new information.

In contrast, only 7 of the 21 interviewees (33%) referred to learning something from an expository text passage. Of these seven participants, two students mentioned their previous belief while five students merely stated the new information. Responses in this category included:

Nancy (Gr. 3): *It's interesting that an octopus doesn't hunt for its prey.*

Oscar (Gr. 4): *Ostriches just hide their head* [sic] *on the ground.*

It appears that interviewees who read refutation text passages were more likely to mention their previous, incorrect, beliefs and state the correct information while interviewees who read expository text passages were more likely to simply state the correct information. Students who referred to learning information from expository text passages were also likely to have gleaned information unrelated to a target misconception. Seven students, describing what they learned from expository text passages, focused on factual information other than the target misconception. Responses of this nature included:

Penny (Gr. 4): *I didn't know there were 34,000 kinds of spiders.*

Quinn (Gr. 3): *I didn't know that they* [gorillas] *weighed that much.*

Of the 21 interviewees, 14 were also able to pinpoint the sentences in a refutation text that made them think differently about a topic, including Rachel (Gr. 4), who said, "*Now I know that camels don't store water in their humps. It* [pointing at a sentence in the refutation text passage] *told you they don't and instead they store fat.*" When asked which paragraph he enjoyed reading the most, Steven (Gr. 3) replied: "*The one about ostriches because I learned that ostriches don't stick their head* [sic] *in the sand.*" He added that he changed his mind about his original belief (that an ostrich would hide its head in the ground) "*when it* [pointing at a sentence in the refutation text passage] *said they couldn't breathe.*"

Misconceptions and Resistance to Change

Although it is evident from the results of the posttest and the delayed posttest that the target misconceptions in the thesis study were resistant to change, the data do not permit an exploration of the reasons for that resistance. However, the individual interviews provided some insights into the robustness of misconceptions. Although several students said that they learned something new from a passage, they still maintained their misconceptions, according to the results of the posttests. Trevor (Gr. 4), who most enjoyed reading the refutation text passage about seasons, gave as his reason "*it's amazing because the sun is farther away when it's summer,*" yet his answer on the posttest indicated that he still believed that the Earth was

closer to the sun during the summer. That misconceptions are resistant to change was also evidenced by the student who still believed that spiders are insects, despite having completed a unit on spiders in the classroom and reading an expository text passage based on that misconception during the implementation phase of the study.

Results of the Culminating Activity

For the culminating activity, each student received a booklet in which each page contained the two text passages for a target misconception as well as a picture or illustration (see Appendix E). I read the booklet aloud, pausing between pages while students made notes about the similarities and differences that they noticed. After reading the booklet aloud, I began a discussion about elements in the text passage pairs that were the same or different. In all three implementation groups, students focused on details that were the same, rather than noticing those details that were different. After I pointed out that one of the paragraphs contained information that many people believed to be true although the information was actually incorrect, the majority of the students in all three implementation groups were able to identify both the paragraph and the incorrect information. I believe that the ability of participants to identify the textual cues contained in the text passages speaks to the importance of explicitly teaching text structure as a comprehension strategy.

The notes that participants made prior to the discussion also showed the children's emphasis on similarities. Only Ursula, a Grade 4 student with high

reading comprehension ability, attempted to list differences between the text passage pairs. She noted five points that she thought were different, and of these five, two could be construed as relating to the eight commonly held misconceptions that were the topics of the text passages. These two points were: *bats attacking people*; *an ostrich putting it's* [sic] *head in the ground.*

The culminating activity was somewhat disappointing, from a research perspective, since I was unable to gather much new information about the text passages types. However, from an educational perspective, the culminating activity was successful because it allowed both participants and nonparticipants to access and to discuss the information that was contained in all the text passages that were used in the thesis study.

Summary

In this chapter I presented and interpreted the quantitative and qualitative data that I collected during the thesis study. I described the original data set, its revision, and the subsequent revised data set. I used the revised data set to conduct several analyses, beginning with the immediate and delayed effects of text type. Refutation text passages were significantly more effective than expository text passages when used as a strategy for correcting the misconceptions of students in Grades 3 and 4. The immediate effectiveness of refutation text did not appear to depend on the grade level of the reader, while the effectiveness of expository text was directly related to the grade level of the reader. Then, I discussed the delayed effectiveness of text type. Although corrections that occurred as a result of reading a refutation text

passage appeared more likely than corrections that occurred as a result of reading an expository text passage to be maintained six weeks later, the differences were not significant. I continued with a section on partial corrections, in which I noted that refutation text passages were less likely to result in readers being unsure about the passage topic.

Next, I explored the factors that may have contributed to the effectiveness of the text passages, including reading comprehension ability, gender, textual characteristics, and reader preference for text type. Refutation text passages were more effective than expository text passages for students of all levels of reading comprehension ability, with the exception of Grade 3 students with medium reading comprehension ability. In that instance, both text types were almost equally effective. Both refutation text and expository text passages were more effective for girls than for boys. The textual characteristics of readability level, number of words, and number of syllables did not appear to correlate with the effectiveness of the text passages, perhaps because I had written the text passages in an effort to minimize those characteristics. While the participants in this study did not prefer refutation text passages to expository text passages, the particular passage that they did prefer was more likely to lead to the correction of the topic misconception.

In summary, the results of the thesis study indicate that students in Grades 3 and 4 who read a refutation text passage were more likely to have their misconceptions corrected than if they read an expository text passage.

After six weeks, the corrections that resulted from reading a refutation text passage were more likely to be maintained than the corrections that resulted from reading an expository text passage. Factors that appeared to influence the effectiveness of the text passages in this study included reading comprehension ability and gender of the student, as well as student preference for a particular passage. Although the study was conducted at a single school and with a small group of participants, the results warrant further research on the use of refutation text for students in Grades 3 and 4.

CHAPTER 5

CONCLUSION

In this chapter, I provide a brief overview of the thesis study, summarize the results that were presented in Chapter 4, and compare those results to the results of previous refutation text studies. Next, I review the conditions for conceptual change, which were presented in Chapter 2, and discuss ways in which refutation text meets those conditions. I discuss the general limitations, listed in Chapter 1, within the context of the thesis study; I also include three further limitations that are specific to this study. Following recommendations for future research in the area of refutation text is a discussion of the educational implications that arise from this study, as well as from previous studies.

The Thesis Study: An Overview

The purpose of the thesis study was to investigate the appropriateness and effectiveness of using refutation text as a strategy for correcting misconceptions held by students in Grades 3 and 4. I explored the relationships between text passage effectiveness and textual factors such as readability level and topic. As well, I examined the influence of reader characteristics such as reading comprehension ability and gender upon text passage effectiveness.

The theoretical framework for the thesis study was grounded in constructivist theory and was supplemented by models of conceptual change and an interactive-constructive model of reading in science. The research design for the study was mixed methods in which qualitative approaches were

embedded in a quasi-experimental approach. The 40 study participants were Grades 3 and 4 students from an economically and ethnically diverse Victoria school.

I prepared a set of eight refutation text passages with eight corresponding expository text passages based on the target misconceptions previously shown in Table 8. I calculated the readability levels of the text passages using the Dale-Chall formula (Dale & Chall, 1948a) and Fry's Readability Graph (Fry, 2002). The 16 text passages and their readability levels are shown in Appendix B.

The materials for the thesis study consisted of the 16 text passages; a researcher-developed pretest, posttest, and delayed posttest; the Reading Comprehension subtest of the *CTBS*, which is a standardized measure; and a semi-structured interview guide. I visited the research site on five separate occasions during a three month period. The purpose of my initial visit was to explain my study and to distribute consent forms, and during the four subsequent visits, I administered the pretest and the *CTBS* subtest, facilitated the intervention, administered the immediate and delayed posttests, and conducted the culminating activity.

I gathered both quantitative and qualitative data during the course of the study. I presented and interpreted the data in Chapter 4, frequently relying upon tabular and graphical representations. Where appropriate, I used the Chi-square method of analysis to determine the statistical significance of the results. I followed an open coding procedure to analyze the qualitative data.

Summary of Results

The results indicate that for the 18 students in Grade 3 and the 22 students in Grade 4 who participated in the thesis study, the use of refutation text passage was an appropriate and effective strategy for correcting misconceptions. Previous refutation text research has indicated that refutation text is appropriate and effective for students from Grades 5 through 12, while results for students at college and university have been less conclusive (e.g., Guzzetti, 2000; Hynd & Alvermann, 1986a).

In this study, refutation text passages were significantly more likely than traditional expository text passages to result in the immediate correction of a target misconception held by the participants in Grades 3 and 4. Again, these findings are in agreement with previous refutation text research conducted with students in Grades 5 through 12 (e.g., Dole, 2000; Hynd et al., 1994; Maria & MacGinitie, 1987; Yuruk & Geban, 2001).

The results of the thesis study indicate that the immediate effectiveness of refutation text did not appear to depend on the grade level of the reader, while the immediate effectiveness of expository text was directly related to the grade level of the reader, with 30% effectiveness for Grade 3 students and 39% effectiveness for Grade 4 students. Previous research has not been aimed at evaluating the relationships between text type, text effectiveness, and grade level. Therefore, it is unclear whether these results are typical.

I found that the corrections of misconceptions were more likely to be maintained after six weeks if they resulted from reading a refutation text

passage rather than from reading a traditional expository text passage, again regardless of grade level, although the differences were not significant according to a X^2 analysis. The lack of significance may be due to the small number of participants in the thesis study, since previous research has indicated that reading refutation text is significantly more likely than reading expository text to result in maintained corrections (e.g., Guzzetti et al., 1993; Hynd et al., 1994; Maria & Johnson, 1989).

In this study, refutation text passages were less likely to result in readers becoming unsure about the passage topic, and refutation text passages were more effective than expository text passages for Grades 3 and 4 students at most levels of reading comprehension ability, as determined by *CTBS* scores, with the exception of Grade 3 students with medium reading comprehension ability. In that instance, both text types were almost equally effective. However, the possible relationship between text type, text effectiveness, and reading comprehension ability has not been previously explored in the refutation text literature.

The textual characteristics of readability level, number of words, and number of syllables did not appear to correlate with the effectiveness of the text passages, perhaps because the text passages were written with the aim of minimizing differences between those characteristics in various passages. Once again, these relationships have not been explored in previous refutation text research.

Two patterns became evident during my exploration of the relationship between reading comprehension ability of the reader, as indicated by the *CTBS*, and effectiveness of text passages. First, for 9 out of 10 comparison groups (students in the 4 reading group intervals, or RGI, and students in each grade with high, medium, and low comprehension ability) refutation text passages were more effective than expository text passages. The exception was the group of Grade 3 students with medium reading comprehension ability, for whom refutation text passages were effective 40% of the time and expository text passages were effective 45% of the time. Second, there was a general trend in which the effectiveness of the text passages tended to increase as the reading comprehension ability of the comparison group increased. This trend was apparent for both refutation text passages and expository text passages.

In this study, both refutation text and expository text passages were more effective for girls than for boys. This finding is in accord with the well-supported belief that girls tend to be more proficient readers than boys (e.g., Coles & Hall, 2002; Gambell & Hunter; 2000, Simpson, 1996). However, the finding is in contradiction to my hypothesis that boys would have more success with refutation text and traditional expository text because of their preference for informational texts (Gambell & Hunter).

The Grades 3 and 4 participants in this study did not prefer refutation text passages to expository text passages, although previous studies conducted with high school participants have indicated a definite preference for refutation text (Guzzetti et al., 1997; Hynd, 2001). However, the particular

passage that was preferred by those students who were interviewed was more likely to result in a correction of the topic misconception than would be expected based upon the overall effectiveness of text type indicated by the thesis study. While Dole and Niederhauser (1990) investigated the relationship between degree of commitment to misconceptions and likelihood of conceptual change, and Harp and Mayer (1997) explored the role of reader interest in learning from scientific text, previous refutation text studies have not specifically focused on the relationship between student preference and text effectiveness.

The results of the thesis study indicate that the use of refutation text is an appropriate and effective strategy for correcting the misconceptions that are held by students in Grades 3 and 4. Additionally, it appears that refutation text may be even more effective than the traditional expository text more often used in textbooks and tradebooks. The power of refutation text may lie in its ability to meet the conditions required for conceptual change, and the correction of misconceptions is a process of conceptual change.

Refutation Text and the Conditions for Conceptual Change

As I described in Chapter 2, conceptual change is a complex process that occurs as a result of the interaction of a number of factors. These factors, or conditions for conceptual change, include characteristics of an individual's prior knowledge and of the new information, as well as motivational factors (Chinn & Brewer, 1993; Pintrich et al., 1993; Posner et al., 1982). An individual's prior knowledge must appear inadequate and the new information

must be intelligible, plausible, and fruitful if conceptual change is to occur; the motivational factors of goals, values, and personal interest also affect the likelihood of conceptual change. The results of the thesis study indicate that refutation text may be more likely than traditional expository text to provide some of these conditions for conceptual change.

Because refutation text explicitly states a misconception and then refutes it, readers of refutation text who hold that misconception are more likely than readers of traditional expository text to recognize that their prior knowledge is incorrect or inadequate. A well-written refutation text passage will present new information in a manner that is understandable, credible, and useful. Although the same can be said for well-written expository text, a traditional expository text passage does not provide the reader with explicit notice that a currently held belief is incorrect. If a reader does not recognize that a current belief is incorrect, there is little motivation to change that belief. In addition, readers rely on textual cues to help them identify and attend to important information contained in a text passage. Refutation text, by its very nature, contains a cue which alerts readers to the presence of anomalous information. Of course, both textual cues and text structure need to be explicitly taught as comprehension strategies (Duke & Pearson, 2002).

According to Dole and Sinatra (1994), the element of motivation can be enhanced by an expert source, by an easily understood message, or by an enjoyable situational context. Refutation text can be viewed as an expert source, since both sides of an issue are presented, whereas traditional

expository text presents only one side of an issue. The fact that both correct and incorrect information are contained in a text passage gives rise to the persuasive characteristics that are inherent in the refutation text structure (Hynd, 2001).

Refutation text may provide readers with the comfort of realizing that they were not alone in their incorrect thinking, since misconceptions are presented as being incorrect beliefs that many people hold. Thus, there is an affective aspect to refutation text. Further, conceptual change occurs when anomalous information is presented in a believable or plausible manner (Chinn & Brewer, 1993), and the explicit reference to a misconception in refutation text may cause readers to find the correct information more acceptable than information presented without consideration of alternate beliefs.

During the thesis study, I did not collect data pertaining to the presence or absence of the conditions for conceptual change. However, the effectiveness of refutation text passages as compared to the effectiveness of expository text passages, indicated by the results of the study, points to the power of refutation text in providing at least some of the conditions required for conceptual change to occur.

Limitations of the Study

Although the results of the thesis study indicate that refutation text may be more effective than traditional expository text when used as a strategy to correct the misconceptions of students in Grades 3 and 4, the findings are limited by a number of factors. First, research has shown that for conceptual

change to occur, concepts should be presented multiple times, in a variety of formats, and texts should be supplemented by demonstrations and discussions. In this study, concepts were presented a single time and because I wanted to conduct an in-depth investigation of refutation text rather than a broad exploration of refutation text in conjunction with other strategies, refutation text was presented as an isolated strategy for promoting conceptual change. Additionally, the activities and texts that formed the basis of the thesis study were decontextualized: the study was conducted in a school at which I did not teach and the activities themselves were not connected to ongoing instruction in the participants' classrooms.

Second, because the study was conducted over a three month period, the corrections of the participants' misconceptions might have been due to factors other than the reading of refutation and expository text passages. The possibility that during the length of the study students may have received information about the eight target misconceptions from sources other than the study text passages is a concern. However, I asked the four classroom teachers of the study participants whether the target misconceptions topics had been covered during instruction. Only two of the text passage topics had been discussed, even briefly. The Grade 3 class had studied bats, but only one participant from this class read a passage about bats (it was an expository text passage and reading it resulted in a correction of the misconception that bats might try to nest in a person's hair). The Grade 3/4 class had studied spiders, but only one participant from this class read a passage about spiders (it was

also an expository text and reading it did not result in a correction of the misconception that spiders are insects). Although some students may have discovered information about the misconception topics outside of the classroom, the likelihood of a significant number doing so is small.

Third, I did not determine the robustness of participants' misconceptions, that is, how committed students were to their beliefs. This particular aspect of prior knowledge was beyond the scope of my study, although I recommend it as a possibility for future research.

Fourth, text passage pairs did not have identical readability levels, a limitation of previous refutation text studies (e.g., Maria & Johnson, 1989). However, I ensured that the readability level of the refutation text passage was equal to or greater than the readability level of the expository text passage. Thus, the higher frequency of correction of misconceptions associated with reading the refutation text passages is not attributable to a lower readability level of those passages.

Fifth, the researcher-designed pretest, posttest, and delayed posttest, while deemed appropriate and valid by my colleagues, could have been developed to allow a check for content validity as well as criterion-related validity (Isaac & Michael, 1997). For example, a more rigorous test would contain more than one question related to each target misconception, which would permit a statistical analysis, such as Cronbach's α, of the robustness of the test results.

Finally, the small number of study participants meant that some of the target misconceptions were held by a limited number of students, particularly the misconceptions about spiders and bats. I addressed this limitation by assigning text passages on those two topics to all students who held those target misconceptions. However, the small number of study participants and the lack of random selection of those participants mean that the generalizability of the study results is limited.

Despite these limitations, however, the results of the thesis study do indicate that the use of refutation text may be appropriate for students in Grades 3 and 4. Furthermore, results indicate that refutation text may be even more effective than traditional expository text in facilitating the correction of misconceptions held by students in Grades 3 and 4. Additional research is needed to verify the results of this study, and there are a number of other aspects of refutation text which also could be investigated.

Recommendations for Future Research

The results of the thesis study, in spite of the limitations identified above, indicate the need for additional, more comprehensive investigation of the use of refutation text with students in Grades 3 and 4. In addition, additional research could be conducted with older participants, since a review of the refutation text literature revealed a lack of replication studies in a number of areas. Future research could investigate a number of text-related issues, including the use of pictures to accompany text passages, the most effective genre and format of refutation text and the most effective location of

the refutation in the text passage, as well as the impact of readability level or concept loading of the text passage.

Paivio's dual coding theory states that concept learning is more effective when information is presented in verbal and non-verbal formats (Paivio, 1991). Mayer, Bove, Bryman, Mars, and Tapango (1996) found that students learned more from a summary consisting of a combination of text and illustration than from a summary consisting only of text or of illustration. Thus, it is reasonable to expect that refutation text in combination with pictures will be even more likely to produce conceptual change than refutation text alone. Studies with participants at a variety of grade levels are needed to determine if this expectation is justified, or if it is justified for particular grade levels or genders or ability levels of participants.

Both the genre and format of refutation text that will be most effective at promoting conceptual change need to be investigated. It has been suggested that soft expository or narrative refutation text might be more effective than expository refutation text for students in lower intermediate grades, although results from the only study conducted at the primary level did not support this suggestion (Maria & Johnson, 1989; Mayer, 1995). A refutation can be contained in text as well as in cartoon or video format, and more research on the most effective format of refutation text is needed at all grade levels.

The most effective location of the refuting statement in a refutation text passage has not been fully explored. The refuting statement can be located at the beginning, middle, or end of that text passage, and only one

study has attempted to determine the most effective location (Maria & MacGinitie, 1987). Additionally, the most effective location of the refutation might vary according to grade level or reading ability of the students. Future research could also focus on the reader, examining preference for format, the level of commitment to prior knowledge, the degree of interest in a topic, or the extent to which conceptual change occurs when a text passage is read.

Text-based factors in the effectiveness of refutation text, such as readability level or the number of concepts contained in a passage, could be further explored. As previously mentioned, few published refutation text studies contain information about text readability. The relationship between the concept density of a text passage and its effectiveness could be investigated using T-units (Hunt, 1965), a method of analysis that was beyond the scope of my study.

Reader-based factors such as student preference for genre or format could be explored with the use of qualitative research techniques such as interviewing and audio- or videotaping followed by open coding, and in fact, could be combined with the exploration of the most effective genre and format for various grade levels. Results of the thesis study indicate that student preference may be a factor in the effectiveness of particular text passages.

A reader's level of commitment to a misconception and the reader's interest in the topic might be factors in the efficacy of a refutation text passage, and I recommend research that builds upon the study conducted by

Dole and Niederhauser (1990), which indicated that the level of commitment was not a factor in the occurrence of conceptual change for students in Grade 6. Dole and Niederhauser suggested that the degree of interest in a topic might be a stronger indicator of conceptual change. Further research could more fully explore these two reader-based factors at all grade levels.

Because of the complexity of the process of conceptual change, further research involving the degree of conceptual change that is brought about through the use of refutation text is also recommended. Even if misconceptions are not corrected, perhaps the use of refutation text can inititate the process of conceptual change as readers experience cognitive dissonance, and the extent to which the change occurs could have implications for educators.

Finally, I suggest that further research in the area of refutation text be conducted using a combination of quantitative and qualitative data. Such studies would be neither nomothetic or idiographic, as defined by Wandersee et al. (1994), but rather a blend of the two approaches, and the use of qualitative techniques would allow further exploration of issues such as student preference for text structure and format. A mixed methods approach could also facilitate increased depth or breadth of future research.

Implications for Educators

The term 'refutation text' has tended to elicit puzzled looks from my fellow graduate students as well as from my colleagues. I suspect that the majority of educators at all grade levels are unaware of the existence of refutation text and its powerful ability to correct misconceptions. However,

the findings presented in the previous chapter, combined with the results of previous refutation text research, yield a number of implications for educators. In this section I discuss six key implications that are connected to explicit instruction, identification of misconceptions, critical literacy, book selection, multiple presentations of concepts, and the dissemination of refutation text research.

The first key implication that arises from the results of this study relates to explicit instruction. It is often recommended that students receive explicit instruction about a variety of genres, such as narrative or expository, and a variety of text structures, such as cause and effect or compare and contrast (e.g., Duke & Pearson, 2002; Moss, 2003). In fact, Duke and Pearson include text structure in their discussion of six effective comprehension strategies that they believe should be explained, modeled, and emphasized for students. Because the participants in this study were able to identify both the refutation text passage and the refuting statement once I had discussed the characteristic features with them, I suggest that students should also receive explicit instruction about the refutation text structure. In fact, instruction about refutation text would be appropriate during instruction about other text structures found in informational texts. Although currently the refutation text format is not widely used, the ability to recognize signal words, such as *however* which is frequently used as a transition in refutation text, would be an asset when reading a variety of text structures and genres.

The second key implication arises from the requirement that, for conceptual change to occur, students must be persuaded that their current conceptions are inaccurate (Chinn & Brewer, 1993). Therefore, children's prior knowledge should be accessed so that misconceptions can be identified before an attempt is made to teach new material and classroom activities can be designed to address those misconceptions. A number of teaching strategies can be used to elicit student misconceptions, including prediction guides, Think Sheets, KWL, two-tier tests, and class discussions. Alvermann et al. (1985) suggest using prediction guides, also known as anticipation guides, which contain a number of statements based on the topic to be read. Students decide whether the statements are true or false, and then as they read, they compare their answers to the information contained in the text. Think Sheets are pages on which students record their ideas and beliefs in one column, the ideas from the book being read in a second column, and similarities or inconsistencies between these two columns in a third column (Dole, 2000). KWL is another three-column strategy in which the first column contains what is known or thought to be known about the topic (K), the second column contains what is wondered (W), and after instruction, the third column contains what was learned (L). A two-tier test consists of a series of two-level questions. The first tier assesses descriptive knowledge about a topic, while the second tier highlights the reasoning behind the answers given in the first tier (Tsai & Chou, 2002). A class discussion is one of the simplest techniques for eliciting student

misconceptions and requires minimal preparation, although the teacher must utilize careful questioning to obtain clear ideas of student misconceptions.

The third key implication involves the need for students and educators to develop their critical literacy skills. While critical literacy is often considered important when students access information on the internet, it is also necessary that readers of textbooks and tradebooks are aware that inaccuracies and misconceptions may be present in those sources as well. Teachers who encounter misconceptions in information text or in narrative text can use those misconceptions to develop a lesson on critical literacy.

The fourth key implication is that books used in the classroom should be selected carefully by the teacher or teacher-librarian. Textbooks and tradebooks are the most common element of science programs. If possible, books chosen for classroom use should contain some refutation text, although it would be difficult to include all misconceptions about a particular topic and refutations of those misconceptions in a single book. Indeed, refutation text and conceptual change text might need to be used sparingly, since as Chambers and Andre (1997, p. 119) suggest, students might become so used to these features that the features would in turn become ineffective. However, a book that includes some refutation text is more likely to effectively correct misconceptions and promote conceptual change. Unfortunately there is a lack of educator awareness of the power of refutation text and its appropriateness for use as a comprehension strategy. Further, as I discuss in the sixth

implication, results of refutation text research have been poorly communicated to educators.

The fifth key implication arising from the thesis study is that concepts should be presented a number of times and in a variety of formats, an implication that echoes the recommendations of Chinn and Brewer (1993) and of Hynd (2001). Students' background knowledge may be incorrect, and misconceptions are highly resistant to change: one participant in the thesis study learned about spiders with the classroom teacher, read an expository passage about spiders, and still believed that spiders were insects. As well, conceptual change may occur in a saw-tooth pattern (Shymansky et al., 1997), which suggests that misconceptions are modified frequently before becoming entirely corrected. Thus, every time a concept is presented there is a further opportunity for a misconception to be modified. Additionally, text alone, even if it is refutation text, is not enough to cause conceptual change for all students. According to Guzzetti (2000), although refutation text appears effective for groups of students on average, it needs to be supplemented for some individuals, particularly those students with ineffective reading strategies. Refutation text used in conjunction with other types of text, or with videos, hands-on experiments, and other activities, increases the likelihood of conceptual change. In my study, however, I focused on the use of refutation text in isolation, as I was interested in depth rather than breadth of information.

The sixth key implication is related to the effective dissemination of the results of refutation text research. As previously discussed, although it would be difficult to include refutation passages for all misconceptions about a particular topic in a single book, the inclusion of some refutation text means a book will likely be more effective in correcting misconceptions and causing conceptual change. Unfortunately, few tradebooks or textbooks contain refutation text. The results of refutation text research need to be communicated to the publishers, editors, and authors of children's books, so that refutation text becomes more widely available to educators, who also need to be made aware of the highly specialized structure of refutation text.

Concluding Remarks

This thesis study helps to fill a gap in the body of refutation text research. Few published studies have compared the use of refutation text and the use of traditional expository text as a strategy for promoting conceptual change for students in grades lower than Grade 6. In fact, an extensive search resulted in only four studies with participants in Grades 5 and below. Those four refutation text studies had participants who were: (a) a mixed group of gifted Grades 5 and 7 students (Maria & Johnson, 1989); (b) a group of Grade 6 students (Diakidoy et al., 2002); (c) a mixed group of Grades 5 and 6 students (Maria & MacGinitie, 1987); and (d) a mixed group comprised of four students at each level from Kindergarten to Grade 3 (Mayer, 1995). A recent study compared the use of conceptual change text with traditional expository text for students in Grade 5 (Mikkilä-Erdman, 2001). However, no published study

has focused on the use of refutation text as a conceptual change strategy for students in Grades 3 or 4.

As well as providing data on previously unresearched grade levels of study participants, this thesis study provides a Canadian context for refutation text studies. To date, despite international interest in refutation text and conceptual change text, there have been no published refutation text studies undertaken in a Canadian setting.

While print texts, especially textbooks, are often viewed negatively by both teachers and students, these texts are the dominant method of science instruction (Freeman & Person, 1998; Newton et al., 2002; Yore et al., 1998). If refutation text is indeed more likely than traditional expository text to lead to the correction of misconceptions, it could (and should) be included in both tradebooks and text books. Unfortunately, when I attempted to improve my own classroom library by adding books containing refutation text, I discovered very few books that had even small amounts of refutation text. Additionally, few educators are familiar with refutation text. The results of refutation text studies need to be communicated to the publishers, editors, and authors of children's books, as well as to educators, so that refutation text can be more widely used as a powerful strategy for facilitating conceptual change.

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Appendix A

Parental and Student Consent Forms

Parent Consent Form

Your child is being invited to participate in a study, entitled Conceptual Change: The Power of Refutation Text, *that is being conducted by Chris Tippett. Miss Tippett is a graduate student in the Faculty of Education at the University of Victoria and she has previously taught at Richmond Elementary. You may contact her at 480-0923 or at ctippett@uvic.ca if you have further questions about the study.*

As a graduate student, Miss Tippett is required to conduct this research as part of the requirements for a Master's degree in Education. It is being conducted under the supervision of Dr. Sylvia Pantaleo, who can be contacted at 721-7845 or at pantaleo@uvic.ca.

In addition to being able to contact the researcher and the supervisor at the above phone numbers, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria (250-472-4362).

Conceptual Change: The Power of Refutation Text

The focus of my research is refutation text, which is a specialized form of expository text. Although previous studies have shown that refutation text is more likely to promote conceptual change than regular expository text, those studies have been conducted with students in high school or upper intermediate grades. The purpose of my study is to determine if refutation text is an effective way to cause conceptual change for younger students, particularly students in Grades 3 and 4.

Research of this type is important because very few studies have looked at the use of refutation text with young readers. Results of this study will add to the body of refutation text research, and may help to persuade publishers of children's books that refutation text is an important text structure that should be included in non-fiction books.

All students in Grades 3 and 4 at Richmond Elementary have been asked to participate in this study to ensure representation of students of varying abilities.

If your child agrees to voluntarily participate in this research, then his/her participation will include 5 different whole-class activities: (a) a standardized reading assessment, such as the Canadian Test of Basic Skills which is currently in use at Richmond Elementary; (b) a pretest; (c) a reading activity combined with an immediate post-test; (d) a delayed post-test; and (e) a culminating activity, where all students receive a booklet containing all text passages used in the study. A small number of students will be asked to participate in a 10 minute interview about their preferences for the different text passages. These

activities will take place over a 3 month period, with specific dates and times to be arranged with your child's classroom teacher. The activities will take place during regularly scheduled Language Arts or Science periods, again at the discretion of the classroom teacher. The total amount of time required to participate in this study will be less than 3 ½ hours.

There are no anticipated or known inconveniences or risks to your child that would result from participating in this research. Classroom teachers will not know which students are participating in this study.

The potential benefits of participation in this study include the possibility that the results will add to the body of refutation text research. Additionally, your child will have the opportunity to read text passages about a variety of science topics.

Your child's participation in this research must be completely voluntary. If your child decides to participate, he or she may withdraw at any time without any consequences or any explanation. At the beginning of each activity, I will remind students that they may withdraw from the study. If your child withdraws from the study, an unrelated activity will be substituted during the remaining activities, and any related data will not be used in the subsequent analysis. If your child decides not to participate in the study, he or she will remain in the classroom and work on activities that will not be used in the study.

Although your child's identity will be known to me, student results will be pooled and expressed as numbers or totals. If your child's work is referred to in any way, a pseudonym will be used to ensure complete anonymity in any report I may write about the study.

Your child's confidentiality and the confidentiality of the data will be protected. All data relating to this study will be kept in a locked filing cabinet for a period of two years following the completion of my thesis. At the end of that time, the data will be destroyed. I will be the only person who has access to the data.

This research may lead to an article that would be published in an education journal. A copy of the article will be supplied to you upon request. A summary report will also be available upon request. A copy of the thesis will be delivered to the district superintendent, the principal, and the classroom teachers. It is anticipated that the findings might also be shared with others through conference presentations and workshops.

If you have any questions or concerns, please contact my supervisor, Dr. Sylvia Pantaleo, at 721-7845 or pantaleo@uvic.ca. I can be contacted at 480-0923, or

at ctippett@uvic.ca. In addition, you may also contact the Associate Vice-President, Research, at 472-4362.

Thank you for your consideration,

Chris Tippett

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researcher.

Name of Participant: _____

_____	_____	_____
Name of Parent or Guardian	*Signature*	*Date*

A copy of this consent form will be given to you, and a copy will be kept by the researcher.

Student Consent Form

You are being invited to participate in a study, entitled Conceptual Change: The Power of Refutation Text, *that is being conducted by Chris Tippett. Miss Tippett is a graduate student in the Faculty of Education at the University of Victoria and she has previously taught at Richmond Elementary. If you have any questions about the study, please talk to your parents. They may know the answers, or they can contact me for further information.*

Conceptual Change: The Power of Refutation Text

The purpose of this study is to find out if some ways of explaining things in writing work better than others for students in Grades 3 and 4. This research is important because very few studies have looked at the use of refutation text with young readers. Results of this study may help to persuade publishers of children's books that refutation text is an important text structure that should be included in non-fiction books.

If you agree to voluntarily participate in this study, then you will take part in 5 different whole-class activities, including a standardized reading test, a pretest, a reading activity and an immediate post-test, a delayed post-test, and a final activity where all students receive a booklet containing all text passages used in the study. You may be interviewed about your preferences for the different text passages. The activities will take place over a 3 month period, and your teacher will decide on the dates and times. The entire study will take less than 3 ½ hours altogether.

All students in Grades 3 and 4 at Richmond Elementary have been asked to participate in this study. There are no anticipated or known inconveniences or risks that would result from participating in this study. The benefits include the possibility that the results will add to what researchers already know about the best ways to explain things in

writing. Also, you will have the opportunity to read about a variety of science topics.

Your participation in this research must be completely voluntary. If you decide to participate, you may withdraw at any time without any consequences or any explanation. At the beginning of each activity, I will remind you that you may withdraw from the study. If you withdraw from the study, an unrelated activity will be substituted during the remaining activities, and any related data will not be used in the final analysis. If you decide not to participate in the study, you will remain in the classroom and work on activities that will not be used in the study.

Although I will know who you are, all results will be added together and shown as numbers. If I write about your work, your name will be changed to protect your identity in any report I may write about the study. Your teacher will not know who is participating in this study.

Your confidentiality (privacy) will be protected. All the information that I collect will be kept in a locked filing cabinet for two years after I finish my thesis. Then the information will be destroyed. I will be the only person who will see the information.

This research may lead to an article that would be published in a journal. A copy of the article will be supplied to you upon request. A copy of the thesis will be delivered to the district superintendent, the principal, and the classroom teachers. I may also present the results at meetings.

Thank you for your consideration,

Chris Tippett

Name of Participant	*Signature*	*Date*

A copy of this consent form will be given to you, and a copy will be kept by the researcher.

Appendix B

Text Passages and Readability Levels

Misconception: Deserts are flat and covered with sand.

Refutation passage

Most people think of deserts as flat, completely covered with sand, and without water. Not all of these ideas are correct. The largest desert in the world is a good example. This desert, the Sahara, is located in Africa. It is so dry that few plants can grow on it. But it has several mountains, and large areas are covered with rocks and boulders. (64 words)

Expository passage

A desert is a large dry area of land that has few trees. A desert is often very hot during the day. It can be quite cold at night. Because deserts have so little water, the plants that do grow do not cover the ground. Deserts may be rocky or sandy, and few animals are able to live in such dry, uninviting places. (64 words)

Table B1

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	4.9	6	5.4
Expository Text	4.3	6	5.2

Note. All results are grade levels.

Misconception: Ostriches bury their heads in the sand.

Refutation passage

Many people believe that an ostrich will bury its head in the sand when it is in danger. This is not true, however. If ostriches buried their heads, they would not be able to breathe! Ostrich chicks may hide from danger by lying with their necks stretched out along the ground. Adults may listen for sound with their heads near the ground, or they might run away. (67 words)

Expository passage

The ostrich is the largest bird in the world. Although it cannot fly, it can run very fast - up to 65 kilometers per hour! If an adult ostrich is frightened, it might run away. It might listen for sound with its head near the ground. If a chick is in danger, it might try to hide by lying on the ground with its neck stretched out. (66 words)

Table B2

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	4.8	6	5.4
Expository Text	4.8	5	4.9

Note. All results are grade levels.

Misconception: It is summer in Canada when the Earth is closer to the sun.

Refutation passage

Some people believe that it is warmer in the summer because the Earth is closer to the sun, but this is not true. In Canada the Earth is actually closer to the sun when it is winter! The Earth's distance from the sun does not cause the seasons. It is the angle of the sun's rays. Summer occurs when the Earth is tilted towards the sun. (66 words)

Expository passage

There are four seasons - winter, spring, summer, and fall. Each season has its own weather and temperatures. These differences are because the angle of the sun's rays changes as the earth moves around the sun. In Canada, the earth is tilted towards the sun in the summer. The sun's rays shine from nearly overhead. This means more heat and longer hours of daylight. (63 words)

Table B3

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	4.8	6	5.4
Expository Text	4.7	6	5.4

Note. All results are grade levels.

Misconception: Camels store water in their humps.

Refutation passage

Some people believe that a camel stores water in its hump. They think that the hump gets smaller as the camel uses up water. But this idea is not true. The hump stores fat and grows smaller only if the camel has not eaten for a long time. A camel can also live for days without water because water is produced as the fat in its hump is used up. (69 words)

Expository passage

The camel lives in the deserts of Africa and Asia. It has long legs and wide feet that are good for walking in sand. Camels store fat in their humps, and this means that they can go for days without food. The hump gets smaller as the fat is used up. A camel can also go without much water because water is produced as its fat is used up. (69 words)

Table B4

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	4.1	6	5.1
Expository Text	4.2	5	4.6

Note. All results are grade levels.

Misconception: Octopuses will attack divers.

Refutation passage

Movies sometimes show octopuses attacking divers and squeezing them to death. However, if an octopus really saw a diver nearby, it would quickly swim away. Octopuses are actually quite timid. They do not often hunt for their food. They hide in holes or cracks and wait for their food to come near. They eat crabs, clams, and shrimp - not people! (60 words)

Expository passage

The octopus is a very timid animal. It hides in holes or cracks along the rocky ocean bottom. Octopuses eat shellfish, like crabs and clams. They do not usually hunt for their food. An octopus will hide and wait for its food to come near. The octopus has eight legs with rows of suckers, a sack-like head, and two beaks. (60 words)

Table B5

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	5.4	6	5.7
Expository Text	5.6	5	5.3

Note. All results are grade levels.

Misconception: Gorillas are omnivores.

Refutation passage

Gorillas live in tropical forests in Africa. The male gorilla is big and powerful and may weigh up to 220 kilograms (485 pounds). The gorilla's strong arms are longer than its legs. It is easy to imagine a gorilla hunting and eating other animals. However, gorillas really eat the leaves, stems, and shoots of plants. In fact, gorillas are quite timid. (61 words)

Expository passage

Gorillas are the largest members of the ape family. They live in tropical forests in Africa. Gorillas have black skin and hair, and their arms are longer than their legs. Male gorillas may weigh up to 220 kilograms (485 pounds). Gorillas are herbivores - they eat fruit as well as the leaves, stems, and shoots of plants. Although gorillas are very powerful, they are quite timid. (65 words)

Table B6

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	5.5	7	6.3
Expository Text	5.5	6	5.8

Note. All results are grade levels.

Misconception: Spiders are insects.

Refutation passage

Some people think that spiders are insects. However, this is not true. Spiders have eight legs while insects have six legs. Spiders have only two body parts - head and abdomen. They do not have a thorax like insects do. Spiders have spinnerets, which they use to spin webs to catch insects to eat. There are more than 34,000 kinds of spiders, including the tarantula. (64 words)

Expository passage

There are more than 34,000 kinds of spiders. The tarantula and the black widow are both spiders. Spiders have two body parts - a head and an abdomen. They do not have a thorax like insects do. Spiders have eight legs. They also have spinnerets, which they use for spinning webs. An insect that gets caught in the web will be eaten. (62 words)

Table B7

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	4.8	4	4.4
Expository Text	4.8	3	3.9

Note. All results are grade levels.

Misconception: Bats try to nest in peoples' hair.

Refutation passage

Some people are afraid that a bat will try to make a nest in their hair. However, most bats try to stay far away from human beings. Also, bats do not make nests. They like to roost upside down in barns, caves, or trees. Most bats eat fruit such as bananas and figs. Even vampire bats are not interested in nesting in people's hair. (64 words)

Expository passage

Bats can be found almost anywhere in the world. There are 40 different kinds of bats in North America alone. Vampire bats feed on cattle, but most other bats eat fruit such as bananas and figs. Some bats eat insects such as moths and beetles. Bats do not make nests. They like to roost upside down in barns, caves, or trees and they usually avoid people. (66 words)

Table B8

Readability Levels

	Dale-Chall	Fry	Average
Refutation Text	4.9	5	5.0
Expository Text	4.9	5	4.9

Note. All results are grade levels.

Appendix C

Data Collection Instruments

Pretest

What Do You Think?

1. An octopus will attack a diver who gets too close.	T	F	?
2. Crocodiles and alligators are different animals.	T	F	?
3. A spider is an insect, like an ant or a bee.	T	F	?
4. Cavemen hunted dinosaurs for food.	T	F	?
5. If it is day on one side of the world, it is night on the other.	T	F	?
6. A camel stores water in its hump.	T	F	?
7. There are more than 100 bones in the human body.	T	F	?
8. If you get near a bat, it will try to tangle itself in your hair.	T	F	?
9. Gorillas are omnivorous - they eat plants and other animals.	T	F	?
10. Deserts are flat, dry, and covered with sand.	T	F	?
11. Magnets have a north and a south pole.	T	F	?
12. An ostrich buries its head in the sand when it is frightened.	T	F	?
13. Water freezes at 0° Celsius.	T	F	?
14. It is summer when the earth is closer to the sun.	T	F	?
15. Paper can be made from trees.	T	F	?

Posttest

Science Trivia

1. Does a camel store water in its hump?
   yes no maybe

2. Will an octopus attack a diver who gets too close?
   yes no maybe

3. Is it summer in Canada when the Earth is closer to the sun?
   yes no maybe

4. Is a spider an insect, like an ant or a bee?
   yes no maybe

5. Did cavemen hunt dinosaurs for food?
   yes no maybe

6. If it is day on one side of the world, is it night on the other?
   yes no maybe

7. Are there more than 100 bones in the human body?
   yes no maybe

8. If you get near a bat, will it try to tangle itself in your hair?
   yes no maybe

9. Are gorillas omnivorous - do they eat plants and other animals?
   yes no maybe

10. Are deserts flat, dry, and covered with sand?
    yes no maybe

11. Do magnets have a north and a south pole?
    yes no maybe

12. Will an ostrich bury its head in the sand when it is frightened?
    yes no maybe

13. Does water freeze at 0° Celsius?
    yes no maybe

14. Can paper be made from trees?
    yes no maybe

Delayed Posttest

Fact . . . or Fiction?

1. The moon can only be seen at night.
   Fact Fiction ?
2. Bats will try to make a nest in a person's hair if it gets close enough.
   Fact Fiction ?
3. There is no gravity in space.
   Fact Fiction ?
4. An ostrich does not bury its head in the sand.
   Fact Fiction ?
5. A spider is an insect, like a grasshopper or a ladybug.
   Fact Fiction ?
6. A gorilla is a herbivore - it only eats plants.
   Fact Fiction ?
7. Fossils are actual preserved animal or plant parts.
   Fact Fiction ?
8. Not all deserts are flat, hot, and covered with sand.
   Fact Fiction ?
9. Batteries have electricity inside them.
   Fact Fiction ?
10. It is winter when the Earth is closer to the sun.
    Fact Fiction ?
11. All metal things sink in water.
    Fact Fiction ?
12. An octopus is a shy animal and is not likely to attack a diver.
    Fact Fiction ?
13. Large magnets are stronger than small magnets.
    Fact Fiction ?
14. A camel stores water in its hump.
    Fact Fiction ?

Appendix D

University of Victoria Certificate of Approval

and

School District Approval

University of Victoria

University of Victoria - Human Research Ethics Committee

Certificate of Approval

Principal Investigator	Department/School	Supervisor
Christine Tippett Graduate Student	EDUC	Dr. Sylvia Pantaleo

Co-Investigator(s):

Title: **Conceptual Change: The Power of Refutation Text**

Project No.	Approval Date	Start Date	End Date
372-03	26-Sep-03	26-Sep-03	25-Sep-04

Certification

This is to certify that the University of Victoria Ethics Review Committee on Research and other Activities Involving Human Subjects has examined the research proposal and concludes that, in all respects, the proposed research meets appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Subjects.

J. Howard Brunt
Associate Vice-President, Research

This Certificate of Approval is valid for the above term provided there is no change in the procedures. Extensions/minor amendments may be granted upon receipt of "Request for Continuing Review or Amendment of an Approved Project" form.

Office of Vice-President, Research - UVic
Room 424, BEC - P.O. Box 1700
Victoria, BC V8W 2Y2

Tel: (250) 472-4362
Fax: (250) 721-8960
E-mail: ovprrc@uvic.ca

372-03 Tippett, Christine

Greater VICTORIA School District

OFFICE OF
ADMINISTRATIVE SERVICES

556 BOLESKINE ROAD, P.O. BOX 700, VICTORIA, BRITISH COLUMBIA V8W 2R1
Fax: (250) 475-4112

John Gaiptman, Superintendent
Phone: (250) 475-4159

George J. Ambeault, Secretary-Treasurer
Phone: (250) 475-4106

October 1, 2003

Ms. Chris Tippett
3155 Mars Street
Victoria, BC V8X 1B9

Dear Ms. Tippett:

Thank you for your recent application regarding your research project, *Conceptual change: The power of refutation text.*

Please be advised that your application has been approved to survey Grades 3 and 4 students at [redacted] and permission to proceed with this project is granted during the 2003-2004 school year.

I wish you success with your project.

Sincerely,

John Gaiptman
Superintendent of Schools

JG/mc

Cc: Mandy Conrad

Appendix E

Culminating Booklet Pages

Deserts

Most people think of deserts as flat, completely covered with sand, and without water. Not all of these ideas are correct. The largest desert in the world is a good example. This desert, the Sahara, is located in Africa. It is so dry that few plants can grow on it. But it has several mountains, and large areas are covered with rocks and boulders.

A desert is a large dry area of land that has few trees. A desert is often very hot during the day. It can be quite cold at night. Because deserts have so little water, the plants that do grow do not cover the ground. Deserts may be rocky or sandy, and few animals are able to live in such dry, uninviting places.

Photo: Encyclopædia Britannica (2003)

The Ostrich

Many people believe that an ostrich will bury its head in the sand when it is in danger. This is not true, however. If ostriches buried their heads, they would not be able to breathe! Ostrich chicks may hide from danger by lying with their necks stretched out along the ground. Adults may listen for sound with their heads near the ground, or they might run away.

The ostrich is the largest bird in the world. Although it cannot fly, it can run very fast - up to 65 kilometers per hour! If an adult ostrich is frightened, it might run away. It might listen for sound with its head near the ground. If a chick is in danger, it might try to hide by lying on the ground with its neck stretched out.

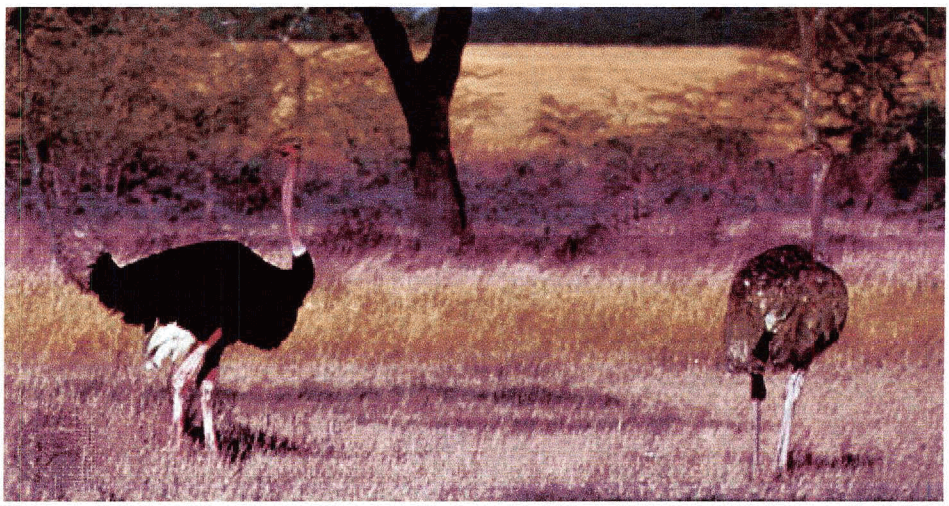

Photo: Encyclopædia Britannica (2003)

Seasons

Some people believe that it is warmer in the summer because the Earth is closer to the sun, but this is not true. In Canada the Earth is actually closer to the sun when it is winter! The Earth's distance from the sun does not cause the seasons. It is the angle of the sun's rays. Summer occurs when the Earth is tilted towards the sun.

There are four seasons - winter, spring, summer, and fall. Each season has its own weather and temperatures. These differences are because the angle of the sun's rays changes as the earth moves around the sun. In Canada, the earth is tilted towards the sun in the summer. The sun's rays shine from nearly overhead. This means more heat and longer hours of daylight.

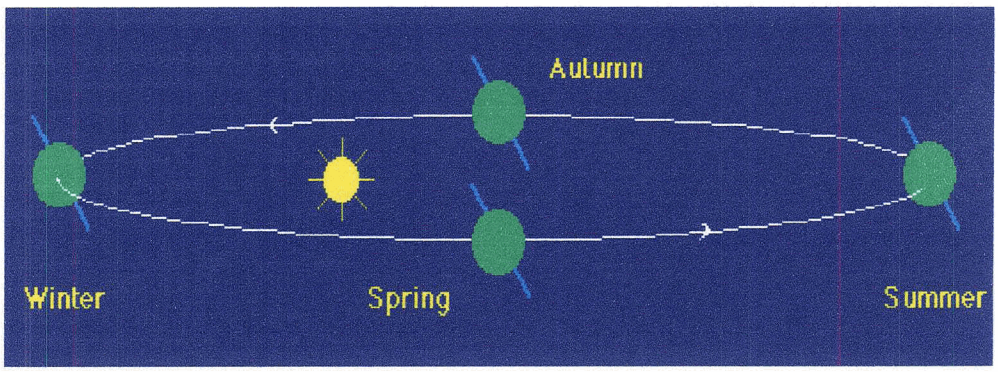

Photo:http://csep10.phys.utk.edu/astr161/lect/time/seasons.html

The Camel

Some people believe that a camel stores water in its hump. They think that the hump gets smaller as the camel uses up water. But this idea is not true. The hump stores fat and grows smaller only if the camel has not eaten for a long time. A camel can also live for days without water because water is produced as the fat in its hump is used up.

The camel lives in the deserts of Africa and Asia. It has long legs and wide feet that are good for walking in sand. Camels store fat in their humps, and this means that they can go for days without food. The hump gets smaller as the fat is used up. A camel can also go without much water because water is produced as its fat is used up.

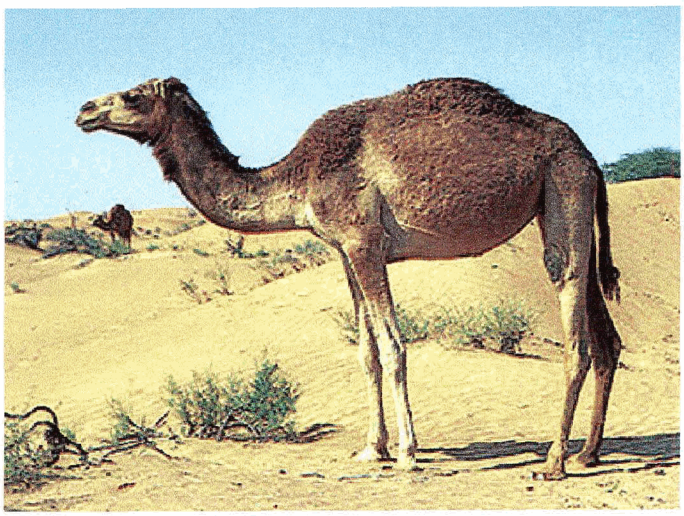

Photo: Encyclopædia Britannica (2003)

The Octopus

Movies sometimes show octopuses attacking divers and squeezing them to death. However, if an octopus really saw a diver nearby, it would quickly swim away. Octopuses are actually quite timid. They do not often hunt for their food. They hide in holes or cracks and wait for their food to come near. They eat crabs, clams, and shrimp - not people!

The octopus is a very timid animal. It hides in holes or cracks along the rocky ocean bottom. Octopuses eat shellfish, like crabs and clams. They do not usually hunt for their food. An octopus will hide and wait for its food to come near. The octopus has eight legs with rows of suckers, a sack-like head, and two beaks.

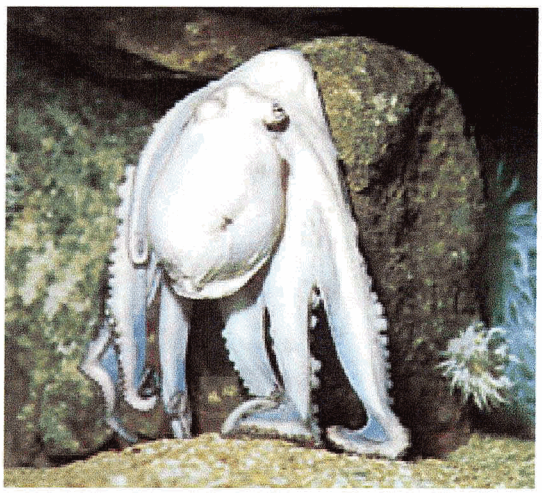

Photo: Encyclopædia Britannica (2003)

The Gorilla

Gorillas live in tropical forests in Africa. The male gorilla is big and powerful and may weigh up to 220 kilograms (485 pounds). The gorilla's strong arms are longer than its legs. It is easy to imagine a gorilla hunting and eating other animals. However, gorillas really eat the leaves, stems, and shoots of plants. In fact, gorillas are quite timid.

Gorillas are the largest members of the ape family. They live in tropical forests in Africa. Gorillas have black skin and hair, and their arms are longer than their legs. Male gorillas may weigh up to 220 kilograms (485 pounds). Gorillas are herbivores - they eat fruit as well as the leaves, stems, and shoots of plants. Although gorillas are very powerful, they are quite timid.

The Spider

Some people think that spiders are insects. However, this is not true. Spiders have eight legs while insects have six legs. Spiders have only two body parts - head and abdomen. They do not have a thorax like insects do. Spiders have spinnerets, which they use to spin webs to catch insects to eat. There are more than 34,000 kinds of spiders, including the tarantula.

Photo: Encyclopædia Britannica (2003)

There are more than 34,000 kinds of spiders. The tarantula and the black widow are both spiders. Spiders have two body parts - a head and an abdomen. They do not have a thorax like insects do. Spiders have eight legs. They also have spinnerets, which they use for spinning webs. An insect that gets caught in the web will be eaten.

The Bat

Some people are afraid that a bat will try to make a nest in their hair. However, most bats try to stay far away from human beings. Also, bats do not make nests. They like to roost upside down in barns, caves, or trees. Most bats eat fruit such as bananas and figs. Even vampire bats are not interested in nesting in people's hair.

Bats can be found almost anywhere in the world. There are 40 different kinds of bats in North America alone. Vampire bats feed on cattle, but most other bats eat fruit such as bananas and figs. Some bats eat insects such as moths and beetles. Bats do not make nests. They like to roost upside down in barns, caves, or trees and they usually avoid people.

Photo: Encyclopædia Britannica (2003)