5-1-2017

More Bang for your Buck: Bolstering Learning Via Refutation Text with Refutation-based Elaborated Feedback

Jacqueline R. Cordova
University of Nevada, Las Vegas

MORE BANG FOR YOUR BUCK: BOLSTERING LEARNING VIA REFUTATION TEXT WITH REFUTATION-BASED ELABORATED FEEDBACK

By

Jacqueline Rae-Wangberg Cordova

Bachelor of Science -- Psychology
South Dakota State University
1997

Master of Science -- Educational Psychology
University of Nevada, Las Vegas
2006

A dissertation submitted in partial fulfillment
of the requirements for the

Doctor of Philosophy -- Educational Psychology

Department of Educational Psychology and Higher Education
College of Education
The Graduate College

University of Nevada, Las Vegas
May 2017

UNLV | GRADUATE COLLEGE

Dissertation Approval

The Graduate College
The University of Nevada, Las Vegas

March 31, 2017

This dissertation prepared by

Jacqueline Cordova

entitled

More Bang for your Buck: Bolstering Learning via Refutation Text with Refutation-Based Elaborated Feedback

is approved in partial fulfillment of the requirements for the degree of

Doctor of Philosophy – Educational Psychology
Department of Educational Psychology and Higher Education

Carolanne M. Kardash, Ph.D.
Examination Committee Chair

E. Michael Nussbaum, Ph.D.
Examination Committee Member

Gale M. Sinatra, Ph.D.
Examination Committee Member

Hasan Deniz, Ph.D.
Graduate College Faculty Representative

Kathryn Hausbeck Korgan, Ph.D.
Graduate College Interim Dean

Abstract

The current study examines the effects of refutation text and refutation-based elaborated feedback on conceptual understanding, self-efficacy, interest, beliefs, attitudes, and knowledge, within the context of learning about climate change. The study also tests whether elaborated feedback moderates the refutation text effect through an interaction. One hundred and fifty nine undergraduate students were recruited to participate in this study, which was administered via computer. They completed measures of their self-efficacy and interest in learning about climate change, as well as climate change beliefs, attitudes, and knowledge. Approximately half of the participants read a refutation text and half read a comparison expository text. Participants then completed a series of multiple choice questions either with or without elaborated refutation-based feedback, creating four mutually exclusive groups based on type of text by type of feedback design. Participants then answered five open-ended questions as a measure of deep conceptual understanding before completing the self-efficacy, interest, beliefs, attitudes, and knowledge measures again. There were no significant interaction effects of text and feedback by time on the variables of interest. However, there was a significant increase in overall interest, beliefs, and knowledge from pretest to posttest. Limitations and future research directions are discussed.

Acknowledgements

First, to my amazing husband, Kevin, thank you for your unwavering support through this process. You have been there to listen when I needed to talk through my ideas, cheer me on when I needed encouragement, and chip in with the girls whenever I needed just a little more time to complete a task. To my spunky, smart, and mighty girls, Grace, Isabella, Emily, and Joelle, I am very grateful to each of you for helping me stay focused on what is most important throughout this process, and for the constant, much needed comic relief. Thank you to my mom, Joan Wangberg, for modeling what strength and tenacity look like, and for always believing in me and showing me unconditional love. And to the rest of my family and friends, thank you for your love and support.

To my committee members, both past and present, including Dr. CarolAnne M. Kardash, Dr. Gale M. Sinatra, Dr. E. Michael Nussbaum, Dr. Hasan Deniz, and the late Dr. Gregory Schraw, thank you for your direction, advice, support, and patience during this journey. To Dr. CarolAnne Kardash, a special thank you for your willingness to step up from committee member to Chair to get me through this process. I appreciate the time and energy you have given reading, educating, guiding, editing, and encouraging me, especially through this final phase. Your knowledge, patience, direction, and support have helped shape, not just this project, but also my interest in future projects. To Dr. Gale Sinatra, thank you for being my mentor over the years. You have been instrumental in shaping my research interests and ideas, and you have given me so many opportunities to learn, grow, and share through collaborations with you, as well as others. Your expertise, insight, and guidance, as well as your skill in bringing together an amazing research team that supports, helps, and encourages one another, have been invaluable. I will be forever grateful for having you in my corner, ready to listen, and provide advice

whenever needed. Thank you for your feedback during the design and implementation of this study, as well as your continued counsel. To Dr. E. Michael Nussbaum, thank you for being willing to step in and serve on my committee so far into this process without hesitation, and for the many research opportunities you have allowed me to participate in. My work with you on other related projects (such as the refutation text project from which the refutation text used in this study was taken) has helped to shape this project. To Dr. Hasan Deniz, thank you for your thoughtful consideration, feedback, and support throughout this process. And, to Dr. Gregory Schraw, for his wisdom and direction through the development of this study, I have the utmost appreciation. His guidance in designing this study and in choosing and developing the materials were an essential part of this project. His memory will forever live on through his many contributions to the field and through his students, like me, who have learned and grown through their work with him.

To the students who have been a part of Dr. Sinatra's research team, thank you for providing assistance and support whenever needed. A special thank you to Dr. Doug Lombardi for your feedback during the writing of the refutation text used in this study, guidance on choosing a climate change knowledge assessment, and ultimately, allowing me to adapt and use a measure you created. To Dr. Viviane Seyrania and Robert Danielson, I would like to thank you for sharing your materials with me.

Finally, I would like to express how grateful I am to both past and present faculty, staff, and students in and around the Department of Educational Psychology and Higher Education who have shared their expertise with me through coursework, research projects, conversations, and other collaborations. For being a great sounding board and cheerleader throughout this process, I would like to extend a special thanks to Dr. Nancy Hamilton. I also appreciate your

assistance with scoring a portion of data to establish interrater reliability for one of the instruments used. I would also like to offer my appreciation to Dr. Fred Kuch for creating the program used to collect data. To Young Bok Kim and his staff, thank you for arranging lab space to collect data and for always being willing to go above and beyond to troubleshoot any technological issues that came up along the way. And last but not least, to all of the students who participated in this study, thank you for your time.

Dedication

I would like to dedicate this to my Dad, Kenny, gone but never forgotten. Even after all these years, I can still picture the pride and unconditional love he always had in his eyes with my every accomplishment. I know he is looking down on me today, as always, with that proud twinkle in his eyes.

Table of Contents

List of Tables

Chapter 1: Introduction

People often form their conceptions of scientific phenomena based on their everyday real-world experiences (Vosniadou & Brewer, 1992). Unfortunately, these conceptions often conflict with the accepted scientific conception. These inaccurate conceptions are often termed misconceptions. Although misconceptions arise in most domains, they are particularly common in science (Shymansky et al., 1997; Thijs, 1992). For instance, one specific content area where a lack of understanding and misconceptions abound is in learning about climate change. Even with the current public focus and a scientific consensus on the cause and effects of climate change, misconceptions regarding climate change are plentiful. Some common misconceptions include inaccurate conceptions regarding the causes (e.g. pollution, ozone holes, changes in solar energy), effects (e.g. skin cancer, thinking climate change assertions are embellished), and resolution/mitigation (e.g. believing nothing can be done to mitigate the effects, misunderstanding the complexity of controlling carbon dioxide emissions) of climate change, as well as misconceptions about climate systems/science (e.g. confusing weather and climate, confusing UV and infrared radiation and the role in the earth's surface temperature) (Choi, Niyogi, Shepardson, & Charusombat, 2010; Dutt & Gonzalez, 2012; Lombardi & Sinatra, 2012).

Misconceptions are strong and can be difficult to reduce (Shymansky et al., 1997; Thijs, 1992), possibly because learners develop their conceptions based on their personal experiences, thereby making their misconceptions hard to change (Dole & Sinatra, 2008; Sinatra et al., 2012). For instance, not understanding the distinction between the shorter-term weather and the longer-term climate, students may view one recent very cold winter as justification for why global temperatures cannot be rising (Sinatra et al., 2012). In order to overcome inaccurate conceptions, instructional interventions designed to address specific common misconceptions and persuade individuals to consider alternate perspectives are a necessary part of science education (Sinatra & Broughton, 2011; Vosniadou, 2008).

Refutation Text and Changes in Beliefs, Attitudes, and Conceptions

Texts are one of the most common ways messages to be learned are presented in a school setting. Traditional expository texts (which simply explain concepts) are commonly used in science education. However, they may not be particularly effective in persuading learners to change their misconceptions, as they can be tough to understand for many learners (McKeown, Beck, Sinatra, & Loxterman, 1992). As difficult as it can be to induce change in beliefs or conceptions, specially designed persuasive texts can be very effective. Two-sided refutation texts, which introduce a common belief or misconception, refute it, and then present the preferred belief/conception, have been demonstrated through a wealth of research to be a time-efficient, highly effective method for fostering a change in conceptions, beliefs, and attitudes (Guzzetti, Snyder, Glass, & Gamas, 1993; Hynd, 2001).

With extensive evidence supporting the effectiveness of refutation texts, researchers have become very interested in why refutation text is so effective and have therefore begun to examine factors such as the cognitive processes involved in reading that might explain its effectiveness (Sinatra & Broughton, 2011). The relationships between individual variables (e.g., content interest and epistemological beliefs) and refutation text in learning have also become of interest as researchers learn more about the role of individual difference variables in learning (Kendeou, Muis, & Fulton, 2011).

Thus far, there have been conflicting findings when it comes to the cognitive processing, as demonstrated by things like reading times, involved in reading refutation text (Broughton, Sinatra, & Reynolds, 2010). Some research of the cognitive processes involved indicates that refutation text may be effective because refutation statements may act as a type of advanced organizer, alerting the reader that there is an inconsistency between their current knowledge and the preferred scientifically accurate view (Ariasi & Mason, 2011). It is possible that less attention is required to process this refutation segment of text quickly. Readers will likely then spend more time doing one of the following. They may spend more time looking back through the text if allowed to in an effort to reconcile the inconsistency. They may also spend more time processing the accurate information to follow the refutation statement to try to reconcile the discrepancy between what they thought they knew and the preferred information provided. Such increased processing time could then plausibly account for conceptual change learning as well as marked changes in beliefs and attitudes.

Refutation Text and Motivational Constructs

As noted above, refutation text research has also begun to examine the relationship between other individual variables, such as epistemological beliefs and the effectiveness of refutation text on learning (Kendeou, Muis, & Fulton, 2011). However, little to no research exists that examines the effect of refutation text on motivation to learn more about a particular topic. It is possible that in addition to its positive effects on learning and belief/conception change, refutation text may also have a positive impact on a learner's self-efficacy and interest in learning more about a topic. According to Zimmerman and Schunk (2008), making a learning task more interesting may be one way to enhance motivation. Because research indicates that refutation text is preferred over traditional expository text (Hynd, 2001; Mason, et al., 2008), it is possible that refutation text may be more engaging than the traditional expository texts generally used in science classrooms. This is important to know because, if so, choosing refutation texts over traditional expository texts may not only increase the likelihood for conceptual change learning and belief change, but may also increase the likelihood that students will become more interested in engaging in future learning about important topics. In addition to potentially increasing the likelihood for future engagement, this is also significant because students who are more motivated pay more attention to their learning processes and outcomes, display more progress when motivated to choose a task, and display greater effort and persistence, thereby attaining greater mastery. Greater mastery would then likely lead to higher perceived self-efficacy. They are also more likely to seek help when necessary and experience more satisfaction when presented the chance to learn (Zimmerman & Schunk, 2008).

Augmenting the Refutation Effect through Performance-Based Feedback

Now that we know just how efficient and effective refutation text is as an instructional medium for changing conceptions, it is also important to further investigate ways the refutation text effect can be changed through other activities such as feedback. Performance-based feedback, which links a student's actions and the response, is considered by experts to be key to effective instruction (Brooks, Schraw, & Crippen, 2005). Because feedback may have the power to help a learner identify discrepancies between their performance and the desired performance, and potentially resolve these discrepancies (Butler & Winne, 1995; Shute, 2008), it is important to consider the role of feedback in learning when belief or conceptual change is the goal. Immediate, task-related, elaborated feedback may help to promote content engagement, correct errors in performance, and promote the mindful processing of feedback, which in turn, may positively impact both academic achievement as well as motivation for learning more and perceived self-efficacy (Gao & Lehman, 2003; Narciss, 1999; Narciss, 2004; Narciss & Huth, 2006; Van der Kleij, Eggen, Timmers, & Veldkamp, 2012). In their model of the effect of feedback, Bangert-Drowns, Chen-Lin, Kulik, and Morgan (1991) suggest that learners evaluate their response based on the feedback they are provided. They then adjust their knowledge, goals, interest, and self-efficacy. Given the effectiveness of refutation text, coupled with the effectiveness of elaborated performance-related feedback, it is possible that performance- related feedback constructed using refutation-based language may further enhance learning for belief or conceptual change as well as impact self-efficacy and interest for learning more about a topic.

The most effective feedback for promoting mindful processing is that which is highly informative, task-centered, response-specific, and non-threatening to self-esteem. Several important features of refutation text are in line with these important feedback characteristics. For instance, the presentation of the common misconception and the scientifically accurate conception as is done in refutation text would likely be both highly informative and task-specific. Common techniques used when constructing refutation statements in texts (stating "Many people believe…However, this is incorrect" for example) may also be much less threatening to learners than explicitly telling learners that their responses are incorrect. When incorporated into elaborated feedback, refutation text-based language may promote more mindful processing of feedback and may promote conceptual or belief change and possibly self-efficacy and interest in topic-specific learning. Therefore, incorporating some of the features of refutation text into elaborated feedback may increase the effectiveness of feedback and prove to be especially beneficial for learning situations where conceptual change is the focus.

Therefore, one purpose of the proposed study was to replicate the positive effects observed previously in the literature for refutation text compared to a control text and to examine the effect of refutation-based elaborated feedback on beliefs and attitudes about climate change, conceptual understanding and knowledge change, and the motivational constructs of self-efficacy and interest within the context of learning about climate change. Importantly, I extended previous research by examining whether elaborated feedback would moderate the refutation text effect to influence performance on learning, beliefs, attitudes, interest, and self-efficacy measures. For instance, I expected that those who read the refutation text and received elaborated feedback after each multiple choice question would exhibit significantly higher conceptual understanding compared to those who received only refutation text or feedback, as the feedback might augment the refutation text effect by providing another opportunity for further text processing offline and another opportunity to correct any misconceptions and revise their conceptions. I anticipated further that those who read the control expository text and received no feedback would likely exhibit the lowest conceptual understanding. Given previous research demonstrating the effectiveness of both refutation text and elaborated feedback in isolation, it was unclear whether elaborated feedback using refutation statements after reading the control text would lead to increased understanding over refutation text alone with no feedback, or whether refutation text alone would be more or equally effective. My specific research questions and their accompanying hypotheses are presented following my review of literature, to which I now turn.

Chapter 2: Literature Review

This literature review consists primarily of four sections. The first section provides a discussion of the theory and research that investigates how refutation text changes one's prior beliefs and inaccurate conceptions. The second section focuses on theory and research regarding the use of performance feedback in education to enhance learning and motivation for future learning. The third section briefly discusses the potential effect of refutation text and performance feedback on interest, self-efficacy, beliefs, and attitudes. The fourth section describes the rationale, research questions and hypotheses for the present study.

Section 1

Text and Conceptual Change Learning

People often form conceptions about scientific phenomena based on their everyday real world experiences (Vosniadou & Brewer, 1992). Unfortunately, these conceptions often conflict with the accepted scientific conception. These inaccurate conceptions are often termed misconceptions. Although misconceptions arise in most domains, they are particularly common in science. Misconceptions are generally strong and previous research indicates that reducing science misconceptions can be very difficult (Shymansky et al., 1997; Thijs, 1992). In order to overcome inaccurate ideas, instructional interventions designed to address specific common misconceptions and persuade individuals to consider alternate perspectives are often a necessary part of science education (Sinatra & Broughton, 2011; Vosniadou, 2008).

Underlying Theory Regarding Belief and Conceptual Change

Persuasion is described as "an interactive process through which a given message alters individuals' perspectives by changing the knowledge, beliefs, or interests that underlie those perspectives" (Murphy & Alexander, 2004, p 338). Although they have developed somewhat separately, research in persuasion shares some of the same philosophical and psychological ancestry and a similar focus as conceptual change research (Woods & Murphy, 2001). Both persuasion and conceptual change learning share a basic focus on changing one's ideas and both involve the need to understand the individual and message characteristics that help facilitate that change (Vosniadou, 2001). Whereas persuasion research often focuses more on attitude and belief change in ill-structured domains however, conceptual change research focuses on changing conceptual knowledge in well-structured domains, such as science and math (Vosniadou, 2001).

Persuasion. Persuasion research has deep philosophical roots dating back to the ancient Greeks and their focus on rhetoric and the art of changing another's mind (Woods & Murphy, 2001). Interest in persuasion re-surfaced in the beginning of the 1900s as attitudes and attitude change became of interest to researchers. According to Woods and Murphy (2001), Allport (1935) proposed that the answer to changing behavior was in changing attitudes, but that attitudes are not easily changed. Therefore, persuasive messages were considered as a potential avenue toward attitude change.

In the 1950's, research into persuasive communication started to take off. Woods and Murphy (2001) point out that the most popular theory on persuasive communication at that time was Hovland, Janis, and Kelley's (1953) learning theory approach (LTA). It assumed that the degree of attention paid to the message in addition to the degree the message was comprehended and accepted influenced the level of persuasion. Hovland et al.'s (1953) work informed many of social psychology's modern persuasion models, including Roloff's (1981) Social Exchange Theory, Chaiken's (1987) Heuristic Model of Persuasion, and Petty and Cacioppo's (1986) Elaboration Likelihood Model (ELM) (Woods & Mason, 2001).

According to Dole and Sinatra (1998), there are two main types of models of attitude/belief change: combinatorial models and process models. Combinatorial models are those that quantitatively describe how individuals form or change beliefs through combining specific bits of information. Differing numerical weights assigned to different components of change indicate their contribution to the process of change. Conversely, process models try to explain the cognitive mechanisms that contribute to attitude/belief change (Dole & Sinatra, 1998).

The most significant modern belief/attitude change model in the persuasion literature is likely the Elaboration Likelihood Model (ELM), which is a dual process model that proposes two ways in which persuasive messages lead to belief change (Woods & Mason, 2001). The first is the central route. The second is the peripheral route. Central processing is most likely to occur when the receiver is motivated and has the ability to think about (and elaborate) the message. However, even if the receiver is not motivated or not able to think about the message, or the message is ambiguous, but peripheral cues are present, a low level of elaboration may still be possible. If peripheral, contextual cues (e.g. credibility of the communicator, association of the message with something else positive) are accepted, there may be low elaboration. In this model, the more the message is elaborated, the greater the likelihood is for persuasion (Petty & Cacioppo, 1986).

Conceptual change. Conceptual change research is situated in constructivist-based theories of learning, where learners are viewed as active participants in knowledge acquisition (Tippett, 2010). It dates back to the Swiss psychologist, Jean Piaget's fundamental concepts of schemas, assimilation, and accommodation, which are key to an individual adapting to their environment. Piaget hypothesized that humans develop mental representations of ideas and beliefs into schemas. These schemas, considered to be the foundation of thinking, are used to assimilate new information into their developing understanding of the world. When new information conflicts with a currently held schema, however, accommodation, which involves changing the current schema to adapt to the new information, is necessary (Ormrod, 2004). Piaget's identification of the significance of prior knowledge, and the ideas of assimilation and accommodation, helped inform the development of a seminal conceptual change model advanced by Posner, Strike, Hewson, and Gertzog (1982) (Tippett, 2010). Ideas of conceptual change in science learning being akin to the "scientific revolutions" first discussed by Kuhn (1970) and Lakatos (1970) also influenced Posner et al.'s model of conceptual change (Deniz, Donnelly, & Yilmaz, 2008).

Through their seminal model, Posner et al. (1982) tried to explain how individuals modify their current scientific ideas when challenged with a different, competing idea. They proposed that learning is a rational, gradual process of conceptual change involving both assimilation and accommodation. However, their theory focuses primarily on accommodation and the conditions necessary for a new concept to replace an existing concept. Posner et al. (1982) proposed that four conditions were necessary for accommodation to occur. First, the learner must be dissatisfied with their current concept. For instance, the learner may have encountered a number of issues or anomalies that their current concept cannot address. Second, the new concept must be "intelligible." It must be understandable. Third, the new concept must seem plausible, in that it must seem capable of solving the issues left unsolved by the old concept and it should be consistent with other knowledge. Finally, the new conception should be fruitful, in that it could be extended to research new areas. Although it has been since revised, this early model of conceptual change proposed by Posner et al. (1982) served as the basis for some of the early research on the use of refutation text (Tippett, 2010).

Pintrich et al. (1993) contested the characterization of conceptual change as a “cold” rational process. They advocated for the inclusion of motivational, affective, and contextual variables in conceptual change models. Therefore, researchers began to develop models of conceptual change that took affective and motivational constructs into account (Sinatra, 2005). For instance, the 1998 Cognitive Reconstruction of Knowledge Model (CRKM) proposed that interactions between learner (e.g. background knowledge, motivational factors) and message characteristics (e.g. comprehensibility) influence the level of topic engagement, which in turn, determines the likelihood for conceptual change (Dole & Sinatra, 1998).

Currently, the conceptual change process is discussed from varying theoretical perspectives, which differ in four ways (Sinatra & Broughton, 2011). First, researchers vary in the degree to which they focus on conceptual change as driven by developmental cognitive growth or as driven by experience. For instance, whereas some researchers focus more on the qualitative changes or ontological shifts in conceptual knowledge throughout the course of a child’s cognitive development (Carey, 1991; Chi, 1992), other conceptual change researchers focus on conceptual change induced through instruction (Vosniadou & Mason, 2012).

A second area of difference among conceptual change researchers is the degree to which conceptions are considered to be conceptually coherent frameworks of knowledge, although scientifically inaccurate, or whether knowledge is thought to be composed of fragmented bits of information (Sinatra & Broughton, 2011). For instance, many conceptual change researchers view naïve knowledge as a fairly well-structured, coherent body of knowledge that can be thought of as theory-like in that, although it may be scientifically inaccurate, it can be used to provide explanations of phenomena (Carey, 1992; Vosniadou & Mason, 2012). Others, like diSessa (1993) and colleagues, view naïve knowledge as a group of fragmented, semi-independent, "knowledge in pieces" elements (called "p-prims") that interact to combine into a larger, more complex understanding of phenomena.

A third difference is the degree to which they view conceptual change as spontaneous or intentional (Sinatra & Broughton, 2011). For instance, spontaneous conceptual change is the change that happens unintentionally, outside of the learner's conscious intent or control, as a result of experience with the environment (Inagaki & Hatano, 2008). Intentional conceptual change, on the other hand, refers to conceptual change that occurs through some control of the learner, for instance, that which is initiated and regulated by the learner (Sinatra & Pintrich, 2003). Most conceptual change researchers view these as two different types of conceptual change, rather than as a theoretical difference. However, researchers do vary as to how common they think each type is (Sinatra & Broughton, 2011).

A fourth difference is whether conceptual change is considered as a mostly rational, cognitive process or as a socially situated process (Sinatra & Broughton, 2011). Those who tend to view conceptual change as a mostly individual, cognitive process tend to study conceptual change as it occurs through maturation and/or instruction. In this case, researchers tend to focus on how individuals' knowledge structures change whereas those who view conceptual change as more of a socially situated process focus more on changes in the language and actions of groups in the broader sociocultural context (Sinatra & Broughton, 2011). Although the perspectives of conceptual change researchers vary in regards to the dimensions discussed, most conceptual change researchers hold views somewhere in the middle on at least one of these theoretical considerations (Sinatra & Broughton, 2011). In regards to these four dimensions, the perspective in this study is conceptual change as the intentional restructuring of a conceptually coherent framework of knowledge through individual, cognitive processing induced through instruction (experience).

Changing Beliefs and Conceptions Though Text

Just as specific learner variables (e.g. background knowledge, motivational characteristics) can impact the likelihood for changing one's conceptual understanding, so can specific message characteristics, such as the comprehensibility or compelling nature of the message (Dole & Sinatra, 1998). Text has traditionally been one of the main avenues through which a message to be learned is presented in the school setting and there is a strong link between text comprehension and learning. Unfortunately, the traditional expository texts (which merely explain a conception) usually found in science textbooks are often hard for learners to understand (McKeown, Beck, Sinatra, & Loxterman, 1992). This is especially troublesome as learners need to be able to understand the text material presented in order to change their misconceptions (Rukavina & Daneman, 1996).

Although traditional expository texts may not be very effective in persuading learners to change their misconceptions, specially designed persuasive texts can be. A persuasive text is one that has been constructed to counter learners' existing beliefs/conception and offer an alternative understanding (Chambliss & Garner, 1996; Murphy & Alexander, 2004). There are three types of texts commonly used to present a persuasive argument (Hynd, 2001). The first is a one-sided persuasive text. This text type is designed to offer only the one side that is preferable for the reader to adopt. The second type is a two-sided non-refutation text. This type of text explains both sides, but presents one side more strongly by explaining it better, providing more evidence, or somehow making it more compelling without stating that it is the preferred side. The third type of persuasive text is a two-sided refutation text. This type of text introduces a common belief, refutes it, and presents the alternative, preferred belief/conception (Hynd, 2001). I deploy the third type in the current study because it is believed to be the most effective (Guzzetti, Snyder, Glass, & Gamas, 1993; Hynd, 2001).

Historically, much research has been conducted on the effectiveness of these different text types. In general, two-sided refutation texts are more effective in persuading individuals to change their beliefs and conceptions than one-sided or two-sided non-refutational persuasive texts (Guzzetti, Snyder, Glass, & Gamas, 1993; Hynd, 2001). However, all three persuasive text types may be useful in the right context. For example, in a study conducted by Buehl, Alexander, Murphy, and Sperl (2001), ninety-three undergraduate students read a one-sided persuasive text on education reform, as well as a two-sided nonrefutation text on the V-Chip. They found that whereas the one-sided text was effective in strengthening the beliefs of those whose prior beliefs were in line with the text, the two-sided nonrefutation text was effective for knowledge strengthening and change, but the change was not always in the direction preferred in the text.

Brief Historical Overview of Findings from Past Research on Refutation Text

Research on the effectiveness of refutation text on changing student conceptions has been conducted since the 1980's (Tippett, 2010). A 1993 meta-analysis of 70 studies from reading (23 studies) and science (47 studies) education carried out between 1982 and 1991 with students of varying abilities and grade levels was conducted by Guzzetti, Snyder, Glass, and Gamas to examine the effects of different text-based approaches in eliminating misconceptions. They found that the research done in the 80's indicated that text can be effective in eliminating misconceptions when it is refutational or when it is used in conjunction with other strategies that create cognitive conflict. Non-refutation text alone was not found to be effective.

Since Guzzetti et al.'s 1993 study, refutation text research in reading and science learning has continued. The refutation text research of the 1990's expanded our understanding of its effectiveness. Studies conducted in the 1990's further supported findings by Guzzetti et al. (1993) that long-term conceptual change after reading a refutation text was likely to be maintained over time. For instance, Hynd and her colleagues found that high school students continued to exhibit conceptual change at a two week follow-up, and preservice teachers exhibited enduring conceptual change two months after reading a refutation text (Hynd, McWhorter, Phares, & Suttles, 1994; Hynd, Alvermann, & Qian, 1997). Other 90's studies gathered more evidence to support the finding that refutation text presented in an expository format may be more effective than other formats (e.g. presentation in a more story-like, narrative form) (Gordon & Rennie, 1987) and are likely to be preferred by learners (Alvermann, Hynd, & Qian, 1995; Guzzetti, Williams, Skeels, & Wu, 1997). In the 90's, we also started to learn a little more about other factors that might affect learning through refutation text. Dole and Niederhauser (1990) found that level of commitment to prior misconceptions had little impact on learning for conceptual change via text. Qian (1995) found that high school students with less sophisticated epistemological beliefs who read a refutation text were not as likely to change their conceptions as those with more sophisticated epistemological beliefs. Although reading refutation text has been shown to be highly effective overall, for students with reading difficulties, implementation via discussion may be necessary to be effective (Guzzetti et al., 1997).

Current Refutation Text Related Research

As will be demonstrated in the following review of recent research, research on refutation text has continued to shed light on: the forms and conditions under which refutation is effective

(Diakidoy, Kendeou, & Ioannides, 2003; Frede, 2008); the degree to which conceptual change is maintained through reading refutation text (Frede, 2008; Mason & Gava, 2007); the text structure and format preferred by readers (Hynd, 2001; Mason, Gava, & Boldrin, 2008); and the relationship between other factors (i.e. interest, epistemological beliefs) and the effectiveness of refutation text (Mason & Gava, 2007; Mason et al., 2008). Some researchers have also started to shift focus to the cognitive processes involved in reading refutation text (Broughton et al., 2010; Kendeou & van den Broek, 2005; Kendeou & van den Broek, 2007; Mikkila-Erdmann, Penttinen, Anto, & Olkinuora, 2008; van den Broek & Kendeou, 2008).

Current research on the effectiveness of refutation text. In a conceptual change study of 215 sixth-graders from rural Cyprus learning about energy, Diakidoy et al. (2003) randomly assigned participants to one of three groups. A control group (n=62) received the standard instruction, which consisted mainly of questions and presentations by the teacher, while two experimental groups used text as an adjunct to the standard instruction. One of the experimental groups (n=76) read a lengthy expository text, whereas the other (n=77) read a comparable, lengthy, refutation text. Diakidoy et al. (2003) found that those who also read a refutation text performed significantly better than those who received the standard instruction alone or those who also read an expository text when learning about energy. Their results indicate that refutation text may be even more effective when used in conjunction with standard instruction with middle school students unaccustomed to learning about a complex topic via text.

Frede (2008) assigned sixty pre-service teachers into three groups to examine the effect of instructional method on learning about seasons and moon phases. One group read a refutation text whereas a second group read an expository text. The third group participated in a hands-on, collaborative, refutation modeling activity. Overall, the refutation activity and the refutation text were significantly more effective than reading the expository text at both immediate and delayed posttest (one month later). Those who participated in the refutation activity outperformed those who read the refutation text. The results highlight the effectiveness of refutation text and other refutation activities in facilitating and maintaining learning for conceptual change.

Like Frede's (2008) study of pre-service teachers, Mason and Gava's (2007) study of epistemological views and text with eighth grade students also demonstrated that reading a refutation text led to maintained conceptual change at a two month follow-up. They found that students who had more advanced epistemological beliefs (those who believed in complex, uncertain knowledge) and who read a refutation text experienced greater reductions in misconceptions about evolution than those who read a traditional expository text.

Hynd (2001) conducted a qualitative study to gather information on the perception of various text formats from high school physics students. She found that participants preferred refutation texts over other texts. Results further indicated that students liked expository refutation more than narrative refutation texts. Hynd (2001) found there were a number of characteristics that students indicated they liked. For instance, students were made aware of the discrepancy of the text information and their own prior beliefs. Students also found the text to be understandable, credible, useful for solving other issues, repetitive, and they also felt like the text was relatable. Interestingly, many of the characteristics students liked about the refutation text are the same characteristics discussed in the literature as characteristics necessary for inducing conceptual change. For example, Posner et al.'s 1982 model of conceptual change discusses message characteristics such as being understandable and fruitful.

In their study of the role of text, epistemological beliefs, and topic interest in conceptual change, Mason et al. (2008) assigned 94 fifth graders to one of two groups. One group read a refutation text about light, whereas the other group read a comparable traditional expository text. Along with text type, interest and epistemological belief scores were dichotomized and used as between-subjects variables. Conceptual understanding at three time points (pre, post, one week delayed post) was used as the within-subject variable, and reading ability was used as a covariate. Mason et al. (2008) found that refutation text facilitated conceptual change learning significantly more than the traditional expository text. Those with high interest outperformed those with low interest, and when considered in combination at each posttest time, those with more advanced epistemological views, higher interest, and those who read a refutation text exhibited the highest conceptual understanding. There was a significant reduction in conceptual understanding from immediate to delayed posttest, however. Similar to Hynd (2001), Mason et al. (2008) also found that students who read the refutation text indicated they preferred the text significantly more than regular science texts. This was not the case for those who read the traditional expository text.

Diakidoy, Mouskounti, and Ioannides (2011) conducted another outcome-centered study comparing refutation text to traditional expository text. They compared differences in comprehension and learning outcomes with 61 undergraduate psychology students learning about energy. Both text groups showed a significant increase in learning from pretest to a two week delayed posttest, although those in the refutation text group significantly outperformed those who read the expository text. Those with low/inaccurate knowledge benefitted significantly more from reading the refutation text than those who read the traditional expository text. The same was not found for those with high knowledge. Recall scores were used as the measure of comprehension. Using pretest knowledge scores as a covariate, results indicated that those with high knowledge recalled significantly more of the information presented in the text and created more valid inferences than those with low/inaccurate knowledge. However, text type had an effect on valid inferences only, with those who read the refutation text generating significantly more valid inferences than those who read the traditional expository text. Students with high knowledge exhibited significantly fewer distortions during recall than those with low/inaccurate knowledge, regardless of which text they read.

Most recently, Braasch, Goldman, and Wiley (2013) conducted three experiments to further examine the effect of text structure and prior knowledge on conceptual change learning. In the first experiment, one hundred and eighteen undergraduate students were identified as having either a fragmentary or a coherent misconception profile. Within each profile group, participants were then randomly assigned to one of two text types concerning airflow. One text type was an accurate repetition text, which repeated the correct conception of airflow two times. The other was a contrast text, which contrasted an airflow related misconception with the correct conception. Results indicated that individuals in the coherent misconception profile decreased the number of responses indicating targeted misconceptions, while those with a fragmented profile did not. In regards to the generation of short answers, those with coherent misconception profiles generated a larger proportion of accurate core concepts as compared to those with a fragmented profile. The results indicated that contrasting the misconception and correct conception alone (without a refutation statement) did not enhance learning beyond that which occurred through reading a corresponding text that simply repeated the scientific conception twice. However those with more coherent misconceptions may have experienced slightly more learning than those with fragmented misconceptions.

In their second experiment, Braasch et al. (2013) inserted an explicit refutation statement into the contrast text used in the first experiment, as well as further highlighted the scientific accuracy of the repeated scientific explanation in the comparison text. One hundred and five undergraduates participated. Results indicated that those who read the repetition text spent more time reading compared to those who read the refutation text. In regards to recognition learning, results indicated that those reading the refutation text experienced greater gains in learning over time as compared to those who read the repeating text. However, both groups did exhibit significant gains over time. Results also indicated that individuals in the coherent misconception profile decreased the number of responses indicating targeted misconceptions, while those with a fragmented profile did not. In regards to generation of core concepts, those with coherent misconceptions generated more correct core concepts, as did those who read the refutation text. Results indicated that refutation text was more effective for conceptual change learning than repetition of the correct conception.

The third experiment was conducted to determine whether reading a text containing a misconception would negatively impact learning for those who did not previously hold the misconception. Using the same procedures, all four texts used in experiments one and two were used in Braasch et al.'s third experiment. One hundred and ten undergraduates who all demonstrated at least a partially correct conception of airflow participated. There were no significant differences in reading times among the four texts. In regards to recognition learning, gains were made by students within all four text conditions by those with partially accurate conceptions. In regards to concept generation, text type had no effect. Results of the third study indicated that introducing a misconception via text to students who may not hold the misconception does not have a negative impact on their learning. Overall, the results of the three experiments indicate that although presenting the incorrect and correct conception together may be necessary for conceptual change, as indicated by the Landscape Model, this alone is likely not enough. An explicit refutation statement is also a necessary component to alert a learner to their misconception, in addition to presenting the misconception and the correct conception together. Further, there are likely no negative effects of explicitly addressing misconceptions through refutation text on learning for those who do not hold the misconception.

As evidenced by the review of research regarding refutation text so far, much of the current research has continued to investigate the conditions under which refutation is effective, preferred text format, and the relationship between other individual characteristics and the effectiveness of refutation text. Because reading comprehension involves the formation of a coherent, accurate mental representation of the text presented, researchers have largely focused on the resulting product, but as McCrudden and Kendeou (2012) point out, the products are directly related to the processes involved in reading comprehension. Consequently, current research involving refutation text has started to move beyond focusing on offline outcomes and have begun to also focus on further investigating the online cognitive processes involved and strategies used when reading refutation text to gain insight into how refutation texts are effective in changing one's conceptual understanding (Sinatra & Broughton, 2011). Whereas some researchers have suggested that refutation texts may promote high engagement, thereby increasing the likelihood for conceptual change, others think the clear, concrete structure of refutation texts may actually require less attention from the reader, thereby making the information presented easier to learn and recall (Broughton et al., 2010).

Current research on the cognitive processes involved in reading refutation text. Researchers like Kendeou and colleagues have started to focus more on the cognitive processes that take place during reading to try to understand why refutation text is effective for conceptual change. Kendeou and van den Broek conducted a series of three studies to further investigate the role of inaccurate prior knowledge and comprehension processes in text comprehension. Although all three studies by Kendeou and van den Broek to be discussed are relevant, only the second and third study actually used refutation text, however. In the first study (Kendeou & van den Broek, 2005), two experiments were conducted to look at the effect of prior knowledge on both online processes and offline products. Online comprehension processes refer to those processes that take place during reading such as elaborating, paraphrasing, inferring, monitoring comprehension, etc. Offline products refer mainly to the resulting mental representation of the text topic formed by the reader.

For the first experiment, fifty-seven undergraduate introductory psychology students were divided into two groups. The first group (29 students) held misconceptions about electricity, the second group (28 students) did not hold misconceptions about electricity. Students in both groups were asked to read and recall an expository text about electrical current. Online process data collected included reading times and think aloud data. Students read the text one sentence at a time and were interrupted at specific points and asked to think aloud about the previous sentence. Five categories (understanding, uncertainty-confusion, explanations, paraphrases, and other) were used to classify the processes readers used while reading the text based on the think aloud data collected. There were no significant differences between the groups in any of the specified categories. Think aloud response content was further analyzed by explanation content. Knowledge-based explanations (valid and invalid) referred to those explanations that provided information beyond that which was in the text, whereas text-based explanations referred to those that reflected only information from the text. There was no significant difference between the groups on number of knowledge-based or text-based explanations. However, the group who had prior misconceptions reported significantly more invalid knowledge-based explanations and fewer valid explanations. Results regarding the offline product data indicated that readers who had prior misconceptions recalled less of the text, made more invalid inferences, and fewer valid inferences.

In the second experiment, 37 undergraduate students were again separated into two approximately equal groups based on whether or not they had misconceptions. The materials and procedures used were the same as those used in the first experiment, with one exception being that participants were not stopped for think alouds. There was again no significant difference between the groups with respect to reading times. Readers in each group spent no more or less time reading either the entire text or the target sentences. After controlling for reading comprehension, there was a significant difference between the groups with respect to the inferences made. Those with misconceptions made more invalid inferences and fewer valid inferences. There was also a marginally significant difference between the groups on total recall scores, with the misconception group scoring lower than those without misconceptions.

The results of these two experiments indicate that those with misconceptions did not differ with respect to the time they spent reading the target sentences containing information that conflicted with their misconceptions or the whole text. These findings suggest that although inaccurate prior knowledge may negatively impact memory of the text, it may not impact the kind of processing that takes place while reading the text. Though the kind of processing that takes place may not be different, the results of experiment one suggest that inaccurate prior knowledge may be more likely to interfere with the inferences made while reading the text, which may in turn negatively impact the final mental representation of the concept.

The second study conducted by Kendeou and van den Broek (2007) was a two-experiment study of the impact of prior knowledge (misconceptions vs. no misconceptions) and text structure (expository vs. refutation) on the comprehension processes used while reading scientific texts on Newtonian mechanics. In experiment one, eighty participants were divided into two groups: those with misconceptions (40) and those without (40). Each participant read two (out of four) texts, one refutation text and one expository text regarding Newton's first or third laws of motion, while doing think alouds throughout. After completing a distracter task, participants also wrote down what they could recall from the text after each reading. Think aloud data were coded into eight categories (comprehension monitoring, associations, intrasentential connections, intersentential connection, correct inferences, incorrect inferences, conceptual change strategies, and other). As in their 2005 study, Kendeou and van den Broek found that the misconception group produced more inaccurate inferences and fewer accurate inferences during their think alouds. They also found that the group with misconceptions used significantly more "conceptual change strategies" (i.e. think aloud responses indicated awareness of a cognitive conflict, comparing and contrasting information trying to resolve discrepancy in knowledge, etc.) than those without prior misconceptions. This effect was further investigated by text type and an interaction was discovered. The misconception group displayed significantly more conceptual change strategies only when reading a refutation text (not when reading an expository text). There were no significant differences between the misconception and non-misconception groups in regards to the other comprehension processes. In regards to recall after reading the text, the readers with misconceptions recalling significantly less text content, regardless of text structure or topic. Kendeou and van den Broek (2007) also found that for those with misconceptions, much of the variance (18%) in the proportion of text recalled after reading could be accounted for by the frequency of correct inferences made during think alouds.

In the second experiment, 60 undergraduate students were separated into 2 equal groups based on whether or not they had misconceptions. The materials and procedures used were the same as those used in the first experiment, with the exception that instead of using think alouds, participants read the texts through one sentence at a time without interruption and reading times were used as the indication of online processing. The results indicated that participants read the target *Newton's laws* sentences (sentences that clearly stated accurate information about the laws of motion) more quickly in the refutation text than in the non-refutation text. This effect was further investigated by misconception group. An interaction was discovered. The misconception group spent significantly more time reading the laws of motion target sentences than the non-misconceptions group when reading the refutation text, but not when reading the non-refutation text. Participants read target *explanation* sentences (sentences that either gave support for specific refutations in the refutation text or gave examples in the non-refutation text) in the refutation text significantly more quickly than in the non-refutation text. In regards to recall after reading the text, the readers with misconceptions recalled significantly less text content, regardless of text structure or topic. In assessing the relationship between the think aloud responses and sentence reading times, Kendeou and van den Broek (2007) found that longer sentence reading times were largely accounted for by the length of the sentence and the number of associations (prior knowledge activations) elicited by the sentence.

The use of more conceptual change strategies and the longer target sentence read times when reading about Newton's laws via refutation text by those with misconceptions found in this study may indicate that learners with inaccurate prior knowledge notice inconsistencies between their prior knowledge and the text when reading refutation text. A surprising finding, however, is that overall, learners spent less time reading refutation text than non-refutation text, which may indicate that learners either find refutation texts easier to read or that reading speed is increased because refutation texts help learners explicitly integrate prior knowledge and information to be learned into a more coherent framework. The findings of these two experiments also lend support to the notion that prior knowledge accounts for text recall.

The third study (van den Broek & Kendeou, 2008) in this series of studies was performed to further investigate the online cognitive processes involved in reading refutation text. Van den Broek and Kendeou (2008) started by running simulations to generate computational data. They then conducted two experiments to collect empirical data to compare to the computational data. They proposed that the reason refutation texts are effective is largely due to accurate and inaccurate conceptual information being presented together, therefore increasing the likelihood that readers activate both simultaneously.

The purpose of the simulation was to determine the accurate and inaccurate idea units available for activation in both a refutation text and a corresponding non-refutation text. The results of the simulations suggest that whereas correct and incorrect idea units are co-activated when reading a refutation text, no simultaneous co-activation of incorrect and correct ideas happens when reading a non-refutation text. Therefore, it is possible that the reason conceptual change is more likely via refutation text than non-refutation text may be due to the co-activation of incorrect and correct ideas simultaneously which may better allow the reader to detect the inconsistency between their incorrect prior knowledge and the correct scientific idea.

In the first experiment in this study, van den Broek and Kendeou (2008) had two groups of readers, one with high misconceptions (n=40) and one low misconceptions (n=40), read the two texts (one refutation and one non-refutation) that were used in the simulation. A think-aloud protocol was used to examine their use of online cognitive processes (monitoring comprehension, conceptual change strategies, using prior knowledge, paraphrases, text repetitions, correct inferences, and correct inferences) while reading the text. Just like in Kendeou and van den Broek's 2007 study, readers in the high misconceptions group used more conceptual change strategies when reading a refutation text but not when reading a non-refutation text. Also as in their previous study, those with high misconceptions made fewer correct inferences and more incorrect inferences for both text types than those with low misconceptions. There were no significant differences for the other processes including comprehension monitoring and use of prior knowledge by misconception group or text type.

In the second experiment, van den Broek and Kendeou (2008) again separated participants into two equal groups (30 per group) based on whether they had high or low misconceptions. The materials and procedures used were the same as those used in the first experiment, with the exception that instead of using think alouds, sentence reading times were used as the indication of online processing. The results showed that those with high misconceptions took significantly more time to read the sentences containing the correct information than those with low misconceptions when reading the refutation text, but not when reading the non-refutation text. For the refutation text, there was no significant difference in reading times between the two misconception groups in regards to other target sentences. There was also no significant difference by text type for those with low misconceptions. The results of this experiment suggest that online cognitive processes may be different, based on the level of accuracy of prior knowledge, when co-activation of the incorrect and correct idea by readers occurs through reading refutation text.

The two experiments lend support to van den Broek and Kendeou's (2008) hypothesis that the reason refutation texts are so effective is largely due to the simultaneous co-activation of accurate and inaccurate conceptual information. This co-activation may increase the likelihood that readers with misconceptions will become aware of the discrepancy between their prior knowledge and the scientifically accurate knowledge presented in the text. The longer read times of correct information and use of more conceptual change strategies by readers with high misconceptions when reading a refutation text as compared to those with low misconceptions may indicate that co-activation makes it possible for readers with inaccurate prior knowledge to engage in behaviors (i.e. use conceptual change strategies like detecting the discrepancy or contrasting the conflicting information presented) that help them create coherence in their mental representation of a concept, thereby increasing their likelihood for conceptual change.

The studies of online comprehension processes by Kendeou and van den Broek suggest that the processes involved in reading refutation text may be different than those involved in reading expository texts. The findings are consistent with suppositions made by previous conceptual change researchers who have hypothesized that becoming aware of inconsistencies between prior knowledge and scientifically accurate information is key to changing conceptions.

Broughton et al. (2010) sought to replicate and further extend Kendeou and van den Broek's work on the cognitive processes involved in reading refutation text through their study of attention allocation in conceptual change learning about the change of seasons. However, Kendeou and van den Broek (2008) based their study on the Landscape model of reading comprehension, which assumes that prior beliefs and misconceptions would need to be activated along with the preferred or scientifically accurate concept simultaneously for a shift in beliefs/conceptual frameworks to take place through reading a text. By contrast, Broughton et al. (2010) used the literature in attention allocation to ground their study. According to the literature in attention allocation, readers may pay more attention to text features that are highly salient, thereby increasing text recall and learning, or alternatively, things like interest in the text may facilitate recall and learning without the reader allocating additional attention (Reynolds, 1992; Shirey, & Reynolds, 1988). Broughton et al. (2010) proposed that the effectiveness of refutation text may not lie solely in the co-activation of inaccurate prior knowledge and the accurate conception as assumed by the Landscape model. Instead, they propose that, as the literature in attention allocation suggests, it is possible that readers could actually devote less attention to refutation materials and still learn more due to greater interest in the refutation text.

Broughton et al. collected data in two phases. Data from a total of eighty three undergraduate student participants from either introductory educational psychology or measurement and assessment in education courses were used in their analyses. Participants in both phases were randomly assigned to read either a refutation text or a traditional expository non-refutation text, and reading times were collected. Additionally, participants from the second phase were also interviewed to determine if any sentences stood out to them and whether they thought the information in the text conflicted with their prior knowledge. Results indicated that there was a significant difference by text, after controlling for reading ability. Those who read the refutation text spent significantly less time reading than those who read the traditional expository text. Upon closer examination, Broughton et al. (2010) determined that the difference in reading times was due to the segments of text containing the refutation. Specifically, the text segments containing the refutation in the refutation text were read more quickly than the corresponding text segments in the expository text. In terms of learning effects, both text groups demonstrated significant gains in conceptual understanding, with no significant interaction by text type over time. In terms of overall misconception reduction, there was no significant interaction and no main effect of time. However, from pretest to posttest alone, the refutation text group did demonstrate a significantly greater reduction in misconceptions as compared to the expository text group. There was also a significant difference in misconceptions between pretest and delayed posttest with no significant interaction or main effect by text type.

In terms of the interviews conducted by Broughton et al. (2010), both the text that was designed to be refutational and that which was informational were indicated as attended to, important, interesting, and contradictory to what they previously believed. Participants in both groups indicated that they changed their mind as a result of reading the text, as evidenced by the learning effects demonstrated. Findings from Broughton et al. (2010) lend some support to their assertion that readers may in fact allocate attention differently to refutation text versus expository text, largely in regards to the specific refutation statements contained. Based on the shorter read times for refutation statements and the interview data collected, the results suggest that it is possible that readers do find refutation texts more interesting, important, and possibly even easier to read. These findings are consistent with Hidi's (2001) position that greater interest may lead to "automatic allocation of attention," thereby reducing the cognitive resources used, thus permitting greater speed in the processing of information.

In addition to examining the effect of text structure on cognitive processing, Kendeou, Muis, and Fulton (2011) extended the previous research conducted by van den Broek and Kendeou by studying the additional effects of epistemic beliefs on comprehension processes involved in reading science texts. They proposed that an interaction between text structure and epistemic beliefs would affect the "off-line product" through its impact on the "on-line processes" that occur while reading. Two experiments were conducted. In the first experiment, forty six Canadian undergraduate students participated in think alouds while reading two out of four texts regarding Newton's 1^{st} and 3^{rd} laws of motion, one refutation and one non-refutation.

Think aloud data were coded and categorized into eight categories (comprehension monitoring, associations, paraphrases/test repetitions, text-based inferences, correct knowledge-based inferences, incorrect knowledge-based inferences, conceptual change processes, and other) representing the cognitive processes exhibited by participants. Results from the first experiment indicated that, after controlling for prior knowledge, non-refutation text led to significantly more text-based inferences than refutation text. Results also indicated that for the refutation text, those with more sophisticated epistemic beliefs used more conceptual change processes than those with less sophisticated epistemic beliefs. There was no difference in regard to the conceptual change processes used between those with more or less sophisticated epistemic beliefs while reading the non-refutation text. Results indicated that conceptual change processes were used mostly while reading sentences that stated the correct conception or explained why misconceptions were inaccurate. Results indicated there was no difference by epistemic beliefs or text structure in the recall of text information.

In their second experiment, Kendeou et al. (2011) again investigated the interaction between text structure and epistemic beliefs during on-line processing with 35 Canadian undergraduate students. The same procedures were used with one exception. Rather than using a think aloud methodology, sentence reading times were collected as an indication of on-line processing. Sentence reading times from experiment two were compared to the think aloud data gained in experiment one to see if the number of cognitive processes exhibited in experiment one predicted the reading times collected in experiment two, while taking into consideration syllables per sentence, text structure, and epistemic beliefs. Results indicated that longer reading times were significantly accounted for by the number of syllables per sentence and the number of paraphrases or text repetitions used. Decreased reading times were accounted for by the number of text-based inferences and monitoring comprehension processes used. In this experiment, text structure and epistemic beliefs had no effect on the recall of text information. There were also no significant interactions or main effects for text structure, topic, or epistemic beliefs on reading times per syllable in regards to target sentences contained in the texts.

The results of the two experiments conducted by Kendeou et al. (2011) indicate that readers with more sophisticated epistemic beliefs may use different processes, specifically more conceptual change strategies, when reading a refutation text. The results support the notion that various cognitive processes involved in reading refutation text may require more or less time than others. The longer reading times connected to rereading/paraphrasing may be due to the reader having a difficult time integrating the information they were reading into their knowledge representation. Results of both studies indicated that memory recall of text was not impacted by either text structure or epistemic beliefs.

McCrudden and Kendeou (2012) also sought to further explore the cognitive processes involved while reading refutation text. They asked nine high school science students to read a refutation text regarding Newton's first law of motion while performing think alouds. They then completed a post-test and participated in in-depth interviews. The data collected were used to assess prior conceptions as well as conceptions formed after reading the text so that students who experienced conceptual change could be identified. Think aloud data of four students identified as having exhibited conceptual change were analyzed to further examine the cognitive processes involved, while the interview data from these same four students were used to shed light on the readers' conceptual understanding and perception of their comments expressed during their think aloud. Results indicated that the cognitive processes exhibited by the four participants shared four characteristics. First, participants noticed the inconsistency between their prior conception and the scientific conception being presented via refutation text. Second, the participants acknowledged that their prior conception was not sufficient for fixing the discrepancy. Third, all four readers demonstrated monitoring processes, indicating that readers who experience conceptual change may monitor their conceptual understanding as they read to try to maintain consistency in their knowledge while reading. Finally, all four participants demonstrated the ability to transfer the knowledge they gained to solve one problem presented in the text to another related problem, thus indicating that the new conception was useful for resolving other related problems. The results further indicate that readers who experience conceptual change use a number of cognitive strategies to resolve inconsistencies in knowledge while reading refutation text, including making knowledge-based inferences and monitoring their comprehension. The results lend some support to the hypothesis that co-activation of inaccurate prior knowledge and the accurate conception as assumed by the Landscape model accounts for the effectiveness of refutation text in conceptual change learning.

Mikkila-Erdmann, Pentinnen, Anto, and Olkinuora (2008) conducted a study to determine whether eye tracking methods could be used to track cognitive conflict while reading a refutation text. They also sought to investigate the potential effect of text type on cognitive conflict. Thirty sixth grade students were assigned to read a refutation or explanatory text. Eye-tracking software was used to explore the use of total fixation time (time spend reading text), selective regression path duration (fixations on the sentence), and look from time (fixations on prior text while reading an important text unit) as indications of cognitive processing during reading. The results indicated that there was no effect of text type on the change in knowledge scores or comprehension processes. Therefore, they chose to combine the two text groups and further investigate based on the level of conceptual change from pretest to posttest. They found that those who exhibited greater conceptual change displayed more re-reading of previous text than those who did not exhibit conceptual change. Therefore, they concluded that look from time may be an appropriate measure of cognitive conflict while reading science texts.

Ariasi and Mason (2011) also used eye-tracking methodology to examine the effect of text structure in cognitive processing while reading for conceptual change learning. Forty Italian, undergraduate, psychology students were divided into two groups. One group read a refutation text regarding tides whereas the other read a comparison non-refutational expository text. In terms of off line learning, results indicated that although both groups showed gains in conceptual understanding, those who read the refutation text showed greater gains than those who read the non-refutation text. In regards to online processing, gaze fixation times during first-pass reading of refutation segments and control segments were used to determine whether those who read a refutation text would allot less attention than those who read a non-refutation as hypothesized, possibly due to refutation segments acting as advanced organizers. They found that those who read the refutation text did give less attention to segments that contested their prior knowledge than those who read the corresponding segments in the non-refutation text. Based on total fixation time on text segments presenting the accurate conception, the results indicated that those who read the refutation text fixated on those segments longer than those who read the non-refutation text, which they suggested may be due to the refutation structure of the text directing readers to the new information to be learned thus slowing cognitive processing of the sentence while the reader tries to resolve and integrate conflicting information. Look-back fixation time on the sentences containing scientifically accurate information during second-pass reading was greater for those who read the refutation text. They suggested that this re-inspection of conflicting information would reflect the strategic, conscious effort to resolve inconsistencies between prior knowledge and the scientifically accurate knowledge presented in the text. Finally, results indicated that although prior knowledge and reading times did not explain off-line learning in the refutation text group, the three key eye movement indicators used in this study could account for a great deal of the variance in off-line learning. The more processing time spent by the reader on text segments that contradicted their prior knowledge and those that explained the new scientifically accurate conception, the greater the learning outcome. However, in regards to total reading time, those who spent more time reading the text experienced lesser gains in conceptual knowledge. For those who read the non-refutation text, prior knowledge and reading time did account for much of the variance in the learning outcome. However, the three key eye movement indicators used in this study did not predict the learning outcome. Thus, most of the variation in conceptual understanding at posttest for those who read the non-refutation text was predicted by prior knowledge.

In a series of two studies conducted by Penttinen, Anto, and Mikklia-Erdmann (2011), comprehension processes while reading refutation text were further examined. In the first study, a case study approach was first used to investigate the conceptual change learning regarding photosynthesis of one participant. Fifteen Finnish, undergraduate, education students then read an expository photosynthesis related text, while their eye movements were being tracked. They were then asked to explain their eye movements. Results of the first study indicated that participant responses could be categorized into either text base construction (i.e. indications of memorization of text, and also thoughtful processing of text without connections beyond text) or situation model construction (i.e. moving beyond just text comprehension to elaboration, or comparing to prior knowledge). Twenty-three Finnish, undergraduate education students participated in the second study. The procedures were the same as in the first study with the exception that participants also read a related one page refutation text passage refuting three common misconceptions before reading the expository text, in an effort to increase their awareness of their prior conceptions and enhance the likelihood for conceptual change. Results indicated that the ten participants who experienced conceptual change spent more time reading than the three participants who did not experience conceptual change. The ten participants who already held the correct scientific conception at pretest exhibited the shortest reading times. Those who experienced conceptual change also exhibited more text base construction.

As indicated by the previous research discussed, it is likely that readers may exhibit shorter reading times for the refutation segments of text (as compared to their average reading times), whereas they are likely to exhibit longer reading times for text segments introducing the correct scientific information when reading a refutation text as compared to those reading a traditional expository text. One reason may be that the refutation segment may act as a necessary advanced organizer, which may reduce the amount of attention that readers allocate as reflected by shorter read times of refutation segments (Ariasi & Mason, 2011). The time taken to read the following text segment containing the correct information may then be longer for those who read the refutation text as compared to those who read a non-refutation text, as they work to integrate the new information and resolve the inconsistencies between their prior knowledge and the new knowledge presented, after the inconsistency is flagged by the prior refutation statement.

A wealth of previous research indicates that in regards to various text formats, refutation text is highly effective in persuading individuals to change their conceptions and beliefs. It is also generally preferred to other text formats by readers. Based on the research reviewed herein, an effective refutation text should not only be clear, credible, and easy to comprehend, but it should specifically 1) activate prior misconceptions in prior knowledge, 2) contain a direct, explicit refutation statement, 3) present the correct scientific conception along with the incorrect misconception, and 4) be written in expository language. It is likely that the simultaneous activation of prior knowledge (including misconceptions) and the new, scientifically accurate conception likely accounts for much of the effectiveness of refutation text (Kendeou & van den Broek, 2008). Through this simultaneous activation of misconceptions and presentation of conflicting scientific information, refutation text may more effectively capture the reader's attention by creating surprise and/or interest (Broughton et al., 2010; Cordova, Sinatra, Jones, Taasoobshirazi, & Lombardi, 2014).

Given the effectiveness of refutation text in conceptual change learning, researchers have begun to investigate the use of other instructional tools in augmenting the refutation text effect. For instance, Danielson, Sinatra, & Kendeou (2016), used graphics and analogies to augment the effect of refutation text. Another common instructional tool often used in learning, although thus far, not specifically examined within the context of conceptual change learning, is performance-based feedback, to which I now turn.

Section 2

Performance-based Response Feedback in Learning

Performance-based feedback can be a very important source of information for learners. In fact, Brooks, Schraw, and Crippen (2005) suggest that effective instruction almost always involves providing some type of performance-related feedback, which links the student's actions and the response. Feedback is a key component in most theories of learning (Bangert-Drowns, Chen-Lin, Kulik, & Morgan, 1991). When delivered effectively, it should enhance learning processes, as well as outcomes (Shute, 2008). Feedback has the power to help students overcome misconceptions, restructure their knowledge, improve academic performance, facilitate metacognitive monitoring, and increase motivation (Wang & Wu, 2008). It can help a learner recognize a discrepancy between their current performance/knowledge and the desired performance/response. When feedback helps the learner to resolve this discrepancy, it may also enhance effort and motivation (Shute, 2008).

According to Brooks et al. (2005), giving students response feedback after they respond to problems has been demonstrated to be especially effective in computer-assisted instruction. It is possible that feedback may be particularly impactful in a computer-based learning environment because it can be given immediately, which allows for any inconsistencies between the learner's response and the desired response to be immediately addressed, for instance, while they are taking a test. Mason and Bruning (2001) point out that one of the most crucial results of feedback is that it assists learners in recognizing their errors and realizing the misconceptions they have. This could make feedback a potentially invaluable tool when the learning goal is related to belief or conceptual change. In addition to helping learners assess the expected performance, gauge their degree of knowledge/understanding, and detect their misconceptions, another important characteristic of feedback highlighted by Mason and Bruning is its ability to motivate further learning.

Summary of Relevant, Common Types of Response Feedback

Different types of feedback have different effects. Three common types of feedback often used in traditional instruction include the following. Knowledge of results (KR) is feedback that simply tells the learner if the response given is correct or incorrect. Knowledge of correct response (KCR) informs the learner of the correct response. Elaborated feedback (EF) provides further explanation or extended relevant information. It usually focuses on the correct response, may explain why a response is incorrect, and may reveal what the right answer is (Shute, 2008).

KR is usually not as helpful as KCR or EF as it contains less information. KCR and EF both generally give information regarding the correct response with KCR directly informing the learner of the correct response. However, EF typically goes a step further in terms of informativeness and is generally most effective. Elaborated feedback in the type of feedback employed in the present study.

Although most types of feedback provided in computer-based environments contain verification as to whether an answer is correct or incorrect, the degree and type of elaboration provided varies widely. Three main types of elaboration include informational, topic-specific, and response-specific elaboration. Informational elaboration is the least specific. It provides relevant information that can be used by a learner to infer the correct answer, without actually providing the correct answer or information about incorrect answers. Topic-specific elaboration presents more specific information about the question/topic, but doesn't specifically address incorrect answers. Response-specific, on the other hand, is the most specific in that it addresses both incorrect responses as well as the correct answer. It explains why a chosen answer is incorrect and tells the learner what the correct response should be. Some research indicates that of the three types of elaboration used, response-specific feedback likely facilitates academic performance most (Mason & Bruning, 2001).

Based on both verification and elaboration, Mason and Bruning (2001) highlight eight general feedback approaches that can be used individually or in combination in computer based instruction. These include no feedback, knowledge of response, answer until correct, knowledge of correct response, topic contingent, response contingent, bug related, and attribute isolation feedback. No-feedback contains neither verification nor elaboration. Learners may receive an overall performance score but receive no information regarding specific test items. As previously mentioned, knowledge-of-response feedback is feedback that simply tells the learner if the response given is correct or incorrect. Answer-until-correct feedback provides verification, but not elaboration. It requires the learner to answer an item correctly before moving on to the next item. Again, knowledge-of-correct-response feedback informs the learner of the correct response, with no elaborated information. Topic-contingent feedback provides verification and some general elaboration. If a learner provides an incorrect response, they are either returned to the location in the learning material containing the correct response or may be given further information from which they can determine the correct response. This type of feedback requires the learner to discover the right answer. Response-contingent feedback (also called extra-instructional feedback) provides verification and more item-specific elaboration. Upon giving an incorrect response, learners are told why the answer is incorrect, what the correct answer is, and why it is correct. Bug-related feedback provides verification and elaboration regarding the specific errors made. It doesn't give the learner the correct answer, but it does give them information regarding specific systematic errors made so that they can obtain the correct response. Attribute-isolation feedback provides verification and elaboration regarding key characteristics of the target concept to improve understanding.

Theory on the Role of Feedback in Learning

One influential model of feedback in text-based instruction was proposed by Kulhavy and Stock (1989). They proposed that there are three cycles that comprise the feedback process. In the first cycle, the learner is given a task to which he or she must respond. In the second cycle, the learner is provided feedback based on their response in the first cycle. In the third cycle, the task is again presented as a test item to which the learner is expected to respond. Each cycle involves the learner processing task-related input, comparing the input to some standard, and then constructing a suitable response. A learner's confidence in their response (response certitude) is a key factor in this model. Based on this model, the learner is assumed to assess their confidence in their response during the first cycle based on their prior knowledge and understanding of the task. The discrepancy between the feedback provided in the second cycle and their confidence in their initial response provided in the first cycle will impact the amount of time and effort a learner will expend on correcting errors. According to their model, those who are highly certain their response in the first cycle is correct who have their response verified as correct through feedback should spend the least time processing elaborated feedback. Those with high response certitude whose responses are confirmed incorrect should exert the most time and effort in an attempt to resolve the discrepancy. Those with low certitude, regardless of whether their answer is incorrect or correct, may or may not understand the material presented and may spend more or less time processing the feedback. This certitude model of feedback in text-based learning has been supported by research. Those who are highly confident in correct responses tend to spend less time processing feedback, while those who are highly confident in incorrect responses tend to spend more time processing feedback, and those with low response certitude generally demonstrate processing times in between (Kulhavy & Stock, 1989; Kulhavy, White, Topp, Chan, & Adams, 1985; Kulhavy, Yekovich, & Dyer, 1976).

Similar to Kulhavy and Stock's response certitude model (1989), Butler and Winne's (1995) model of self-regulated learning proposes that students "filter" the external feedback they receive through their current knowledge and beliefs. They also suggest that feedback influences learning through monitoring of cognitive processes and products, in that monitoring (e.g. becoming aware of discrepancies in knowledge) may influence the goals a learner sets, which may impact the learner's cognitive processes (e.g. feedback processing time), which in turn, may influence performance. Indeed, research indicates that depending on a learner's goals, greater perceived discrepancies between a learner's confidence in their response (certitude) and the correctness of an answer as indicated by the feedback provided are often associated with greater feedback processing times and a greater likelihood of correcting incorrect answers upon retesting (Hancock, Stock, & Kulhavy, 1992; Kulhavy & Stock, 1989; Schultz, 1993).

Butler and Winne (1995) propose five roles feedback can play. First, feedback can confirm understandings or beliefs when they are consistent with instruction. Second, if students lack knowledge, feedback can help learners increase or elaborate their prior knowledge. Third, when learners hold incorrect or inappropriate prior knowledge or beliefs, feedback can help learners replace their prior knowledge/beliefs. Fourth, if a learner's knowledge is mostly correct, it can help learners fine tune their understandings. Fifth, if students hold incorrect theories/prior knowledge that conflict with the new information to be learned, as is the case in conceptual change learning, feedback may help the learner restructure their mental representation of a concept.

Research Regarding Feedback, Academic Performance, and Motivation

Historically, much research has been conducted on the role of feedback in academic performance. One often cited meta-analysis of feedback effects was conducted by Bangert-Drowns et al. (1991) to examine the features and effectiveness of feedback. They analyzed 58 effect sizes from 40 studies, mostly conducted between 1960 and 1990. They found that feedback effects vary by instruction type, use of pretests, feedback type, and whether or not learners were able to look ahead at the answers. They found a large range in effect sizes, including some negative effects. Due to a number of factors that will be discussed, the overall mean effect size of the studies indicated only a small, positive role of feedback in academic performance.

Although confounded with instruction type, whether or not learners were able to look ahead at answers (also called pre-search availability) was highly related to effect size. When learners were not allowed to look ahead, feedback made a significant positive contribution to performance. However, allowing learners to look ahead at the answers significantly weakened the effect of feedback. In terms of type of instruction, feedback regarding text comprehension and test performance had a large effect on performance. Feedback in programmed instruction yielded the lowest effect size, which may have been partially accounted for by whether learners were allowed to look ahead to the answers. Immediate feedback seemed to result in lower effect sizes than delayed feedback, however, this is likely also related to programmed instruction as well, as timing of feedback was also confounded with instruction type. Bangert-Drowns et al. (1991) found that methodological design was another factor related to effect size, with pretesting seemingly related to lower effects of feedback, as compared to studies that used posttest data only. They also found a marginally significant effect of feedback by feedback type, with knowledge-of response feedback having little to no effect, and knowledge-of-correct-response feedback having a higher effect on performance. Their results indicated that for feedback to be effective, correction should be provided in conjunction with knowledge of whether the response was correct or incorrect.

Overall, the results of Bangert-Drowns et al. (1991) meta-analysis indicates that two of the main feedback-related factors that account for the most variance in performance are whether or not learners were allowed to look ahead to the answers and feedback type. They found that the studies that produced the highest effect sizes were those that “controlled for pre-search availability, used corrective feedback, did not administer a pretest, and focused on text comprehension or classroom testing," (p. 229), whereas studies that failed to use at least one of these features showed no feedback effect.

Based on their meta-analysis of feedback effects from 40 research studies, Bangert-Drowns et al. (1991) suggested that feedback is effective for learning IF it facilitates "mindful reception" by the learner; that is, if it prompts the learner to attend to the information provided and think about the underlying meaning and significance to the task at hand. They proposed a five-stage model demonstrating the effect of feedback. The first stage represents the current condition of the learner, including their interest, self-efficacy, goals, prior knowledge, etc. Second, search and retrieval strategies are initiated by questions during or after instruction. Third, a response is constructed by the learner. Fourth, the learner evaluates their response based on the feedback provided. Finally, the learner adjusts their knowledge, goals, interest, self-efficacy, etc.

Kluger and DeNisi (1996) conducted another meta-analysis of approximately 470 effect sizes from 131 studies that included feedback interventions. They also found wide variability in effects with an average effect size of 0.38 and approximately 32% negative effects. They suggested that feedback interventions represent a bit of a "double-edged sword" in that though generally productive for learning, they do not always lead to better performance, and in some cases may actually be detrimental to learning. They found that feedback interventions that direct attention to the task, task learning, or task motivation are generally productive for learning and performance, whereas feedback interventions, such as praise or discouragement that direct the learner's attention toward other self-related goals (and away from the task at hand) may not be (e.g. feedback that leads the learner to concentrate on evaluating a teacher's intentions or overall class grade, for instance, rather than the task). They also found that feedback is generally most effective when it provides information on correct answers, when it builds on changes from previous trials thus increasing motivation, and does not threaten self-esteem. Computerized feedback was also generally more productive for learning than that provided verbally by a person, as it is likely more task-focused. The results further support the notion that some forms of feedback are much more effective than others and the importance of choosing feedback carefully.

The meta-analyses conducted by Bangert-Drown et al. (1991) and Kluger and DeNisi (1996) represent just two of the meta-analyses that have examined studies of feedback in education. As indicated by Hattie and Timperley (2007), a number of meta-analyses have included information on feedback in classroom learning. Overall, these meta-analyses have examined approximately 196 studies with approximately 6,972 effect sizes. Although they all demonstrate high variability, the overall effect size of 0.79 has led some to characterize feedback as one of the top 5 to 10 most influential factors in classroom-based learning and achievement (Hattie & Timperley, 2007).

In addition to examining the role of feedback in learning, feedback researchers also examine the role of motivational variables in the effectiveness of feedback, as well as the impact of feedback on motivation. For instance, Narciss (1999) sought to examine the motivational effects of different types of feedback in a computer-based learning environment. She expected that the informativeness of feedback provided could impact self-efficacy, perceptions of performance, persistence, and concept formation. One hundred and fifty six undergraduate students participated. Participants completed an achievement motivation questionnaire, then completed Bruner's concept-formation task. Participants received one of three types of feedback each time they suggested a concept. Feedback conditions included KR feedback (low informativeness), knowledge of mistakes feedback (medium informativeness), or knowledge regarding how to continue (high informativeness). Results indicated that those who received highly informative feedback significantly outperformed those who received low information. The covariates of self-efficacy and “need of achievement” had no effect on performance. Using self-efficacy and “need of achievement” as covariates, there were also no significant effects of feedback on task persistence. However, when self-efficacy was used as a between-groups factor (high, medium, and low), there was a significant effect. Those with high self-efficacy who received highly informative feedback significantly outperformed those who received low informative feedback. Also using self-efficacy and “need of achievement” as covariates, there were no significant effects of feedback on performance satisfaction. However, when self-efficacy was used as a between-groups factor (high, medium, and low), there was a significant effect. Those with high self-efficacy who received highly informative feedback were significantly more satisfied with their performance than those who received low informative feedback. The results of Narciss’s (1999) study indicate that more informative feedback may facilitate higher academic achievement and suggest that a learner’s individual motivational factors, such as self-efficacy, may impact persistence and performance satisfaction.

The term informative tutoring feedback (ITF) refers to a type of complex elaborated feedback that gives the learner information they can strategically use to successfully complete a task (Narciss, 2004). For instance, this type of feedback can help the learner detect errors or use better cognitive strategies. Some examples include providing signals, cues, and hints for retrieving information, hints regarding potential error sources or successful strategies to use, examples, etc. In contrast to traditional elaborated feedback, ITF are presented without immediately providing the correct response. ITF also allows the learner the chance to try again. Narciss (2004) conducted two experiments to investigate whether ITF maintains motivation and contributes to performance, as well as the role of self-efficacy in task effort and completion when learning with ITF. One hundred and eighty six German undergraduate students participated in the first experiment which involved completing concept identification tasks. Participants had the option to complete as many concept identification tasks as they wanted to, could spend as much time on a task as they chose, and could cancel a task anytime they wanted to. Between subject variables included 3 feedback conditions (KR; KR and information on the location of the error; KR, information on the location of the error, and information on how to proceed) and 3 self-efficacy groupings by level (low, medium, high). Data regarding task engagement (number of tasks worked on), persistence (percentage of tasks completed), effort (time on task), and concept identification performance (number of tasks successfully completed) were collected, as well as self-report data regarding performance satisfaction. The results indicated that although there was not a significant interaction between self-efficacy and feedback and no significant effect of feedback type, there was a significant effect of self-efficacy group, which had a significant effect on persistence, effort, and performance, but not on engagement. Students with medium or high self-efficacy cancelled less tasks and those with high self-efficacy performed significantly better and were significantly more satisfied with their performance than those with low or medium self-efficacy. Results also indicated that those with high self-efficacy who received ITF demonstrated higher task engagement and performance that those in the other groups. This may suggest that when giving participants the choice as to the number of tasks they could engage in and the effort and persistence exerted, that ITF fostered engagement and performance for those with high self-efficacy only, and that the study design allowing for those choices did not foster enough engagement for those with low and medium self-efficacy to experience successful performance and satisfaction.

Therefore, in the second experiment conducted by Narciss (2004), standard time constraints were set for the 90 technical college students who participated, though the other conditions remained largely the same. One exception is that only two feedback conditions (KR, ITF) were used. Results comparing participants from experiment one and participants from experiment two indicated that those in experiment two who were given a set amount of time demonstrated higher engagement and effort, but less persistence. The second experiment revealed a significant effect of feedback, as well as self-efficacy, though no significant interaction between the two variables. Results indicated that those who received ITF exhibited higher engagement, effort, and satisfaction with performance. Results also indicated that those with high or medium self-efficacy displayed higher engagement and performance satisfaction. Those with high self-efficacy demonstrated greater performance.

Overall, the results of the two experiments (Narciss, 2004) indicate that certain types of elaborated feedback, such as ITF, may be beneficial for both motivation and achievement, especially when learners are required to engage in a task for a specified length of time. If students are able to end a learning task before they have engaged with the material for a reasonable amount of time, feedback may not be effective. Factors that indicate learner motivation may therefore be important to consider in studies of feedback effectiveness.

Narciss and Huth (2004) delineated a framework for designing informative tutoring feedback based on the research regarding elaborated feedback that may be helpful when designing other types of elaborated feedback as well (even if not ITF). They proposed that for feedback to be effective, one must take into account the instructional objectives (e.g. learning goals, tasks, typical errors, etc.), the learner (prior knowledge, skills, motivation, etc.), and feedback factors (e.g. purpose, content, presentation format/timing, etc.). They suggested that the value of the feedback will be determined by learner characteristics and instructional goals, which must be considered when designing the feedback content and format.

In their discussion of designing bug related tutoring feedback (BRT) (a type of complex ITF that concentrates on helping students detect and fix errors through providing information for error correction without providing the correct response and allowing for multiple response tries), Narciss and Huth (2006) suggest three goals in designing feedback from an ITF framework. The first includes choosing feedback that can help the learner correct errors without giving them the correct response. In this regard, the ITF framework suggests that three things contribute to a feedback message's quality (Narciss & Huth, 2006). These include the functional features regarding the instructional role of the feedback (e.g. reinforcing correct responses, indicating a discrepancy between response and desired response, initiate and/or maintain motivation), the technical features regarding the presentation of feedback (e.g. timing, amount, mode) and the content of the feedback. Therefore, it is important to be aware of the typical errors made, where they originate, and what cognitive tasks are required to correct the error.

The second goal involves making sure the learner will "mindfully" process the feedback. Therefore, guidelines offered by the ITF framework include not providing feedback until after the learner has constructed their response, not presenting the correct response right away with the elaborated feedback, providing the elaborated feedback in steps and giving learners the chance to try to apply this information again, using a mastery level learning criterion to assess performance, and presenting complex feedback auditorily when possible to prevent interference (Narciss & Huth, 2006). The final goal involves studying the effects of various feedback types while testing for differential effects of individual difference characteristics (such as motivational characteristics) and various conditions.

Narciss and Huth (2006) conducted a study of the role of bug-related tutoring feedback in math achievement and motivation with 50 fourth graders in a computer-based learning environment. The results of a preliminary study of "systematic errors" (errors that can be explained based on the task requirements and the usual incorrect strategies used) in written subtraction conducted with 76 German third graders in conjunction with prior research indicate that most errors in written subtraction happen systematically (Huth, 2004). Procedural hints were then developed which indicated the error location, type of error, correct strategy, and a worked example of unsystematic errors. From this, a BRT-feedback algorithm was developed with three feedback stages. The first stage was KR feedback, with a message to try again if the response was incorrect. The second indicated the error location and provided a strategy hint if a systematic error was detected or a worked example if the error was not systematic. In each case, the learner was given the opportunity to make a third attempt to apply the corrective feedback. In the third feedback stage, the error location was indicated, the accurate step by step procedure was presented visually and auditorily, and then the correct solution was presented at the same time as the incorrect solution so the learner could compare. A new task type was presented only after mastery was achieved. This BRT feedback algorithm was compared to a two-stage feedback algorithm presenting KR feedback after the first incorrect response followed by KCR feedback after the second incorrect response. They predicted that the BRT-feedback would be superior to KR-KCR feedback for correcting errors and achievement, as well as motivation (performance satisfaction, as well as perceived effort, task difficulty, task enjoyment, and learning progress). The results indicated that learners who received BRT-feedback achieved mastery for more tasks, corrected more errors from pretest to posttest, demonstrated higher performance at posttest, and rated their motivation as higher than those who received KR-KCR feedback.

The results suggest that some types of elaborated feedback, such as the BRT-feedback provided in this study, may facilitate successful task performance as well as motivation, which is in line with current motivation theories. Mastery experience facilitated by BRT-feedback may have promoted perceptions of competency, thus helping to foster motivation (Narciss & Huth, 2006; Bandura, 1997). The results of this study, in conjunction with theory and previous research, indicate that task-related elaborated feedback that can be strategically used to correct errors and facilitate mindful processing may have a positive effect on both academic achievement and motivation to learn more (Narciss, 1999; Narciss, 2004; Narciss & Huth, 2006).

Vollmeyer and Rheinberg (2005) also suggested that feedback should have a positive impact on motivational state and the use of more effortful strategies, which in turn should mediate the effect of feedback on learning. Two hundred and eleven high school and undergraduate psychology students participated in their study. Half of the students received minimal feedback about the number of links they identified while completing a biology-lab task, while half did not. Surprisingly, results indicated that motivational state did not mediate the effect of feedback on achievement. However, effortful systematic strategy use did. They found that strategy use predicted motivational state and that motivational state predicted performance. Therefore, they concluded that learners who were told they would receive feedback chose to use a more systematic strategy in the learning task, which positively impacted their motivation while learning, thus resulting in greater achievement.

Gao and Lehman (2003) examined the effects of web-based instructional materials with three different levels of interaction, including a control group with little interaction (n=34 college students), a reactive interaction group who received immediate elaborated feedback (n=30 college students), and a proactive group who participated in a generative activity (n=31 college students), on academic achievement, time on task, and motivation toward learning materials. In regards to achievements, they found that students in both interaction groups outperformed the control group, with no difference between the reactive and proactive group. In regards to motivation, the reactive group who received immediate elaborated feedback showed more motivation toward the materials than the control group, with no difference between the proactive group and the other two groups. Specifically, reactive group demonstrated higher attention and satisfaction with the learning materials than the control, with no difference between the proactive group and the other two groups. Both the reactive and proactive group demonstrated significantly more time on task than the control, with no difference between the two. Interviews with students from each group revealed that those in the reactive group were positive toward the elaborated feedback. They thought it reinforced what they read, clarified mistakes, allowed them to know what the correct answer was immediately, and motivated them to learn. Those in the generative group gave mixed reactions. Whereas about half thought the generative activities encouraged them to reflect on what they learned, and review the content, the other half were negative toward the generative activities. The results indicate that immediate elaborated feedback may enhance student interaction and engagement with the content, thus facilitating mindful processing, learning, and motivation toward the learning materials.

In their study of web-based learning, Wang and Wu (2008) investigated the relationships among feedback, self-efficacy, learning strategy use, and academic performance. Seventy-six pre-service teaching students from a university in Taiwan were given a homework assignment to be completed and uploaded, along with questionnaires regarding their self-efficacy and the cognitive strategies they used. Homework was then sent anonymously to other students in the class to provide feedback. Students were given the opportunity to revise homework based on the feedback and again upload it into the system, along with again completing the questionnaires. Feedback provided was analyzed and categorized by type, including KR, KCR, and elaborated feedback. In regards to the effect of self-efficacy on learning behaviors and performance, the results indicated that self-efficacy did not predict feedback given. However those who provided elaborated feedback had higher self-efficacy than those who did not. Students with higher self-efficacy used more and higher level learning strategies. Self-efficacy was not, however related to assignment scores. In regards to the effect of feedback on academic performance and self-efficacy, results indicated that students performed better on revised assignments after receiving peer feedback. Whereas KCR predicted improved performance, however, KR and elaborated feedback did not. Those who received more elaborated feedback demonstrated a significant increase in self-efficacy. Some of the results, particularly the finding of no effect of elaborated feedback on performance should probably be interpreted carefully as each student received feedback from one different peer, rather than carefully designed elaborated feedback from an instructor. This result is not consistent with previous research and it is possible that this may be explained by the quality and structure of the elaborated feedback provided.

Dujnhower, Prins, and Stokking (2012) conducted a study of feedback and feedback reflection on writing process (planning/revising, effort, help-seeking), performance, and motivation (self-efficacy, mastery goal, and performance goal). Eighty-two undergraduate students receiving either feedback with improvement strategies (41) or feedback without improvement strategies (41) were included in their analyses. Of those who received feedback with improvement strategies (experimental feedback condition), twenty-one were given a reflection assignment asking students about their intention to use the feedback, while twenty in a control feedback condition were asked to reflect on their perceptions of the feedback. Of those who received feedback without improvement strategies (control feedback condition), twenty-three received the experimental reflection assignment and eighteen received the control reflection assignment. A subset of eleven students (2 to 3 from each group) also participated in interviews. There were no significant main effects of feedback. Oddly however, an interaction suggests that those who received feedback with improvement strategies gained from the control reflection, while those who received feedback without improvement strategies gained from the experimental reflection. There were no effects of feedback or reflection on writing processes or motivation. Although no differences in self-efficacy were found by feedback, results indicated that a higher number of improvement strategies provided predicted lower self-efficacy and that improvement strategies were more detrimental to self-efficacy for those with low to moderate self-efficacy. The number of improvement strategies provided helped predict student planning/revising as well, with more strategies predicting more planning/revising. Number of strategies was not predictive of effort, help-seeking, or goals. Results indicated that the number of reflections predicted mastery goal orientation when it was initially low to moderate. Interviews revealed that those who received feedback with strategy improvement had mixed feelings toward the strategies. Most didn't see them as motivating or demotivating. Some appreciated the suggested strategies and found them helpful; others, however did not, particularly when it was a strategy they already knew, was perceived as too time-consuming, were not in line with their own writing habits, or were perceived as an indication the teacher didn't think they could resolve the problem on their own. It seems that while both feedback with improvement strategies and reflection regarding intention to use feedback were in some instances beneficial to performance, when combined, they were not effective. Maybe because both lead to contemplation about one's own writing approach, together they may have hindered the writing process. In regards to more improvement strategies provided predicting lower self-efficacy, the findings from the interviews may suggest that this is because students interpreted the number of strategies provided as an indication that the teacher thought they could not come up with the strategies on their own for those who already had relatively low self-efficacy. This reduction in self-efficacy may have played a part in negatively impacting the benefits of improvement strategies when coupled with additional reflection on their intentions to use the feedback. Although it may seem that feedback with improvement strategies should have positively impacted achievement motivation, it is possible that students' somewhat negative interpretations of the strategies provided may have led to no impact on goals, as well. The results highlight the importance of aligning feedback with improvement strategies to individual student capabilities for it to be effective. Although reflections regarding feedback may sometimes be effective, when coupled with feedback containing improvement strategies, they may be counterproductive.

Van der Kleij, Eggen, Timmers, and Veldkamp (2012) examined the effects of written response feedback (immediate knowledge of correct response + elaborated feedback, delayed knowledge of correct response + elaborated feedback, and delayed knowledge of results) in a computer-based assessment. They also examined differences in cognitive processing of feedback as indicated by feedback reading times and the impact of individual student characteristics (attitude and motivation) on cognitive processing with 152 first-year undergraduate Economics students. They found no significant differential effects of feedback on learning. However, they found differences in perceived usefulness of computer-based assessments and the degree to which students thought the feedback facilitated learning among the feedback types. Those who received immediate knowledge of correct response + elaborated feedback found computer-based assessments to be most useful, followed by those who received delayed knowledge of correct response + elaborated feedback. Those who received delayed knowledge of response feedback only did not find computer-based assessment as useful as the other two groups. Those who received immediate knowledge of correct response + elaborated feedback felt they learned more from feedback in a computer-based assessment than knowledge of response only. There was no difference between either of the delayed feedback conditions. Results also indicated that those who received immediate knowledge of correct response + elaborated feedback spent significantly more time reading the feedback than those in the other two conditions, with no significant difference between those who received elaborated feedback at delay and those who only received knowledge of response. Those who received immediate knowledge of correct response + elaborated feedback also stated that they paid more attention to the feedback, and were more likely to read the feedback when they guessed at a response. Results also indicated that students paid more attention to feedback when their response was incorrect. Students who received either immediate or delayed knowledge of correct response + elaborated feedback exhibited significantly more positive attitudes toward the feedback than those who received only knowledge of response. There were no significant differences between the groups in regards to their rating of assessment difficulty. Student motivation to learn the subject was about the same for all groups, with students generally motivated to learn more. Both student attitude and motivation were positively correlated with feedback reading time. The results of this study indicate that students likely prefer immediate to delayed feedback and more informative, elaborated feedback and that those who received immediate, elaborated feedback were most likely to spend time processing the feedback. Positive student attitudes and motivation were also related to more time spent reading the feedback.

Timmers, Braber-van den Broek, and van den Berg (2013) used Bangert-Drowns et als.' five stage model (as previously described) to investigate learner's initial task-value and success expectancy beliefs (initial motivational state of learner), student effort (assessing prior knowledge and response construction), and feedback behavior (evaluation) in computer based assessment of information literacy. One hundred and fifty one first year undergraduate health students participated. Results indicated that 75% of the students sought additional feedback. Overall, students thought the assessment was more difficult than they expected it to be. Results indicated a positive relationship between task-value beliefs and effort, though no relationship was found between success expectancy and effort. Feedback-seeking behavior was positively related to task-value beliefs and success expectancy before completing the assessment. However, total feedback study time was not related to task value beliefs or success expectancy. The results of this study indicate that task-value beliefs and success expectancy may also be important motivational factors to consider when designing computer based assessments.

Feedback plays a key role in learning. It helps learners: ascertain what the expected performance is; gauge their level of comprehension/performance; and, especially essential to conceptual change learning, detect misconceptions/errors and recognize discrepancies between their current understanding and the desired understanding. Research indicates that the effects of feedback may be mediated by individual characteristics, such as attitudes, goals, response confidence, and self-efficacy. Along with feedback features (timing, format, content, etc.), these individual characteristics also may help account for some of the variability found in feedback effects. In addition to helping a learner restructure or elaborate their knowledge, both theory and research indicate that feedback may also impact motivation such as students' self-efficacy, their attitude and motivation toward the learning materials used, and their motivation toward future learning.

Due to the variability in feedback effects, one must carefully consider several factors when designing/choosing feedback. As discussed previously, it is important to consider the type, timing, mode, focus, instructional objectives, content, whether or not learners can look ahead to the answers, etc. in addition to individual learner characteristics of the target audience. For instance, research indicates that immediate feedback that is more informative with information regarding incorrect and correct responses, and task-focused is likely preferred, and may promote more mindful processing, and thus be more effective. Looking ahead at the correct answers should not be allowed, and the feedback should not threaten self-esteem.

Augmenting the Refutation Text Effect through Elaborated Feedback

Because of the importance of the refutation statement in flagging inconsistencies between current and preferred beliefs and because refutation text has been demonstrated to be such a time-efficient, highly effective avenue through which changes in beliefs, attitudes, and conceptions can be facilitated, it is important to consider alternative ways to incorporate refutation text/activities into learning for conceptual change, as well as ways to further augment the effectiveness of refutation text. One way to augment the effectiveness of refutation text on learning, particularly conceptual change learning, may be through the use of specialized elaborated feedback. As discussed previously, research indicates that feedback, which plays a key role in learning, can help a learner detect their own misconceptions and recognize a discrepancy between their current performance and the desired performance. In addition to helping a learner restructure or elaborate their knowledge, when feedback helps the learner to resolve the discrepancy between their prior beliefs/knowledge and the preferred view, it may also enhance effort and motivation toward future learning.

Depending on a learner's goals, greater perceived discrepancies between a learner's confidence in their response (certitude) and the correctness of an answer as indicated by the feedback provided are associated with greater feedback processing times and a greater likelihood of correcting incorrect answers upon retesting. This could be especially effective when used with refutation texts in conceptual change learning, as the mindful processing of elaborated feedback may help the learner further recognize the incongruence between their current beliefs and the correct scientific conception, and give learners an additional opportunity to further restructure their knowledge. The awareness of this further restructuring of knowledge to be more in line with the accepted scientific view by the learner as facilitated by the feedback may be perceived as a successful learning experience by the learner, and may thus also further increase their self-efficacy and interest for learning more about a topic.

As discussed previously, feedback that is highly informative, task-centered, response-specific, and does not threaten self-esteem is most effective for promoting mindful processing. With this in mind, there are a number of features from refutation text that may be particularly beneficial when incorporated into elaborated feedback. For instance, functionally, a refutation statement followed by the co-presentation of the common misconception along with the scientifically accurate conception could further facilitate the identification of the discrepancy between current beliefs and preferred beliefs. This approach would likely be highly informative to the reader, as it would give them information on both the incorrect and correct responses. However, because it doesn't actually explicitly say whether the chosen response is correct or incorrect, it is likely to promote more mindful processing. Using techniques commonly used when constructing refutation text, feedback statements can also be worded in such a way as to possibly reduce the threat to self-beliefs. For instance, stating something like, "Many people believe… However, this is incorrect…" followed by the correct conception as is often used in refutation texts, may appear less threatening to a learner than being explicitly told the specific response they provided is wrong. The mindful processing of feedback using refutation statements is likely to lead to greater recognition of inconsistencies between incorrect responses and the desired response as well as gains in performance, effort, and motivation (for example: interest, and self-efficacy) for learning more about a given topic.

Section 3

Motivational/Engagement Variables

Interest. Interest is one factor that may help enhance motivation and facilitate the use of self-regulation skills (Hidi & Ainley, 2008). Interest tends to have a positive effect on attentional processes, effort, persistence, learning, strategy selection, and achievement goals both while engaging in a task, and in selecting tasks (Hidi & Ainley, 2008). Interest is thought to develop through four phases starting with a "triggered situational interest", followed by "maintained situational interest, emerging individual interest, and well-developed individual interest" (p. 80, Hidi & Ainley, 2008). Making a learning task more interesting and engaging may be one way to enhance motivation (Zimmerman & Schunk, 2008). Choosing more interesting instructional materials, for instance, may increase topic interest and engagement with a learning task. In turn, this triggered interest may positively impact future goals to further engage with the topic.

In addition to its positive impact on learning, research demonstrates that refutation text is generally found to be more interesting than the traditional expository texts used in most science courses (Hynd, 2001). It is possible that refutation text may better trigger a situational interest in a topic than traditional expository text, thus helping to activate further development of interest and self-regulated learning of that topic. Therefore choosing refutation text over the traditional expository text or incorporating refutation text into feedback may not only impact learning, but also may enhance interest in future learning of a topic.

Self-efficacy. Self-efficacy is an individual's domain –specific belief in his or her personal capabilities to plan and successfully carry out the actions necessary to meet a goal (Bandura, 1997). Self-efficacy beliefs are domain specific and are a key construct in promoting learning and engagement (Bandura, 1997; Linnenbrink & Pintrich, 2002). Higher self-efficacy beliefs in a domain are generally associated with more self-regulation and higher performance. Generally, learners with higher self-efficacy are also better at self-regulating their learning, in part due to a more effective use of knowledge and metacognitive skills (Schraw, Krippen, & Hartley, 2006). According to Zimmerman (2000a, 2000b) self-efficacy beliefs enhance a student's motivation for learning through self-monitoring and evaluation, as well as strategy use and goal setting. They impact the amount of effort and persistence a learner is likely to exert during a learning task (Pajares, 1996). Just as elaborated feedback can have a positive impact on the self-efficacy of a learner, so might refutation text, and/or refutation statements incorporated into elaborated feedback. Although it could be possible that learners who read a refutation text may experience low self-efficacy and negative emotions when they realize their prior knowledge is not correct, I think it is more likely that the clear, understandable, repetitive, relatable format through which refutation text presents the scientific explanation may actually reduce levels of negative emotions and increase self-efficacy.

Beliefs. Griffin and Ohlsson (2001) differentiate knowledge from beliefs by defining knowledge as "the comprehension or awareness of an idea or proposition ("I *understand* the claim that humans evolve from early primates") (pg. 1)." Beliefs, on the other hand, are truth-value judgments about a proposition (Griffin & Ohlsson, 2001). Once a proposition is stated, one can either reject it as false, accept it as true, or withhold judgment as to whether they believe the claim is true or false. One's knowledge regarding a concept should precede a judgment of whether it is true or false. However, beliefs sometimes serve a social or affective purpose, and, therefore, it is possible for one to accept or reject a claim, "independent of its coherence with relevant knowledge (p. 2)."

Persuasion research, as discussed previously, typically focuses on changing beliefs and attitudes in areas that are often controversial, such as is the case with climate change related beliefs (Buehl, et al., 2003). Text is one of the major avenue through which persuasive arguments are made when belief change is the focus. Refutation text, as is used in this study, is one of the most effective forms of persuasive texts for promoting belief change (Guzzetti et al., 1993; Hynd, 2001).

Attitudes. Attitudes are composed of three features, including an attitude object, evaluation, and tendency (Eagly & Chaiken, 2007). The attitude object (climate change in this study) elicits a tendency toward an evaluative attitudinal response with some level of favorability or unfavorability. Whereas beliefs refer to whether or not one accepts a claim as true or rejects it as false, attitudes refer to a more subjective evaluation of a claim/object as positive or negative (Griffin & Ohlsson, 2001). Research indicates that refutation text, as is used in this study, is also effective in promoting attitude change (Hynd, 2001). Although refutation text was not specifically used, Sinatra et al. (2012) did find that persuasive text could be used to impact attitudes toward and behavioral intent regarding human-induced climate change.

Section 4

The Present Study

The purpose of the proposed study was twofold. One goal of this study was to further examine the cognitive processing involved in reading refutation text and elaborated feedback, including whether differences in reading times of instructional materials containing refutation statements might be one potential explanation for differences in conceptual change learning, and belief change. The larger goal, however, was to determine whether elaborated refutation feedback augments the effects of refutation text. To this end, the effects of refutation text and refutation-based elaborated feedback on attitudes, beliefs, conceptual and knowledge learning, and the motivational constructs of self-efficacy and interest were examined.

The effect of feedback on learning and motivation and the effect of refutation text on learning are well-documented. However, no studies have examined the effect of refutation text on a learner's self-efficacy and interest in learning more about a topic or the interaction between refutation text and elaborated feedback on conceptual change learning and motivation. This was the first study to use elaborated response feedback using refutation statements embedded in a multiple choice questionnaire to try to further augment the changes in conceptions facilitated through reading refutation text.

Research Questions

The following four research questions guided this study:

1. What are the effects of text type on reading times across different types of text segments?
2. What are the effects of text type and elaborated feedback on conceptual understanding?

3. What are the effects of text type and feedback on self-efficacy, interest, beliefs, attitudes, and knowledge regarding climate change over time?
4. Is pretest knowledge related to other posttest variables?

Hypotheses

Kendeou and van den Broek (2007) found that participants spent less time reading refutation than non-refutation text, with target sentences containing the scientifically accurate information being read more quickly by those who read a refutation text as opposed to those who read an expository text. However, under further investigation they found that those with misconceptions actually spent more time reading these target sentences than those with no misconceptions when reading the refutation text, but not when reading the expository text (Kendeou & van den Broek, 2007; van den Broek & Kendeou, 2008). Broughton et al. (2010) also found that those who read a refutation text spent less time reading than those who read an expository text. However, unlike Kendeou and van den Broek, they determined that the difference in reading times was likely due to the refutation segments, as those were read more quickly than the corresponding text segments in the expository text. Ariasi and Mason (2011) found that those who read a refutation text spent less time on segments that contested their prior knowledge than those who read the corresponding non-refutation text and more time on the segments presenting the accurate scientific conception. This research lends support to the notion that refutation statements may act as a type of advance organizer, thus directing readers who read a refutation text to spend more time processing the scientific information. Therefore, in regards to my first research question, I expected to find significant differences in the reading times associated with the refutation segments, base text segments, and/or control text segments within and between the texts. I expected to find shorter reading times for refutation segments as compared to base text segments for the group that read the refutation text. I also expected to find a significant difference in the time spent reading the base text segments between the two text groups with those reading the refutation text exhibiting longer reading times for the base text than those who read the traditional expository text.

Although there are a couple of refutation text studies that found no significant difference in conceptual change learning between those who read refutation text and those who read non-refutation text (Kendeou, Muis, & Foulton, 2011; Mikkila-Erdman, et al., 2008), most previous research indicates that refutation text is more effective than the traditional expository text often used in science education (Guzzetti, Snyder, Glass, & Gamas, 1993; Hynd, 2001; Tippet, 2011). Given the effectiveness of elaborated performance-based feedback in instruction, specifically in its ability to help learners recognize and overcome discrepancies between their actual and desired performance, (Brooks, Schraw, & Crippen, 2005; Butler & Winne, 1995; Shute, 2008), it seemed that incorporating features of refutation text into elaborated performance-based feedback on an assessment might be especially effective when learning a conception involves changing current, inaccurate conceptions. In regards to research questions 2 and 3, I expected that those who read the refutation text and received elaborated feedback would display the greatest conceptual understanding at posttest, and significantly greater gains/changes in knowledge, beliefs, and attitudes regarding the greenhouse effect and climate change than the other three groups. I anticipated that those who read the expository text and received no feedback would likely exhibit the lowest conceptual understanding scores and little to no change in knowledge, beliefs and attitudes. However, given the effectiveness of both refutation text and elaborated feedback, it was unclear how text type and feedback condition might interact. Given the demonstrated effectiveness of refutation text, I thought it possible that those who read the refutation text and received no feedback might outperform those who read the expository text and received feedback, thus displaying larger increases in knowledge, beliefs, and attitudes. On the other hand, it was equally likely that those who read the expository text, but received refutation-based feedback during the assessment intervention might outperform or perform equally to those who read the refutation text alone, as the feedback could act as an additional opportunity for students to become aware of misconceptions they may hold, along with another opportunity to further process the information contained in the expository text in an effort to resolve any inconsistencies in knowledge, beliefs, and attitudes.

Refutation text is generally preferred over non-refutation text by learners (Hynd, 2001; Mason, et al., 2008), and therefore may be more likely to enhance a learner's interest in further engagement with a topic compared to non-refutation text. Immediate, highly-informative, response-specific, elaborated feedback is also likely to promote not only academic achievement, but also an adjustment to goals, self-efficacy, and interest (Bangert-Drowns, Chen-Lin, Kulik, & Morgan, 1991; Gao & Lehman, 2003; Narciss, 1999, 2004; Narciss & Huth, 2006; Van der Kleij, Eggen, Timmers, & Velkamp, 2012). Therefore, in regards to potential changes in self-efficacy and interest in learning more as a result of text and feedback as additionally addressed by research question 3, I thought it likely that those who read the refutation text and received feedback would also show increases in both self-efficacy and interest. I expected those who read the expository text and received no feedback to show no increase in self-efficacy or interest. It was unclear as to whether those who read the expository text and received feedback or those who read the refutation text and received no feedback would show the same increases in self-efficacy and/or interest.

As to the fourth (and final) research question, I didn’t expect the pretest knowledge measure to be correlated in excess of 0.50 with other posttest variables. However, were pretest knowledge correlated in excess of 0.50, I planned to use it as a covariate in some analyses.

Chapter 3: Methodology

Participants and Setting

One hundred and fifty nine students from a large southwestern university in the United States participated in this study to fulfill a research requirement for introductory educational psychology or educational assessment. Participants ranged in age from 18 to 51 (M=23.6, SD=6.02). There were 128 female (80.5%) and 28 male (17.6%) students, with 3 students who did not indicate their gender. The majority of students identified themselves as Caucasian/White (49.7%), followed by Mexican American/Chicano (17 %), and Asian American/Asian (14.5%). Other ethnicities represented included African American/Black (5.7%), Native Hawaiian/Pacific Islander (2.5%) Puerto Rican (.6%), Other Latino (4.4%) and Other (5%). One student (0.6%) did not disclose their ethnicity. In regards to education level, most of the participants were juniors (44%), followed by sophomores (34%), seniors (16.4%), freshman (3.8%), and other (1.3%), with one student (0.6%) failing to indicate their education level. Self-reported GPA ranged from 2 to 4 with a mean GPA of 3.25. Three cases were removed from analyses due to a glitch in the order of materials presented to subjects through the computer software used. Two additional cases were removed because they failed to complete whole portions of the instruments presented. Therefore, the number of participants for analysis was 154.

Design

The study utilized a 2 (type of text: refutation, non-refutation) X 2 (presence of feedback: yes, no) X 2 (time of testing: pretest, posttest) experimental design (Appendix A). The type of text and type of feedback variables were manipulated between-subjects, while the time of test variable was manipulated within-subjects. This design should have controlled for all serious threats to internal validity (Shadish, Cook & Campbell, 2002). The use of control conditions for each factor (non-refutation text; no feedback) in this design should also have helped control for such threats as history, maturation, and testing, for example. The use of random assignment should have helped control for differential selection, thereby allowing for the assumption that any individual differences among participants should have been balanced among groups. Although random assignment should have controlled for differences, given its importance in this study, topic knowledge was also assessed at pretest so that we could control for prior knowledge as a covariate if necessary. Some analyses with posttest scores only use a 2 (type of text: refutation, non-refutation) X 2 (presence of feedback: yes, no) design.

Materials

Independent Variables

Text. One independent variable used in this study was text. Based on the demonstrated effectiveness of refutation text on conceptual change learning, one level of this variable was a refutation text designed to facilitate conceptual change in climate change understanding. The text used in this study has been used in previous research (Nussbaum, Cordova, & Rehmat, 2017). It consists of 890 words in ten paragraphs (see Appendix B). It has a Flesch-Kincaid grade level of 7.8. The Flesch reading ease score is 57.8. The other level of this variable was an expository text, similar to those used in traditional science textbooks. This text is equivalent to the refutation text in terms of the number of words, paragraphs, reading level, and scientific information contained, however the refutation text segments were removed and some additional information was added to balance the length and readability (see Appendix C). It consists of 887 words in ten paragraphs. It has a Flesch-Kincaid grade level of 8.1 and a Flesch reading ease score of 55.7. To recap, both texts contain identical base text segments. Whereas the refutation text also contains additional refutation segments, the comparison expository text contains additional non-refutation text to balance the two texts.

Feedback. A second independent variable used in this study was feedback given to participants after each question as they completed seven multiple choice questions. This questionnaire with explanatory feedback was used as a treatment intervention only and was not used as an outcome variable in this study. Elaborated feedback using refutation statements was tested, as compared to a control group who also answered the seven multiple choice questions, but received no feedback. Participants were asked to answer a set of seven multiple choice questions with or without elaborated refutation-based feedback provided after each question, after the text intervention was completed. The feedback items were designed to promote clear conceptual understanding regarding the key concepts addressed in the texts (online intervention). The purpose of this post-processing feedback intervention was to give participants another chance to reflect on and correct their misconceptions by giving them the opportunity for further processing of the new information, and thus further reconstruction of their knowledge. See Appendix D for the multiple choice questions with corresponding feedback used.

Dependent Variables

Text processing time measure. Sentence reading times were collected using a computer software program that allowed us to record the time it took students to read each sentence. Students advanced through the text one sentence at a time by pressing the space bar. Look-backs were not allowed. My intention was to compute sentence reading times by the millisecond, controlling for the number of words per sentence. In regards to the text passages, an average sentence reading time per text passage, average reading time of refutation segments (for those in the refutation text group), average reading time for the control text segments (for those in the comparison text group), and average reading time for the base text segments presenting the correct scientific information (both texts) were to be calculated. However, as indicated and explained in further depth in the results and discussion sections, only overall average read times for entire texts were calculated based on the results of other more important analyses. In regards to feedback, the time to complete the feedback intervention was calculated.

Conceptual understanding. Participants' conceptual understanding was assessed at posttest through five constructed response questions regarding the greenhouse effect and anthropogenic climate change (see Appendix E). The items targeted the common misconceptions regarding the greenhouse effect and climate change that were addressed through the texts used in the study. The purpose of the five constructed response items was to assess their deep learning as indicated by the coherence, structure, and depth of their explanations. Items were scored blind to text and feedback condition using a scoring rubric, some of which was based on a scoring rubric used in previous research using the refutation text used in this study (Nussbaum et al., 2017). The rubric was further revised and refined during scoring. Responses previously scored were rescored as the rubric was revised. The final rubric used is contained in Appendix F. Also blind to text and feedback condition, a second rater scored 19 to 20% of the responses for each item. The interrater agreement for each item ranged from 0.78 to 0.93 (M=0.88). A single conceptual understanding score was then created by summing all of the items, with some items being multiplied by an adjustment factor so that they were all on the same 5 point scale. For instance, the score on an item worth up to only 4 points maximum would be multiplied by 1.25 to put it on the 5 point scale. This adjustment was used so that all items would be weighted equally when summed to create the composite score (as was done by Nussbaum, Cordova, and Rehmat, 2017).

Self-efficacy measure. A six-item self-efficacy questionnaire (based on guidelines described by Bandura, 2006) was used to measure participants' self-efficacy for learning about climate change. Participants were asked to rate their capability for completing important topic-specific tasks on a 7-point scale ranging from 1 (Cannot Do At All) to 4 (Moderately certain can do) to 7 (Completely certain can do). An overall self-efficacy score was created by averaging the ratings across the items. Internal consistency of the items was excellent at both pretest (Cronbach's α= 0.91) and posttest (Cronbach's α= 0.94). The self-efficacy items are contained in Appendix G.

Interest measure. A six-item researcher-developed questionnaire was used to measure participants' interest in learning about climate change. Students were asked to rate "how true of you each statement is" on a 7 point Likert-type scale from 1 (not at all true of me) to 4 (somewhat true of me) to 7 (completely true of me). An overall interest score was created by averaging the ratings across the items, with excellent internal consistency both at pretest (Cronbach's α= 0.91) and posttest (Cronbach's α= 0.93). The items developed to measure interest are contained in Appendix H.

Climate change beliefs measure. A six-item questionnaire was administered to measure beliefs about climate change. Participants were asked to rate "how true of you each statement is" on a 7-point Likert scale from 1 (not at all true of me) to 4 (somewhat true of me) to 7 (completely true of me). An overall beliefs score was created by averaging the ratings across the items. Internal consistency of the items was acceptable at both pretest (Cronbach's α= 0.77) and posttest (Cronbach's α= 0.77). The items developed to measure beliefs are contained in Appendix I.

Climate change attitudes measure. A four-item survey using semantic differential scales, which has been used in previous research, was administered to measure attitudes toward global climate change (Seyranian, 2013). Participants were asked to rate their attitudes about global climate change on four scales including the level of urgency, truth, harmfulness, and how frightening, each on a 7-point Likert scale. An overall attitudes score was created by averaging the ratings across the items. Internal consistency of the items was good at both pretest (Cronbach's $\alpha = 0.87$) and posttest (Cronbach's $\alpha = 0.85$). The attitudes measure is contained in Appendix J.

Knowledge measure. A 27-item assessment called the Human-induced Climate Change Knowledge measure (HICCK), which has been used in prior conceptual change research to measure knowledge of human-induced climate change (Lombardi, Sinatra, & Nussbaum, 2013), was adapted for use in this study. Six additional items specific to the topic area addressed through the texts and feedback were added. Participants were asked to rate 33 statements on "the degree to which you think that climate change scientists agree with these statements" on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Lombardi et al. note that the scale measuring agreement among climate scientists was used to better assess knowledge of the scientific understanding of climate change, rather than participants' own acceptance regarding scientific conceptions of climate change. Sample items include "Current climate change is caused by increasing dust in the atmosphere." and "Earth's average temperature has increased over the past 100 years. This is evidence of climate change." In two past studies, reliability of the HICCK was adequate to good with a Cronbach's alpha ranging from 0.69 to 0.81 (Lombardi et al., 2013; Lombardi, Seyranian, & Sinatra, in submission). Internal consistency of the adapted HICCK measure used in the current study was questionable, though adequate at pretest

(Cronbach's α= 0.69) but very good at posttest (Cronbach's α= 0.86). The adapted Human-induced Climate Change Knowledge measure used in the current study is contained in Appendix K.

Procedures

Each subject participated in one in-person session conducted in a computer lab at UNLV. This session took between one and two hours, but no more than two hours. Once participants had given informed consent, they completed a series of attitudinal surveys to measure their: 1) self-efficacy for learning about climate change, 2) interest in learning about climate change, 3) beliefs about climate change, 4) attitudes toward climate change, and 5) knowledge about climate change.

Through the computer program used to administer the study, approximately half of the participants were randomly assigned to read the refutation text, while the other half were assigned to read the comparison expository text. Immediately following reading the text passage, participants were asked to complete a series of multiple choice questions, and participants within each of the two text conditions were then randomly assigned to receive either no feedback or elaborated refutation feedback after each question.

Participants were then asked to complete five open-ended questions designed to measure their conceptual understanding of the greenhouse effect and anthropogenic climate change. They then, again, completed the self-efficacy, interest, beliefs, attitudes, and knowledge questionnaires they completed prior to the text and feedback interventions. Finally, a demographics questionnaire was presented (Appendix L).

All questionnaires, surveys, text passages, and feedback were administered via computer. The text passages and feedback were presented via computer one sentence at a time so that sentence read times could be recorded. The main focus of this study is on the value added through the use of refutation feedback with refutation text and the effect of refutation text and feedback on self-efficacy and interest for future learning rather than on how learners navigate the texts. Therefore, per committee preference and in order to control for confounds in reading times, students were not able to move backwards through the surveys, texts, or questions with feedback. Rather than allowing look-backs, students were instructed to move at a pace that was comfortable to them and prompted to press the space bar to advance through the text and feedback segments when they felt they understood the information presented on the screen as fully as possible.

Chapter 4: Results

This section begins with preliminary analyses that include data screening. I then address each research question, including an explanation of modifications to planned data analyses necessitated by the preliminary findings.

Preliminary Analyses

Data Screening

The data were examined for outliers, including both univariate outliers (cases in the data where a variable score is extreme) and multivariate outliers (cases in the data with strange combinations of variable scores) (Tabachnick & Fidell, 2014 p. 106). Outliers can lead to a greater likelihood of Type I and Type II errors and thereby lead to results that may not be generalizable (Tabachnick & Fidell, p. 106-107, 2014). Multivariate analysis of variance (MANOVA) was used in this study. Although relatively robust to modest violations of normality, MANOVA is very sensitive to outliers (Pallant, 2010, p. 285). Five cases were deleted as univariate outliers because they had scores deviating more than three standard deviations from the mean. There was no consistent pattern among these cases. One case had very low belief scores at both pretest and posttest as well as low attitude scores at posttest. Another had very low pretest beliefs and attitudes scores as well as low self-efficacy, belief, and attitude scores at posttest. There was also one case with a very low posttest attitude score, one case with a very low pretest self-efficacy score, and one case with a very low pretest interest score. All were deleted.

As the data analysis strategy used in this study included analyses using grouped data, multivariate normality was assessed by calculating Mahalanobis distances and comparing them to a critical value of $\chi^2(10) = 26.13$. Initially, no cases were deleted as multivariate outliers (but see below).

Randomization Check

A series of 2 (text type) x 2 (feedback) ANOVAs were conducted to ensure that there were no significant differences among the four groups for pretest scores on self-efficacy, interest, beliefs, attitudes, and knowledge. Means and standard deviations for all pretest and posttest scores by group appear in Tables 1-6. As seen in Tables 7, 8, and 9, there were no significant differences among pretest scores for interest, beliefs, and knowledge. However, there were significant differences at pretest among the groups for self-efficacy and attitudes. See Tables 10 and 11. As will be explained subsequently, these findings changed the original analysis plan for research question 3. Specifically, the analysis strategy shifted from a 2 (text type) x 2 (feedback) x 2 (time of test) mixed-model MANOVA with five dependent variables to two separate 2 (text type) x 2 (feedback) ANCOVAs for self-efficacy and attitude using pretest scores as a covariate, and a 2 (text type) x 2 (feedback) x 2 (time of test) MANOVA with three dependent variables (interest, beliefs, and knowledge). Moreover, this necessitated recalculating Mahalanobis distances using the three variables (interest, beliefs, and knowledge) to be included in the MANOVA. Mahalanobis distances were compared to a new critical value of $\chi^2(6) = 22.46$. Two cases, both with values larger than 28, were deleted subsequently as multivariate outliers.

Table 1

Means and Standard Deviations for Self-efficacy by Experimental Group by Time

	Pretest		Posttest	
Group	M	SD	M	SD
Expository Text - No Feedback	5.60	0.87	5.53	0.97
Expository Text – Feedback	5.47	1.06	5.70	1.10
Refutation Text - No Feedback	5.08	1.14	5.29	1.22
Refutation Text – Feedback	5.56	0.90	5.67	1.03

Table 2

Means and Standard Deviations for Interest by Experimental Group by Time

	Pretest		Posttest	
Group	M	SD	M	SD
Expository Text - No Feedback	5.43	1.12	5.96	1.07
Expository Text – Feedback	5.13	1.22	5.90	1.18
Refutation Text - No Feedback	5.06	1.39	5.84	1.17
Refutation Text – Feedback	5.18	1.37	5.77	1.22

Table 3

Means and Standard Deviations for Beliefs by Experimental Group by Time

	Pretest		Posttest	
Group	M	SD	M	SD
Expository Text - No Feedback	6.08	0.69	6.47	0.67
Expository Text – Feedback	5.88	0.99	6.25	0.71
Refutation Text - No Feedback	5.93	0.85	6.32	0.69
Refutation Text – Feedback	5.83	0.77	6.30	0.79

Table 4

Means and Standard Deviations for Attitudes by Experimental Group by Time

	Pretest		Posttest	
Group	M	SD	M	SD
Expository Text - No Feedback	6.01	0.97	6.33	0.84
Expository Text – Feedback	5.59	1.30	6.21	0.99
Refutation Text - No Feedback	5.91	1.11	6.27	0.95
Refutation Text – Feedback	5.58	1.03	6.24	0.85

Table 5

Means and Standard Deviations for Knowledge by Experimental Group by Time

	Pretest		Posttest	
Group	M	SD	M	SD
Expository Text - No Feedback	3.69	0.22	4.04	0.40
Expository Text – Feedback	3.63	0.25	4.14	0.39
Refutation Text - No Feedback	3.68	0.26	4.10	0.40
Refutation Text – Feedback	3.67	0.23	4.11	0.37

Table 6

Means and Standard Deviations for Conceptual Understanding at Posttest by Experimental Group

Group	M	SD
Expository Text - No Feedback	10.34	4.36
Expository Text – Feedback	9.25	4.10
Refutation Text - No Feedback	10.18	4.30
Refutation Text – Feedback	10.67	4.29

Table 7

Analysis of Variance Summary for Pretest Interest as a Function of Text Type and Feedback

Source	SS	df	MS	F	p
Between Subjects					
Text type (A)	1.61	1	1.61	0.99	0.32
Feedback (B)	0.25	1	0.25	0.15	0.70
AB interaction	1.52	1	1.52	0.94	0.34
S/AB	226.55	139	1.63		

Table 8

Analysis of Variance Summary for Pretest Beliefs as a Function of Text Type and Feedback

Source	SS	df	MS	F	p
Between Subjects					
Text type (A)	0.51	1	0.51	0.71	0.40
Feedback (B)	1.56	1	1.56	2.17	0.14
AB interaction	0	1	0	0	0.97
S/AB	101.64	142	0.72		

Table 9

Analysis of Variance Summary for Pretest Knowledge as a Function of Text Type and Feedback

Source	SS	df	MS	F	p
Between Subjects					
Text type (A)	0.02	1	0.02	0.52	0.47
Feedback (B)	0.01	1	0.01	0.33	0.56
AB interaction	0.02	1	0.02	0.72	0.40
S/AB	226.55	139	1.63		

Table 10

Analysis of Variance Summary for Pretest Self-efficacy as a Function of Text Type and Feedback

Source	SS	Df	MS	F	p
Between Subjects					
Text type (A)	1.72	1	1.72	1.71	0.19
Feedback (B)	1.24	1	1.24	1.24	0.27
AB interaction	4.01	1	4.01	4.00*	.047
S/AB	141.45	141	1		

*$p < .05$

Table 11

Analysis of Variance Summary for Pretest Attitudes as a Function of Text Type and Feedback

Source	SS	Df	MS	F	p
Between Subjects					
Text type (A)	0.13	1	0.13	0.11	0.74
Feedback (B)	6.12	1	6.12	5.09*	0.03
AB interaction	0	1	0	0.00	0.96
S/AB	226.55	139	1.63		

*$p < .05$

Transformations

The assumptions of linearity, noncollinearity, homogeneity of variance, and homogeneity of regression slopes, as required for the MANOVA and ANCOVAs used in this study, were met. However, even with the deletion of outliers, some of the variables were still negatively skewed in that the skewness statistics when divided by their standard error were greater than ± 1.96. Variables that were negatively skewed included pretest and posttest beliefs, pretest and posttest attitudes, and posttest interest. MANOVA is relatively robust to modest violations of normality provided that they are not due to outliers, and that sample sizes of at least 20 per cell are used

(Tabachnick & Fidell, 2007, p. 251). However, per committee request, Box-Cox transformations (with optimization using XLStat) were performed on these variables as well as pretest interest. Box-Cox transformations allow different values to be chosen for λ in an effort to determine the value that best removes the skew, thus shifting the variable closer to being normally distributed (Nussbaum, 2017; Osborne, 2010). Although transforming the data did bring the skewness statistics within the acceptable range, the transformations changed the original scale of the data, making results of subsequent analyses using the transformed data difficult to interpret. Importantly, analyses using the untransformed data mirrored the results obtained using the transformed data. Therefore, for ease of interpretation, the data analyses reported in this chapter are based on the untransformed data. Means and standard deviations, as well as the source tables for the transformed data, are available upon request.

Feedback Manipulation Check

The overall time it took for participants to complete the multiple choice questionnaire with or without feedback was calculated in seconds and compared to help assess whether the feedback manipulation worked. An independent samples t-test with equal variances not assumed indicated that there was a significant difference between those who received feedback (M =151.52, SD = 50.95) and those who did not (M = 102.78, SD = 26.22), ($t(91.1) = -7.0$, $p <$ 0.001). Those who received feedback took significantly longer to complete the questionnaire than those who did not, indicating that those who received feedback likely did read the feedback provided. An independent samples t-test with equal variances not assumed also revealed that those who received feedback (M =6.32, SD = 0.79) also scored significantly higher on the feedback intervention assessment than those who did not receive feedback (M =5.93, SD = 1.20), ($t(137.68) = - 2.40$, $p = 0.02$).

Primary Analyses

Research Question 1

What are the effects of text type on reading times across different types of text segments? The first question was to be addressed using a mixed-model ANOVA with text type as the between-subjects factor and repeated measures on the text segments. Overall read times were calculated for the two texts with a mean of 389.74 seconds (*SD*=340.49) for those who read the refutation text and a mean of 367.42 seconds (*SD*=110.46) for those who read the expository text. There was no significant difference between the overall read times for the two texts (t (143) = -.53, p = 0.60). Specific read times for the different types of text segments (base text segments, refutation text segments, control text segments) were not calculated, however, due to the difficulty extracting them from the data files and because there were no significant effects of text or the text by feedback interaction on self-efficacy, interest, beliefs, attitudes, knowledge, or conceptual understanding which could be potentially accounted for by differences in reading times (as will be illustrated by subsequent analyses results).

Research Question 2

What are the effects of text type and elaborated feedback on conceptual understanding? The composite conceptual understanding score data were entered into a 2 (text type) x 2 (feedback presence) between subjects ANOVA. As seen in Table 12, there were no significant effects. Means and standard deviations for all variables at pretest and posttest by group are contained in Tables 1 through 6.

Table 12

Analysis of Variance Summary for Conceptual Understanding as a Function of Text Type and Feedback

Source	SS	Df	MS	F	p
Between Subjects					
Text type (A)	13.92	1	13.92	0.76	0.38
Feedback (B)	3.25	1	3.25	0.18	0.67
AB interaction	22.29	1	22.29	1.22	0.27
S/AB	2557.47	140	18.27		

Research Question 3

What are the effects of text type and feedback on self-efficacy, interest, beliefs, attitudes, and knowledge regarding climate change over time? As noted earlier, the original plan to use a mixed-model MANOVA with five dependent variables needed to be modified to a MANOVA with only three dependent variables. As also noted previously, all assumptions, including the assumption of homogeneity of regression, were met. As anticipated, beliefs, interest, and knowledge at pretest were all highly correlated thereby further indicating that the variables are related, and further justifying the use of MANOVA (over separate ANOVAs). Correlations, means, and standard deviations for all variables at pretest and posttest are displayed in Table 13. Beliefs, interest, and knowledge data were entered into a 2 (text type) x 2 (feedback) x 2 (time of test) mixed-model MANOVA with text type and feedback condition as between-subjects factors and time of test serving as a within-subjects factor. With the use of Wilk's λ criterion, the combined dependent variables were significantly affected by test, ($F(2,138) = 1070.76$, $p < 0.01$, Wilks' $\lambda = 0.06$, $\eta p^2 = 0.94$), time, ($F(1,139) = 162.45$, $p < 0.01$, Wilks' $\lambda = 0.46$, $\eta p^2 = 0.54$), and a test by time interaction, ($F(2,138) = 6.86$, $p < 0.01$, Wilks' $\lambda = 0.91$, $\eta p^2 = 0.09$). Follow-up univariate analyses performed on each of the dependent variables indicated that there was only a main effect for time. Each of the three dependent variables (beliefs, interest, and knowledge) demonstrated a significant increase from pretest to posttest. See Tables 14, 15, and 16.

Table 13

Correlations Among Study Variables Including Means and Standard Deviations

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Pretest Self-efficacy	--										
2. Pretest Interest	.37**	_									
3. Pretest Beliefs	.31**	.55**	--								
4. Pretest Attitudes	.17*	.50**	.70**	--							
5. Pretest Knowledge	.28**	.43**	.47**	.32**	--						
6. Posttest Conceptual Understanding	0.03	.18*	.19*	0.10	.32**	--					
7. Posttest Self-efficacy	.61**	.30**	0.11	-0.01	.26**	.23**	--				
8. Posttest Interest	.20*	.77**	.56**	.55**	.23**	.34**	.26**	--			
9. Posttest Beliefs	0.14	.27**	.54**	.45**	.20*	.31**	0.14	.47**	--		
10. Posttest Attitudes	0.05	.39**	.51**	.73**	.18*	.19*	0.02	.53**	.55**	--	
11. Posttest Knowledge	.19*	.24**	.34**	.22**	.39**	.51**	.34**	.31**	.46**	.24**	--
M	5.42	5.21	5.94	5.80	3.67	10.14	5.53	5.88	6.35	6.27	4.10
SD	1.01	1.27	0.82	1.10	0.24	4.26	1.08	1.15	0.71	0.90	0.38

*$p < .05$. **$p < .01$.

Table 14

Analysis of Variance Summary for Interest as a Function of Text Type and Feedback by Time

Source	SS	df	MS	F	p
Between Subjects					
Text type (A)	1.37	1	1.37	0.52	0.47
Feedback (B)	0.39	1	0.39	0.15	0.70
AB interaction	0.72	1	0.72	0.28	0.60
S/AB	365.56	139	2.63		
Within Subjects					
Time of Test (C)	31.58	1	31.58	91.31*	<.01
AC interaction	0.03	1	0.03	0.08	0.78
BC interaction	0.01	1	0.01	0.02	0.88
ABC interaction	0.78	1	0.78	2.24	0.14
SC/AB	48.08	139	0.35		

* $p < .05$

Table 15

Analysis of Variance Summary for Beliefs as a Function of Text Type and Feedback by Time

Source	SS	df	MS	F	p
Between Subjects					
Text type (A)	0.37	1	0.37	0.42	0.52
Feedback (B)	1.50	1	1.50	1.67	0.20
AB interaction	0.37	1	0.37	0.41	0.52
S/AB	126.14	141	0.90		
Within Subjects					
Time of Test (C)	11.59	1	11.59	41.74*	<.01
AC interaction	0.05	1	0.05	0.16	0.69
BC interaction	0.02	1	0.02	0.06	0.80
ABC interaction	0.05	1	0.05	0.19	0.66
SC/AB	39.17	141	0.28		

* $p < .05$

Table 16

Analysis of Variance Summary for Knowledge as a Function of Text Type and Feedback by Time

Source	SS	df	MS	F	p
Between Subjects					
Text type (A)	0.01	1	0.01	0.09	0.77
Feedback (B)	0.01	1	0.01	0.06	0.81
AB interaction	0.01	1	0.01	0.05	0.82
S/AB	21.29	141	0.15		
Within Subjects					
Time of Test (C)	13.2	1	13.2	240.34*	<.01
AC interaction	0	1	0	0.01	0.92
BC interaction	0.13	1	0.13	2.37	0.13
ABC interaction	0.09	1	0.09	1.70	0.20
SC/AB	7.74	141	0.06		

* $p < .05$

As discussed previously, due to significant pretest differences on self-efficacy and attitudes among the groups, self-efficacy and attitudes were entered into two separate 2 (text type) x 2 (feedback) ANCOVAs using their pretest scores as covariates. As seen in Table 17 and 18, these analyses yielded no significant effects.

Table 17

Analysis of Variance Summary for Posttest Self-efficacy as a Function of Text Type and Feedback using Pretest Self-efficacy as a Covariate

Source	SS	df	MS	F	p
Between Subjects					
Pretest Self-efficacy	60.76	1	60.76	81.65*	<.01
Text type (A)	0.00	1	0.00	0.00	0.99
Feedback (B)	0.90	1	0.90	1.21	0.27
AB interaction	0.32	1	0.32	0.43	0.51
S/AB	104.18	140	0.74		

* $p < .05$

Table 18

Analysis of Variance Summary for Posttest Attitudes as a Function of Text Type and Feedback using Pretest Attitudes as a Covariate

Source	SS	df	MS	F	p
Between Subjects					
Pretest Attitude	62.49	1	62.49	166.66*	<.01
Text type (A)	0.01	1	0.01	0.04	0.85
Feedback (B)	0.85	1	0.85	2.27	0.13
AB interaction	0.01	1	0.01	0.03	0.87
S/AB	52.12	139	0.375		

* $p < .05$

Research Question 4

Is pretest knowledge related to other posttest variables? Pearson correlations between pretest knowledge scores and other posttest variables (self-efficacy, interest, beliefs, attitudes, and conceptual understanding), as displayed in Table 13, indicated that pretest knowledge was not correlated in excess of .50 with other posttest variables. Therefore, pretest knowledge was not used as a covariate in any of the analyses.

Chapter 5 : Discussion

The overall purpose of the current study was to investigate the effect of refutation text and refutation-based elaborated feedback on attitudes, beliefs, knowledge, self-efficacy, and interest in learning more within the context of conceptual change learning about climate change. Although there are a plethora of studies already demonstrating the effectiveness of refutation text compared to non-refutation text for changing one's beliefs and conceptions (Guzzetti, Snyder, Glass, & Gamas, 1993; Hynd, 2001), there are a few studies in which there was no significant difference in knowledge change between those who read a refutation text and those who read a non-refutation text (Kendeou, Muis, & Foulton, 2011; Mikkila-Erdmann, et al., 2008). Therefore, one goal was to see if the effectiveness of refutation text over non-refutation text, as expected and evidenced by most relevant research, would be replicated in the current study.

There were two larger main purposes of this study, however. The first was to examine whether incorporating elements of refutation text into elaborated feedback would further augment text-based instruction when conceptual change was the learning goal. One of the keys to effective instruction is performance-based feedback (Brooks, Schraw, & Crippen, 2005). Conceptual change research thus far has not incorporated the use of performance-based feedback within an assessment as an intervention approach. However, the feedback literature indicates that elaborated performance-based feedback can be effective in helping a learner identify and resolve discrepancies between actual performance and desired responses (Brooks, Schraw, & Crippen, 2005; Butler & Winne, 1995; Shute, 2008). Immediate, elaborated feedback that is highly informative and task or response-specific likely promotes content engagement and more mindful processing of feedback, thus leading to enhanced academic achievement, as well as an adjustment to goals, self-efficacy, and interest (Bangert-Drowns, Chen-Lin, Kulik, & Morgan, 1991; Gao & Lehman, 2003; Narciss, 1999, 2004; Narciss & Huth, 2006; Van der Kleij, Eggen, Timmers, & Velkamp, 2012).

Given the previous research demonstrating the effectiveness of refutation-based text for promoting conceptual change, coupled with the literature highlighting the effectiveness of elaborated feedback in instruction, it was reasonable to expect that refutation-based statements incorporated into elaborated feedback provided during an assessment would further augment conceptual change learning, as well as changes in beliefs and attitudes. I expected that there might be an interaction among text type, feedback, and time, with those who received the refutation text and elaborated feedback likely exhibiting the greatest change from pretest to posttest, given that the feedback could potentially provide learners with another chance to further process the information in the text and another opportunity to become aware of any misconceptions and further revise their current conceptions through the mindful processing of the feedback information. I expected those who received the non-refutation text and no feedback to exhibit the lowest likelihood for change. Non-refutation text is generally less effective than refutation text and the lack of feedback would not have given these participants the cue to further process the text they read offline or the additional opportunity to recognize and resolve the discrepancy between their current conception and the correct conception through the feedback. Given the abundance of literature illustrating the effectiveness of both feedback and refutation text, and the lack of previous research incorporating the two, there was really no way to predict whether those who read the refutation text but received no feedback or those who read the non-refutation text but received refutation-based feedback would outperform the other in terms of learning or whether the refutation text alone or non-refutation text with feedback would be equally effective.

The second main purpose was to assess the effect of refutation text and refutation-based elaborated feedback on the motivation constructs of self-efficacy and interest. There is very little research regarding the impact of refutation text on motivational constructs such as self-efficacy and interest. However, given that refutation text is preferred over non-refutation text by learners (Hynd, 2001; Mason, et al., 2008), I thought it possible that reading refutation text may lead to learners being more interested in engaging in future learning. Although learners who read refutation text could experience low self-efficacy as they grapple with being told their prior knowledge is incorrect, I thought it more likely that, given the clear and understandable language highlighting and correcting their misconceptions in the refutation text, self-efficacy might actually increase as they acknowledged their misconceptions and resolved their discrepancies in knowledge. Moreover, some research indicates that, in addition to a positive effect on academic achievement, elaborated feedback may also have a positive impact on student self-efficacy as well as motivation toward future learning, provided a learner engages in a task for a reasonable amount of time (Wang & Wu, 2008; Gao & Lehman, 2003; Narciss, 2004). Therefore, I expected those who read a refutation text and received elaborated feedback to experience greater gains in self-efficacy and interest in learning more about climate change, with those who received the non-refutation text and no feedback showing little to no gain in self-efficacy and interest.

Although not the main focus of this study, a final objective was to determine whether there were differences in reading times between the refutation text segments and base text segments within the refutation text group, and whether there were differences in base text reading times between those who read the refutation text and those who read the expository text as has been demonstrated in previous research. The ultimate goal in examining reading times (as a rough measure of cognitive processing) was to consider whether those differences might help explain differences in attitudes, beliefs, knowledge, self-efficacy, or interest in learning more, resulting from a potential text or text by feedback interaction. I expected to find significant differences in the reading times associated with the refutation segments and base text segments within the refutation text group, and in base text reading times between the two text groups that could then, coupled with findings from previous research, possibly provide insight into the effectiveness of refutation text. Based on Ariasi and Mason (2011), I expected that, within the refutation text group, refutation segments which could act as a type of advanced organizer, would be read more quickly than the base text segments. I expected as well that those who read the refutation text would exhibit longer reading times for the base text segments than those who read the control text as a result of the refutation segments in the refutation text cuing readers to spend more time on the scientific information, thus resolving any discrepancies between their current knowledge and the scientific information being presented (van den Broek & Kendeou, 2008). Such a finding, in turn, might then help explain differences in learning among the groups.

The results of the current study, however, ran contrary to my expectations. Whereas I predicted that there would be an interaction between text type and feedback on beliefs, attitudes, knowledge, self-efficacy, and interest over time, as well as on posttest conceptual understanding, there was none. There were no significant differences among the four groups in self-efficacy, interest, beliefs, attitudes, or knowledge over time, nor in posttest conceptual understanding scores. Rather, regardless of which text was read and whether or not participants received feedback, there were only significant increases from pretest to posttest in interest, beliefs, and knowledge. There was also no significant difference in overall reading times between the two texts. Given that there were no differences in attitudes, beliefs, knowledge, self-efficacy, or interest in learning more resulting from a potential text, feedback, or text by feedback interaction for which to try to explain with reading times, there was no reason to further examine reading times for specific types of text segments.

I think some possible explanations for the lack of anticipated effects may relate to study design and materials choices. For instance, a measure of cognitive processing was desired. Since there was no access to eye tracking software (which was preferred), per committee request, reading times were considered as a rough measure of cognitive processing instead. Although one committee member did have strong reservations, per (previous) committee chair recommendation (given that cognitive processing was not a key focus of this study and using eye tracking software was not an option), reading time was used as a rough measure of cognitive processing. This led to the use of a program that had participants read the texts sentence by sentence and press the space bar to move forward through the text with no option for look-backs. The lack of an option to look back at previous text may have had an impact on the way the refutation text in particular was read and processed, including which conceptual change strategies could be employed. Participants, specifically those who read the refutation text, may have been more likely to move around a bit in the text while reading if allowed, as found in previous conceptual change studies using eye-tracking software. For instance, Mikkila-Erdmann et al. (2008) found that those who experienced the greatest conceptual change displayed more re-reading of previous text than others. Ariasi and Mason (2011) found that those who read refutation text as opposed to non-refutation text displayed greater look-back fixation time on sentences containing scientifically accurate information during second pass reading. Future studies using refutation text should allow for look-backs so readers can have the opportunity to navigate the texts and process the information in a way that more closely mirrors how one would naturally read a refutation text. Future research should also continue to incorporate the use of eye-tracking software to further investigate the use of conceptual change strategies while reading text.

It is also possible that learners with misconceptions may have processed the information in each of the texts differently. Kendeou and van den Broek (2005) found no difference in reading times between those with misconceptions and those without misconceptions when reading a traditional expository text. However, they found that those with misconceptions spent more time on sentences containing the scientifically accurate information and that they used more conceptual change strategies when reading a refutation text, as opposed to a non-refutation text (2007, 2008). Therefore, future conceptual change research should also further examine any differences between those who have misconceptions and those who do not in terms of how they process different types of texts.

Narciss (2004) found that feedback may not be effective if learners do not engage with the information provided. According to Bangert-Drowns et al. (1991), feedback likely only works if it promotes “mindful reception” of the information. Regarding the lack of an effect for feedback in this study, it is possible that respondents who received feedback throughout the multiple choice questionnaire did not actually read and mindfully process the feedback provided. However, because those who received feedback did take significantly longer to complete the multiple choice questionnaire and did perform significantly better on the feedback intervention assessment itself, I think it is likely that they did read the feedback. However, it is still possible that the specific time spent on the task was not enough to promote the type of mindful processing necessary for feedback to be effective in promoting conceptual change. I think it is also possible that the feedback questionnaire may have been too easy and/or the feedback may have been too redundant with the texts used to be additionally effective. Given that this is the first conceptual change study to incorporate refutation-based elaborated feedback into an intervention assessment, future research should continue to examine the effectiveness of elaborated feedback using refutation statements, possibly in conjunction with other less redundant instructional strategies and materials.

In summary, although the results of the study did not support the hypotheses, the findings, in conjunction with past research, do hold several implications for future studies. Specifically, participants should be assessed beforehand regarding misconceptions, as those with misconceptions may process the information that conflicts with their beliefs differently than those without misconceptions. Also, if a measure of cognitive processing is desired, the use of eye-tracking software rather than simple reading times should be used to allow learners to navigate and process the information provided via text or feedback more naturally. It may also be beneficial to incorporate think alouds to further examine how learners process feedback. Including other individual difference variables (such as need for cognition) may also yield important insight into how these variables impact the processing of and effectiveness of elaborated feedback within the context of conceptual change learning.

Appendix A

Study Design

3-way mixed factor design

2 (Text Condition) x 2 (Feedback Condition) x 2 (Time)

	No Feedback B_1	Elaborated Feedback B_3
Refutation Text A_1	A_1 B_1	A_1 B_3
Non-Refutation Text A_2	A_2B_1	A_2 B_3

Independent Variables

Text Condition (2):

- Enhanced Greenhouse effect refutation text (refutational info contained only in this text in blue)
- Enhanced Greenhouse effect non-refutation text (control information contained only in this text to help balance the two texts in blue)

Feedback Condition (2):

- Elaborated feedback (refutation feedback)
- No feedback

Dependent Variables

Text processing time (per segment) (refutation segments, base text segments, control text segments, overall average reading time)

Conceptual Understanding (open-ended questions scored using a rubric) (posttest only)

Self-efficacy for learning more about climate change (pre/post)

Interest in learning more about climate change (pre/post)

Beliefs about climate change (pre/post)

Attitudes regarding climate change (pre/post)

Knowledge about climate change (HICCK) (pre/post) (suggested revisions to make it more appropriate for this study included)

Appendix B

The Enhanced Greenhouse Effect Text Passage (Refutation)

**refutation text specific text is underlined*

Most people have heard of the greenhouse effect, but many don't know exactly what it is. <u>People often confuse the greenhouse effect with global warming. Many people believe that the greenhouse effect is dangerous and that it is created through human activity. You may have thought this too. However, this is incorrect. The Earth's greenhouse effect is NOT dangerous. It is NOT caused by humans.</u> The Earth's greenhouse effect occurs naturally. It helps keep the planet's average temperature comfortable for humans to live on the Earth. Without a greenhouse effect, Earth's average temperature would be about -1°F. This is about 60°F colder than the normal average temperature. Life might not exist on Earth at all without the greenhouse effect.

What is the greenhouse effect? Energy in the form of visible light from the Sun enters the Earth's atmosphere. Some of this solar energy is reflected back into space. Some is absorbed by clouds, gases, and tiny particles in the atmosphere. The Earth's atmosphere allows much of the incoming solar energy to reach the Earth's surface. About half of the energy from the Sun is absorbed by the Earth's land and oceans.

The Earth loses this energy by giving off invisible infrared light. Some gases in the atmosphere absorb infrared light. These are called "greenhouse gases." Water vapor, carbon dioxide, and methane are among these gases. Greenhouse gases re-emit infrared light. Some of this energy is transferred back to the Earth's land and oceans. This increases the Earth's surface temperature. This is the greenhouse effect.

Scientists have observed that the average global temperature is rising. This rising of the Earth's surface temperature is often called global warming. In fact, the twenty warmest years on record have occurred since 1981. The top ten warmest years have taken place in the last twelve years. <u>Some people believe global warming is due to natural causes alone. This is incorrect. Global warming is NOT due to natural causes alone. It is true that climate change happens naturally. However, the rapid warming that the Earth is experiencing now cannot be explained by natural factors alone.</u> Human activities are causing greenhouse gases to build up in the atmosphere. This is causing an increase in the amount of energy that is absorbed and re-radiated back to Earth's surface. As a result, the Earth's surface is warming. This warming of the Earth above natural warming is called *the enhanced greenhouse effect*. This enhanced greenhouse effect is causing global warming.

<u>Some people believe that ozone depletion is causing global warming. You may have thought this, too. However, this is incorrect. Ozone depletion is NOT causing global warming.</u> Ozone depletion can lead to more harmful ultraviolet radiation reaching the Earth's surface. An increase in ultraviolet radiation can have other harmful effects such as tissue damage to plants, animals,

and humans, including skin cancer. However, an increase in ultraviolet radiation as a result of ozone depletion does not really impact the total energy the Earth receives from the sun. Therefore, it does not impact the Earth's overall temperature. Global warming would still exist even if the problem of ozone depletion was solved.

The main greenhouse gas entering the atmosphere through human activities is carbon dioxide. Most carbon dioxide emissions come from burning fossil fuels (coal, oil, and natural gas). Burning fossil fuels are used in transportation and to generate electricity.

Carbon dioxide accounts for less than 1% of the atmosphere. Even so, small changes in carbon dioxide levels can cause major effects. The average temperature on Earth increased by a little more than 1°F during the whole 20th century. Climate scientists predict that the Earth's average temperature will likely increase anywhere from 2° to 11°F over the next century. That doesn't sound like much. But, an increase of even a couple of degrees will affect every aspect of civilization. This includes food production, water resources, and energy supplies.

<u>Many people think that the effects of global warming will not happen in our lifetimes. You may have thought this too, but this is incorrect. We are already seeing the effects.</u> The effects of global warming include melting glaciers and stronger and more frequent storms. They also include greater precipitation. Ocean temperatures and sea levels are rising. Whole ecosystems are being affected. Climate change is causing shifts in where some species of plants and animals live. It also affects the size of plant and animal populations.

<u>Some people believe that there is nothing humans can do to address the problem of climate change. You may have thought this too. However, this is not true.</u> Humans can reduce the amount of greenhouse gases emitted into the atmosphere. This can be done by reducing the use of fossil fuels (such as oil and gasoline) for electricity, heating, and transportation. Using more renewable energy in place of fossil fuels would help. Expanding forests and reducing the amount of trash generated can also help.

You can take small steps like unplugging electrical appliances when not in use. Turning your heater down and your air conditioning up a few degrees can also help. Consider changing your light bulbs to compact fluorescents. Choose to walk, bike, car pool or use public transportation when possible. Avoid buying products you don't need. Seek out other ways to reduce greenhouse gas emissions. Finally, pass on what you have learned.

Appendix C

The Enhanced Greenhouse Effect Text Passage (Non-Refutation Comparison Text)

*control text specific text underlined

Most people have heard of the greenhouse effect, but many don't know exactly what it is. The Earth's greenhouse effect occurs naturally. It helps keep the planet's average temperature comfortable for humans to live on the Earth. Without a greenhouse effect, Earth's average temperature would be about -1°F. This is about 60°F colder than the normal average temperature. Life might not exist on Earth at all without the greenhouse effect.

What is the greenhouse effect? Energy in the form of visible light from the Sun enters the Earth's atmosphere. Some of this solar energy is reflected back into space. Some is absorbed by clouds, gases, and tiny particles in the atmosphere. The atmosphere is mostly transparent to visible light. The Earth's atmosphere allows much of the incoming solar energy to reach the Earth's surface. Some of this energy is reflected back to space. About half of the energy from the Sun is absorbed by the Earth's land and oceans.

The Earth loses this energy by giving off invisible infrared light. The Earth's atmosphere is mostly transparent to visible light from the Sun. It is largely opaque to infrared light given off by the Earth's surface. Some gases in the atmosphere absorb infrared light. These are called "greenhouse gases." Water vapor, carbon dioxide, and methane are among these gases. Greenhouse gases re-emit infrared light. Some of the energy is lost to space. Some of this energy is transferred back to the Earth's land and oceans. This increases the Earth's surface temperature. This is the greenhouse effect.

Scientists have observed that the average global temperature is rising. This rising of the Earth's surface temperature is often called global warming. Surface temperatures have increased since 1880. Most of the warming has occurred since the 1970's. In fact, the twenty warmest years on record have occurred since 1981. The top ten warmest years have taken place in the last twelve years. Human activities are causing greenhouse gases to build up in the atmosphere. This is causing an increase in the amount of energy that is absorbed and re-radiated back to Earth's surface. As a result, the Earth's surface is warming. This warming of the Earth above natural warming is called *the enhanced greenhouse effect*. This enhanced greenhouse effect is causing global warming.

Ozone molecules high in Earth's atmosphere absorb harmful ultraviolet radiation from the sun. This includes UV-B as well as UV-C radiation. Human emissions of chlorinated chemicals have sped up the process of ozone destruction. This has caused a decrease in ozone. Ozone depletion can lead to more harmful ultraviolet radiation reaching the Earth's surface. An increase in ultraviolet radiation can have other harmful effects such as tissue damage to plants, animals, and humans, including skin cancer. However, an increase in ultraviolet radiation as a result of ozone depletion does not really impact the total energy the Earth receives from the sun. Therefore, it does not impact the Earth's overall temperature. Global warming would still exist even if the problem of ozone depletion was solved.

Some greenhouse gases enter the atmosphere through human activity. They include carbon dioxide and methane, as well as nitrous oxide. The main greenhouse gas entering the atmosphere through human activities is carbon dioxide. Most carbon dioxide emissions come from burning fossil fuels (coal, oil, and natural gas). Burning fossil fuels are used in transportation and to generate electricity. Methane is emitted when coal is produced. It is also produced through agriculture. Nitrous oxide is emitted through industry. It is also produced through agriculture. Fossil fuel combustion as well as solid waste also produces nitrous oxide.

Carbon dioxide accounts for less than 1% of the atmosphere. Even so, small changes in carbon dioxide levels can cause major effects. The average temperature on Earth increased by a little more than 1°F during the whole 20th century. Climate scientists predict that the Earth's average temperature will likely increase anywhere from 2° to 11°F over the next century. That doesn't sound like much. But, an increase of even a couple of degree will affect every aspect of civilization. This includes food production, water resources, and energy supplies.

The effects of global warming include melting glaciers and stronger and more frequent storms. They also include greater precipitation. Ocean temperatures and sea levels are rising. Arctic sea ice is declining and river ice breaks up earlier. Whole ecosystems are being affected. Climate change is causing shifts in where some species of plants and animals live. Trees flower earlier. It also affects the size of plant and animal populations.

Humans can reduce the amount of greenhouse gases emitted into the atmosphere. This can be done by reducing the use of fossil fuels (such as oil and gasoline) for electricity, heating, and transportation. Using more renewable energy in place of fossil fuels would help. Expanding forests and reducing the amount of trash generated can also help.

You can take small steps like unplugging electrical appliances when not in use. Turning your heater down and your air conditioning up a few degrees can also help. Use less water. Consider changing your light bulbs to compact fluorescents. Choose to walk, bike, car pool or use public transportation when possible. Avoid buying products you don't need. Seek out other ways to reduce greenhouse gas emissions. Finally, pass on what you have learned.

Appendix D

Feedback Intervention

1. The Earth's greenhouse effect is:

A. caused by human activity alone. B. mostly (>95%) a natural occurrence.

C. caused by a layer of dust encircling the earth. D. none of the above.

Elaborated feedback:

Many people believe the greenhouse effect is created solely through human activity or that it is caused by a layer of dust or pollution encircling the earth. However this is not true. Almost all of the Earth's greenhouse effect (>95%) is a natural occurrence that helps raise our planet's average temperature to a habitable level.

2. The greenhouse effect:

A. is dangerous to life on Earth. B. makes the Earth fit for human habitation.

C. is unrelated to life on Earth. D. none of the above.

Elaborated feedback:

Some believe the greenhouse effect is dangerous to life on Earth. However, this is not true. The Earth's greenhouse helps raise our planet's average temperature, making it habitable. Without the greenhouse effect, life may not exist on Earth at all.

3. Global warming is:

A. not really happening. B. happening and we are already seeing the effects.

C. happening but it is not a big deal. D. happening but we won't see the effects in this lifetime.

Elaborated feedback:

Some people believe that global warming is not really happening or that it is happening but is not that serious yet. However, these beliefs are incorrect. Global warming is already happening. We are *already* seeing the effects, including stronger and more frequent storms, changes in patterns of precipitation, melting ice and glaciers, and increasing ocean temperatures and sea levels. Whole ecosystems are being affected as evidenced in increases and decreases of various plants and animals, as well as some shifting in the geographic ranges some species inhabit due to changes in climate.

4. Global warming is due to:

A. natural causes alone B. human fossil fuel combustion and deforestation

C. stratospheric ozone depletion D. none of the above

Elaborated feedback:

Some people believe that global warming is due to natural causes alone or to stratospheric ozone depletion. However, this is not true. Neither stratospheric ozone depletion nor natural causes alone are causing global warming. Human activities, such as deforestation and the burning of fossil fuels for power and transportation, are causing a build-up of greenhouse gases in the atmosphere. This is causing an increase in the amount of energy that is absorbed by these gases and re-radiated back to Earth's surface before being lost back to space.

5. If stratospheric ozone depletion were fixed, then:

A. there would be no global warming.

B. global warming would still exist.

C. harmful UV radiation would reach the Earth's surface faster.

D. climate change would be reduced drastically.

Elaborated feedback:

Some people believe that stratospheric ozone depletion is causing global warming. However, this is incorrect. Stratospheric ozone depletion is not causing global warming. Global warming still exists even though the problem of stratospheric ozone depletion has been addressed.

6. What can humans do to address the problem of current climate change?

A. Human activities are unrelated to current climate change.

B. Human activities have such a small impact on current climate change that our future behavior can have very little impact on climate change.

C. Human activities are largely responsible for current climate change. However, at this point, there isn't much we can do to address the problem of climate change.

D. Humans can still reduce the long-term effects of climate change by reducing the amount of greenhouse gases we emit into the atmosphere. For instance, we can reduce our use of fossil fuels.

Elaborated feedback:

Some people believe there is nothing humans can do to address the problem of current climate change, but this is not true. Although some climate changes are inevitable due to the increase of greenhouse gas emissions already caused by humans, there *is* still hope for reducing the long-term effects. Humans can reduce the amount of greenhouse gases emitted into the atmosphere by reducing the use of fossil fuels for electricity, heating, and transportation, using more renewable energy in place of fossil fuels, and reducing the amount of trash generated. Small steps like turning your heater down and your air conditioning up a few degrees, cutting down on driving, and avoiding buying products you don't need can all help reduce your greenhouse gas emissions.

7. Which of the following sentences is most accurate regarding the effect changes in the average temperature on Earth could have?

A. Only very large changes (> 15 degrees) in the average temperature could have a large effect on the Earth and its inhabitants.

B. Even small changes of only a couple of degrees in the average temperature could a large effect on the Earth and its inhabitants.

C. Small changes of only a couple of degrees in the average temperature could NOT have a large effect on the Earth and its inhabitants.

D. Even large changes (> 15 degrees) in the average temperature could NOT have a large effect on the Earth and its inhabitants.

Elaborated feedback:

Some people believe that small changes of only a couple of degrees in the average temperature on Earth will make little to no difference for life on Earth. You may have thought this too. However, this is incorrect. Even small changes in the temperature or atmospheric composition of the Earth's atmosphere can have large effects on civilization, including on things like water resources, energy supplies, and food production.

Appendix E

Open-ended Items used to Measure Conceptual Understanding of Climate Change

Instructions:

Please explain the following concepts as completely as possible.

Items:

1. Please explain the greenhouse effect.
2. Please explain the enhanced greenhouse effect.
3. Please explain climate change.
4. Please explain the role of human activity in climate change.
5. Please explain global warming.

Appendix F

Conceptual Understanding Scoring Rubric

1. Please explain the greenhouse effect.

Scored for 3 main ideas (1 total point possible for each idea with the option to give half of a point for mechanisms if respondent gives vague, but correct information regarding mechanisms). Max possible score = 3, Min possible score = 0.

- *Idea 1. Natural*: The participant demonstrates the understanding that the greenhouse effect is a natural phenomenon.
- *Idea 2. Warming of Earth to habitable state*: The participant demonstrates the understanding that the greenhouse effect warms the Earth, thus making it habitable. It is not dangerous. (Without it, the Earth's average temp would be about -1 degrees F, therefore, not habitable.)
- *Idea 3. Mechanisms of the greenhouse effect*: The participant demonstrates some understanding of the mechanisms involved. (The sun's energy comes into the Earth's atmosphere and some is absorbed by clouds, gases, etc. Some reflected back to space. Some reaches the Earth's surface (land and oceans). The Earth's surface loses this energy as infrared light, some of which is absorbed by greenhouse gases, which re-emit the infrared light. Some of this is transferred back to the Earth's surface resulting in an increase in the Earth's surface temperature.) (0.5 for a correct, but vague idea)

2. Please explain the enhanced greenhouse effect.

Scored for 5 main ideas (1 total point possible for each idea with the option to give half of a point for Mechanisms). Max possible score = 5, Min possible score = 0.

- *Idea 1. Human impact:* The participant demonstrates the understanding that the enhanced greenhouse effect is due to human activity (for example. Humans burning fossil fuels).
- *Idea 2. Warming of Earth beyond that which is natural:* The participant demonstrates the understanding that the enhanced greenhouse effect is raising the Earth's average temperature beyond that which is natural (for example, may mention global warming, or an increase in the Earth's temperature).
- *Idea 3. Greenhouse gas emissions or carbon dioxide (CO_2):* The participant demonstrates some understanding that greenhouse gases (particularly CO_2) are increasing in the atmosphere as a result of the enhanced greenhouse effect. (.5 if just say something more general about "gases.")
- *Idea 4. Mechanisms of the enhanced greenhouse effect:* The participant demonstrates some understanding of the mechanisms involved such as the understanding that there is an increase in the amount of energy that is being absorbed and re-radiated back to the Earth's surface due to the excess greenhouses gases in our atmosphere emitted through human activity, such as burning fossil fuels, transportation, and deforestation. (can give .5 if vague understanding)

- *Idea 5. Effects of the enhanced greenhouse effect:* The participant discusses other specific effects beyond the increase in the global temperature, such as rising sea levels, an increase in extreme weather events, melting of glaciers/poles, shifting ecosystems.

3. Please explain Climate Change.

Scored for 2 main ideas, Max possible score: 2, Min possible score: 0

- *Idea 1. Cause*: such as humans, burning fossil fuels, increasing CO2, greenhouse gas emissions, the enhanced greenhouse effect, global warming
- *Idea 2. Specific effects*: such as more extreme weather/storms, melting of glaciers/poles, shifting/changing ecosystems

4. Please explain the role of human activity in climate change.

Scored for 4 main ideas (1 total point possible for each idea with the option to give half of a point or zero). Max possible score = 4, Min possible score = 0.

- *Idea 1. Human causes of climate change*: One point if mentions cars/transportation, deforestation, electricity, greenhouse gases, or co2, or burning fossil fuels.
- *Idea 2. (only if get above point) Links burning fossil fuels to increased CO2 or greenhouse gases in the atmosphere*
- *Idea 3. Effects*: increasing average global temp, extreme weather, melting of glaciers/poles, shifting/changing ecosystems.
- *Idea 4. Mitigation*: specific mitigating action (0.5 point for just conserve, reuse or recycling).

5. Please explain Global Warming.

Scored for 3 main ideas, Max possible: 3, Min possible: 0

- *Idea 1. The average temperature of the Earth is currently warming/increasing*
- *Idea 2. Cause*: says caused largely by humans, burning fossil fuels, or the enhanced greenhouse effect
- *Idea 3. Specific Effects beyond temperature*: such as more extreme weather events, more frequent/more powerful storms, melting glaciers, rising sea levels, shifting/changing ecosystems (.5 for climate change only or saying that it is dangerous/has bad effects, or something else relevant but fairly vague or general)

Appendix G

Self-efficacy for Learning about Climate Change

Instructions:

Following is a list of different activities. Please rate how confident you are that you can do them as of now. Rate your degree of confidence by selecting a number from 1 (Cannot do at all) to 7 (Highly Certain Can Do). Your answers will be kept strictly confidential and will not be identified by name.

Scale to be used:

1	2	3	4	5	6	7
Cannot do At All			Moderately Certain Can Do			Completely Certain Can Do

Items:

1. Understand easy readings about climate change.

2. Understand difficult readings about climate change.

3. Learn the basic concepts about climate change.

4. Learn even the most difficult concepts about climate change.

5. Understand simple concepts about climate change.

6. Understand complex concepts about climate change.

Appendix H

Climate Change Interest Survey

Instructions:

For the following items, please rate how true of you each statement is, ranging from 1 (not at all true of me) to 7 (completely true of me).

Scale to be used:

1	2	3	4	5	6	7
Not at all True of me			Somewhat True of Me			Completely True of Me

Items:

1. I am interested in knowing more about climate change.

2. I think it is important to know what is causing climate change.

3. I am *not* interested in knowing more scientific information about climate change.

4. I would like to know what the role of human activity in climate change really is.

5. Knowing more scientific information about what is causing climate change is important to me.

6. I am interested in learning more about climate change.

Appendix I

Beliefs about Climate Change

Instructions:

For the following items, please rate how true of you each statement is, ranging from 1 (not at all true of me) to 7 (completely true of me).

Scale to be used:

1	2	3	4	5	6	7
Not at all True of me			Somewhat True of Me			Completely True of Me

Items:

1. I believe that the average global temperature is rising.
2. I believe human activity can not impact the Earth's climate.
3. I believe that global warming will lead to serious negative consequences.
4. I believe that human activities are causing the current climate change on the Earth.
5. I believe that the Earth's climate is changing.
6. I believe humans can do nothing to stop global warming.

Appendix J

Attitudes toward Climate Change

Global climate change refers to the change in the earth's climate induced by human activities (e.g., employing fossil fuels). Rate your attitudes about global climate change:

	1	2	3	4	5	6	7	
Not Urgent								Urgent

	1	2	3	4	5	6	7	
False								True

	1	2	3	4	5	6	7	
Harmless								Harmful

	1	2	3	4	5	6	7	
Not Frightening								Frightening

Appendix K

Adapted Human-induced Climate Change Knowledge (HICCK) Instrument

*6 items were added to the original instrument to further address the greenhouse effect and effects of climate change as covered through the study interventions

Instructions:

Below are statements about climate change. Rate the degree to which you think that climate scientists agree with these statements.

Scale to be used:

1	2	3	4	5
Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree

Items:

1. The Sun is the main source of energy for Earth's climate.
2. Human have very little effect on Earth's climate.
3. We cannot know about ancient climate change.
4. Earth's climate has probably changed little in the past.
5. The Sun's brightness is one way to measure solar activity.
6. Sunspot number is related to solar activity.
7. Greenhouse gases make up less than 1% of Earth's atmosphere.
8. Burning of fossil fuels produces greenhouse gases.
9. Humans produce billions of tons of greenhouse gases each year.
10. Humans are reducing the amount of fossil fuels they burn.
11. Greenhouse gas levels are increasing in the atmosphere.
12. Greenhouse gases absorb some of the energy emitted by Earth's surface.
13. The Earth's greenhouse effect was created solely through human activity.
14. The Earth's greenhouse effect occurs mostly (>95%) naturally.
15. The Earth's greenhouse effect is dangerous to life on Earth.
16. The Earth's greenhouse effect makes the Earth habitable.

17. An increase of only a couple of degrees in the Earth's average temperature will have no effect on civilization.
18. An increase of only a couple of degrees in the Earth's average temperature can have major effects on food production, water resources, and energy supplies.
19. Earth's climate is currently changing.
20. Humans are behind the cause of Earth's current climate change.
21. Earth's climate is not currently changing.
22. Current climate change is caused by human activities.
23. Current climate change is caused by an increase in the Sun's energy.
24. Current climate change is caused by the ozone hole.
25. Current climate change is caused by changes in Earth's orbit around the Sun.
26. Current climate change is caused by volcanic eruptions.
27. Current climate change is caused by increasing dust in the atmosphere.
28. Future climate change may be slowed by reducing greenhouse gas emissions.
29. Humans cannot reduce future climate change.
30. Satellites do not provide evidence that humans are changing Earth's climate.
31. Earth's average temperature has increased over the past 100 years. This is evidence of climate change.
32. Average sea level is increasing. This is evidence of climate change.
33. Most of the world's glaciers are decreasing in size. This is evidence of climate change.

Appendix L

Demographics

Instructions:

Please complete the following as accurately as possible.

Items:

What is your current age in years?

________ years old

What is your gender?

a. Male
b. Female

What is your ethnicity?

a. White/Caucasian
b. African American/Black
c. American Indian/Alaska Native
d. Asian American/Asian
e. Native Hawaiian/Pacific Islander
f. Mexican American/Chicano
g. Puerto Rican
h. Other Latino
i. Other

What is your year in college?

a. Freshman
b. Sophomore
c. Junior

d. Senior

What is your college major?

____

What is your college minor (if any)?

____

What is your current G.P.A. (grade point average)?

____

How many High School Science courses have you taken?

____

How many College level Science courses have you taken?

____

References

Alvermann, D. E., Hynd, C. R., & Qian, G. (1995) Effects of interactive discussion and text type on learning counterintuitive science concepts. *The Journal of Educational Research, 88,* 146-154.

Ariasi, N. & Mason, L. (2011) Uncovering the effect of text structure in learning from a science text: An eye-tracking study. *Instructional Science, 39,* 391-601.

Bandura, A. (1997) Self-efficacy: The exercise of control. New York: Freeman.

Bandura, A. (2006) Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.) Self-efficacy beliefs of adolescents (pp. 307-337). Greenwich, Connecticut: Information Age Publishing.

Bangert-Drowns, R. L., Kulik, C. L. C., Kulik, J. A., & Morgan, M.T. (1991) The instructional effect of feedback in test-like events. *Review of Educational Research, 61*(2), 213-238.

Braasch, J. L. G., Goldman, S. R., & Wiley, J. (2013) The influences of text and reader characteristics on learning from refutation s in science texts. *Journal of Educational Psychology.*

Brooks, D. W., Schraw, G., & Crippen, K. J. (2005) Performance-related feedback: The hallmark of efficient instruction. *Journal of Chemical Education, 82*(4), 641-644.

Broughton, S. H., Sinatra, G. M., & Reynolds, R. E. (2010) The nature of the refutation text effect: An investigation of attention allocation. *The Journal of Educational Research, 103,*407-423.

Butler, D. L., & Winne, P. H. (1995) Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*, 245-281.

Chambliss, M. J. & Garner, R. (1996) Do adults change their minds after reading persuasive text? *Written Communication, 13,* 291-313.

Choi, S., Niyogi, D., Shepardson, D. P.,& Charusombat, U. (2010) Do earth and environmental science textbooks promote middle and high school students' conceptual development about climate change?: Textbooks' consideration of students' misconceptions. *Bulletin of the American Meteorological Society,* July, 889-898.

Cordova, J. R., Sinatra, G. M., Jones, S. H., Taasoobshirazi, G., & Lombardi, D. (2014) Confidence in prior knowledge, self-efficacy, interest and prior knowledge: Influences on conceptual change. *Contemporary Educational Psychology, 39*, 164-174.

Danielson, R. W., Sinatra, G. M., & Kendeou, P. (2016) Augmenting the refutation text effect with analogies and graphics. *Discourse Processes, 53*(5-6), 392-414.

Deniz, H., Donnelly, L., & Yilmaz, I. (2008). Exploring the factors related to acceptance of evolutionary theory among Turkish preservice biology teachers: Toward a more informative conceptual ecology for biological evolution. *Journal of Research in Science Teaching, 45*(4), 420-443.

Diakidoy, I.A. N., Kendeou, P., & Ioannides, C. (2003) Reading about energy: The effects of text structure in science learning and conceptual change. *Contemporary Educational Psychology, 28,* 335-356.

Diakidoy, I.A.N., Mouskounti, T., & Ioannides, C. (2011) Comprehension and Learning From Refutation and Expository Texts, *Reading Research Quarterly, 46(*1), 22-38.

Dole, J. A. & Neiderhauser, D. (1990) Students' level of commitment to their naïve conceptions and their conceptual change learning from texts. In J. Zutell & S. McCormick (Eds.), *Literacy theory and research: Analyses from multiple paradigms* (pp. 303-310). Chicago, IL: NRC.

Dole, J. A. & Sinatra, G. M. (1998). Reconceptualizing change in the cognitive construction of knowledge. *Educational Psychologist 33*(2/3), 109-128.

Duijnhouwer, H., Prins, F. J., & Stokking, K. M. Feedback providing improvement strategies and reflection on feedback use: Effects on students' writing motivation, process, and performance. *Learning and Instruction, 22,* 171-184.

Dutt, V., & Gonzalez, C. (2012) Decisions from experience reduce misconceptions about climate change. *Journal of Environmental Psychology, 32,* 19-29.

Frede, V. (2008) Teaching astronomy for pre-service elementary teachers: A comparison of methods. *Advances in Space Research, 42,* 1819-1830.

Gao, T. & Lehman, J. D. (2003) The effects of different levels of interaction on the achievement and motivational perceptions of college students in a web-based learning environment. *Journal of Interactive Learning Research, 14*(4), 367-386.

Gordon, C, & Rennie, B. (1987) Restructuring content schemata: An intervention study. *Reading Research and Instruction, 26*(3), 162-188.

Griffin, T. D., & Ohlsson, S. (August, 2001). *Beliefs versus knowledge: A necessary distinction for explaining, predicting, and assessing conceptual change.* Paper presented at the 23rd Annual Conference of the Cognitive Science Society. Edinburgh, Scotland.

Guzzetti, B. J., Snyder, T. E., Glass, G. V., & Gamas, W. S. (1993) Promoting conceptual change in science: A comparative meta-analysis of instructional interventions from reading education and science education. *Reading Research Quarterly, 28*(2), 116-159.

Guzzetti, B. J., Williams, W. O., Skeels, S. A., & Wu, S. M. (1997) Influence of text structure on learning counterintuitive physics concepts. *Journal of Research in Science Teaching, 34,* 701-719.

Hancock, T. E., Stock, W. A., & Kulhavy, R. W. (1992) Predicting feedback effects from response-certitude estimates. *Bulletin of the Psychonomic Society, 30,* 173-176.

Hattie, J. & Timperley, H. (2007) The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Hidi, S. (2001) Interest, Reading, and Learning: Theoretical and Practical Considerations. *Educational Psychology Review, 13*(3), 191-209.

Hidi, S. & Ainley, M. (2008) Interest and self-regulation: Relationships between two variables that influence learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and Self-Regulated Learning: Theory, Research and Applications,* (pp. 1-30). New York: Lawrence Erlbaum Associates.

Hynd, C. R. (2001) Refutational texts and the change process. *International Journal of Educational Research, 35*, 699-714.

Hynd, C. R., Alvermann, D. E., & Qian, G. (1997) Preservice elementary school teachers' conceptual change about projectile motion. *Science Education, 81,* 1-27.

Hynd, C. R., McWhorter, J., Phares, V., & Suttles, C. (1994) The role of instructional variables in conceptual change in high school physics topics. *Journal of Research in Science Teaching, 31,* 933-946.

Kendeou, P., Muis, K. R., & Fulton, S. (2011) Reader and text factors in reading comprehension processes. *Journal of Research in Reading, 34*(4), 365-383.

Kendeou, P., & van den Broek, P. (2005) The effects of readers' misconceptions on comprehension of scientific text. *Journal of Educational Psychology, 20*(2)*,* 235-245.

Kendou, P. & van den Broek, P. (2007) The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. *Memory & Cognition, 35*(7), 1567-1577.

Kulhavy, R. W. & Stock, W. A. (1989) Feedback in written instruction: The place of response certitude. *Educational Psychology Review, 1,* 279-308.

Kulhavy, R. W., White, M. T., Topp, B. W., Chan, A. L., & Adams, J. (1985) Feedback complexity and corrective efficiency. *Contemporary Educational Psychology, 10*, 285-291.

Kulhavy, R. W., Yekovich, F. R., & Dyer, J. W. (1976) Feedback and response confidence. *Journal of Educational Psychology, 68*(5), 522-528.

Linnenbrink, E. A. & Pintrich, P. R. (2002) Motivation as an enabler for academic success. *School Psychology Review, 31* (3), 313-327.

Lombardi, D. & Sinatra, G. M. (2012) College students' perceptions about the plausibility of human-induced climate change. *Research in Science Education, 42*(2), 201-217.

Lombardi, D., Sinatra, G. M., Nussbaum, E. M. (2013) Plausibility reappraisals and shifts in middle school students' climate change conceptions. Manuscript submitted for publication.

Lombardi, D., Seyranian, V., & Sinatra, G. M. (2013) Source effects and plausibility judgments when reading about climate change. Manuscript submitted for publication.

Mason, B. J., & Bruning, R. (2001) Providing feedback in computer-based instruction: What the research tells us. Retrieved February, 25, 2013 from http://dwb.unl.edu/Edit/MB/MasonBruning.html.

Mason, L., & Gava, M. (2007) Effects of epistemological beliefs and learning text structure on conceptual change. In S. Vosniadou, A. Baltas, & X Vamvakoussi (Eds.), *Reframing the conceptual change approach in learning and instruction* (pp. 165-197). Oxford, UK: Elsevier.

Mason, L., Gava, M., & Boldrin, A. (2008) On warm conceptual change: The interplay of text, epistemological beliefs, and topic interest. *Journal of Educational Psychology, 100,* 291-309.

McCrudden, M. T., & Kendeou, P. Exploring the link between cognitive processes and learning from refutational text. *Journal of Research in Reading, 00(*00), 1-25.

McKeown, M. G., Beck, I. L., Sinatra, G. M., & Loxterman, J. A. (1992) The contribution of prior knowledge and coherent text to comprehension. *Reading Research Quarterly, 27.* 79-93.

Mikkila-Erdmann, M., Pentinen, M., Anto, E., & Olkinuora, E. (2008) Constructing mental models during learning from science text: Eye tracking methodology meets conceptual change. In D. Ifenthaler, P. Pirnay-Dummer, & J. M. Spector (Eds.) *Understanding models for learning and instruction* (pp. 63-79). New York, NY: Springer.

Mory, E. H. (2004) Feedback research revisited. In D. H. Jonassen (Ed.), *Handbook of Research on Educational Communications and Technology* (2^{nd} ed.), (pp. 745-783). Mahwah, NJ: Lawrence Erlbaum Associates.

Murphy, P. K. & Alexander, P. A. (2004) Persuasion as a dynamic, multidimensional process: An investigation of individual and intraindividual differences. *American Educational Research Journal, 41*(2), 337-363.

Narciss, S. (April, 1999) Motivational effects of the informativeness of feedback. Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Canada.

Narciss, S. (2004) The impact of informative tutoring feedback and self-efficacy on motivation and achievement in concept learning. *Experimental Psychology, 51*(3), 214-228.

Narciss, S. & Huth, K. (2004) How to design informative tutoring feedback for multi-media learning. In H. M. Niegemann, D. Leutner, & R. Brunken (Eds.) *Instructional design for multimedia learning* (pp. 181-195.), Munster, NY: Waxmann.

Narciss, S. & Huth, K. (2006) Fostering achievement and motivation with bug-related tutoring feedback in a computer-based training for written subtraction. *Learning and Instruction, 16*, 310-322.

Nussbaum, E. M. (2015) *Categorical and nonparametric data analysis: Choosing the best statistical technique,* New York, NY: Routledge.

Nussbaum, E. M., Cordova, J. R., & Rehmat, A. P. (February, 2017) Refutation texts for effective climate change education. *Journal of Geoscience Education.*

Ormrod, J. E. (2004) *Human learning.* Upper Saddle River, New Jersey: Pearson Education, Inc.

Osborne, Jason (2010). Improving your data transformations: Applying the Box-Cox transformation. *Practical Assessment, Research & Evaluation,* 15(12). Available online: http://pareonline.net/getvn.asp?v=15&n=12.

Pajares, F. (1996) Self-efficacy beliefs in academic settings. *Review of Educational Research, 66,*543-578.

Penttinen, M., Anto, E., Mikkila-Erdmann, M. (2012) Conceptual change, text comprehension and eye movements during reading. *Research in Science Education.*

Qian, G. (November, 1995) *The role of epistemological beliefs and motivational goals in ethnically diverse high school students' learning from science text.* Paper presented at the meeting of the National Reading Conference, New Orleans, LA.

Rukavina, I. & Daneman, M. (1996) Integration and its effect in acquiring knowledge about competing scientific theories from text. *Journal of Educational Psychology, 88,* 272-287.

Schraw, G., Krippen, K. J., & Hartley, K. (2006) Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 36,* 111-139.

Schultz, P. A. (1993) Additional influences on response certitude and feedback requests. *Contemporary Educational Psychology, 18,* 427-441.

Seyranian, V. (2013) Leadership communication strategies for mobilizing social change. Manuscript submitted for publication.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and Quasi-Experimental Designs for Generalized Causal Inference.* Boston, MA: Houghton Mifflin.

Shute, V. J. (2008) Focus on formative feedback. *Review of Educational Research, 78*(1), 153-189.

Shymansky, J. A., Yore, L. D., Treagust, D. F., Thiele, R. V., Harrison, A., Waldrip, B. G., Stocklmayer, S. M., & Venville, G. (1997) Examining the construction process: A study of changes in level 10 students' understanding of classical mechanics. *Journal of Research in Science Teaching, 34,* 571-593.

Sinatra, G. M. & Broughton, S. H. (2011) Bridging reading comprehension and conceptual change in science education: The promise of refutation text. *Reading Research Quarterly, 46*(4), 374-393.

Sinatra, G. M., Kardash, C. M., Taasoobshirazi, G., & Lombardi, D. (2012) Promoting attitude change and expressed willingness to take action toward climate change in college students. *Instructional Science: An International Journal of the Learning Sciences, 40*(1), 1-17.

Thijs, G. D. (1992) Evaluation of an introductory course on “force” considering students’ preconceptions. *Science Education, 76,* 155-174.

Timmers, C. F., Braber-van den Broek, J., & van den Berg, S. M. (2013) Motivational beliefs, student effort, and feedback behavior in computer-based formative assessment. *Computers & Education, 60*, 25-31.

Tippett, C. D. (2010) Refutation text in science education: A Review of two decades of research. *International Journal of Science and Mathematics Education, 8,* 951-970.

Thijs, G. D. (1992) Evaluation of an introductory course on “force” considering students’ preconceptions. *Science Education, 76,* 155-174.

Van den Broek, P. & Kendeou, P. (2008) Cognitive processes in comprehension of science texts: the role of co-activation in confronting misconceptions. *Applied Cognitive Psychology, 22,* 335-351.

Van den Broek, P., Young, M., Tzeng, Y., & Linderholm, T. (1999) The landscape model of reading: Inferences and the online construction of a memory representation. In H. van Oostendorp & S. R. Goldman (Eds.), *The construction of mental representations during reading* (pp. 71-98). Mahwah, NJ: Erlbaum.

van der Keij, F. M., Eggen, T. J. H. M., Timmers, C. F., & Veldkamp, B. P. (2012) Effects of feedback in a computer-based assessment for learning. *Computers & Education, 58,* 263-272.

Vollmeyer, R. & Rheinberg, F. (2005) A surprising effect of feedback on learning. *Learning and Instruction, 15,* 589-602.

Vosniadou, S. (2008) (Ed.). (2008) International Handbook of Research on Conceptual Change. New York, NY: Routledge.

Vosniadou, S. (2001) What can persuasion research tell us about conceptual change that we did not already know? *International Journal of Educational Research, 35,* 731-737.

Vosniadou, S., & Brewer, W. F. (1992) Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology, 24*, 535-585.

Vosniadou, S., & Mason, L. (2012). Conceptual change induced by instruction: A complex interplay of multiple factors. In K. R. Harris, S. Graham, T. Urdan, S. Graham, J. M. Royer, M. Zeidner (Eds.), *APA educational psychology handbook, Vol 2: Individual differences and cultural and contextual factors* (pp. 221-246). Washington, DC US: American.

Wang, S. L. & Wu P. Y. (2008) The role of feedback and self-efficacy on web-based learning: The social cognitive perspective. *Computers & Education, 51*, 1589-1598.

Woods, B. S. & Murphy, P. K. (2001) Separated at birth: the shared lineage of research on conceptual change and persuasion. *International Journal of Educational Research, 35,* 633-649.

Zimmerman, B. J. (2000a) Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13-39). New York: Academic Press.

Zimmerman, B. J. (2000b) Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25,* 82-91.

Zimmerman, B. J. & Schunk, D. H. (2008) Motivation: An essential dimension of self-regulated learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and Self-Regulated Learning: Theory, Research and Applications,* (pp. 1-30). New York: Lawrence Erlbaum Associates.

Curriculum Vitae

NAME: Jacqueline R. Cordova

HOME ADDRESS: 4429 Rockaway Beach Street
Las Vegas, NV 89129
P: 702-340-2076

UNIVERSITY ADDRESS: Department of Educational Psychology and Higher Education
College of Education
University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, NV 89154
E-mail: cordova1@unlv.nevada.edu

I. EDUCATIONAL HISTORY

2006 *M.S. Educational Psychology,* University of Nevada, Las Vegas. Advisor: Dr. LeAnn Putney.

1997 *B.S. Psychology,* South Dakota State University. Honors Graduate.

PROFESSIONAL ORGANIZATIONS

American Educational Research Association, Division C, Learning and Instruction
American Psychological Association, Division 15, Educational Psychology
Conceptual Change Special Interest Group, EARLI
European Association for Research on Learning and Instruction (EARLI)
Golden Key National Honor Society
Motivation and Emotion Special Interest Group, EARLI
Psi Chi

II. HONORS AND AWARDS

Nevada Stars Graduate Assistantship, 2006-2008
Tri-State Pinnacle Award for Non-Profit Programs, 2001.

III. PROFESSIONAL WORK HISTORY

2010-2011	*Research Assistant*, Educational Psychology Department, UNLV. Assisted Dr. Gale Sinatra and Dr. Michael Nussbaum on NSF EPSCoR funded project developing a simulation game to teach about the effect of climate change on Lake Mead. Developed climate change related refutation texts.
2006-2011	*Editorial Assistant*, *Educational Psychologist (EP)*. Assisted Editor, Dr. Gale Sinatra, with correspondence, manuscript review and publication process, and report writing for EP, an APA Division 15 Journal.
2006-2008	*Nevada Stars Graduate Assistant,* Educational Psychology Department, UNLV. Designed and conducted qualitative research on the relationship between domestic violence and self-efficacy with domestic violence survivors. Assisted Dr. LeAnn Putney with special projects, survey data collection, coding, and analysis.
2005-2006	*Graduate Assistant,* Educational Psychology Department, UNLV. Assisted Dr. LeAnn Putney with Graduate Coordinator duties, special projects, interview transcription, qualitative data coding and analysis, and teaching preparations.
2004-2005	*Graduate Assistant,* The Center for Academic Enrichment and Outreach, UNLV. Provided wrap-around services and assistance, including case management, advocacy, and referrals to low income, at-risk families through the Family Support Services Division.
2000—2004	*Volunteer Coordinator,* Safe Nest (Temporary Assistance for Domestic Crisis), Las Vegas. Responsible for daily Volunteer Services Department Operations, including all volunteer personnel recruitment, training, placement, recognition, supervision and risk management. Provided crisis counseling to victims, perpetrators and children affected by domestic violence, as well as taking Emergency Protection Orders.
1998	*Assistant Director,* Li'l Scholar Pre-School, Las Vegas. Coordinated all daily operations for over 100 children in a 24-hour child care facility. Supervised teachers and other staff, as well as provided child-care and instruction to children ranging in age from two to twelve years in a school setting.

IV. SCHOLARLY PUBLICATIONS AND ACTIVITES

Refereed Journal Articles

Cordova, J. R., Sinatra, G. M., Jones,. S. H., Taasoobshirazi, G., & Lombardi, D. (2014) Confidence in prior knowledge, self-efficacy, interest and prior knowledge: Influences on conceptual change. *Contemporary Educational Psychology, 39*, 164-174.

Johnson, M. L., Taasoobshirazi, G., Kestler, J. L., & Cordova, J. R. (2014). Models and Messengers of Resilience: A Theoretical Model of College Students' Resilience, Regulatory Strategy Use, and Academic Achievement. *Educational Psychology.* http://dx.doi.org/10.1080/01443410.2014.893560

Nussbaum, E. M., Owens, M. C., & Cordova, J. R. (2015). 'It's Not a Political Issue!' The Interaction of Subject and Politics on Professors' Beliefs in Human-Induced Climate Change*. Journal of Education for Sustainable Development, 10*.1.

Nussbaum, E. M., Owens, M. C., Sinatra, G. M., Rehmat, A. P., Cordova, J. R., Vesco, J. M., Ahmad, S., Harris, F. C., Dascalu, S. M. (2015). Losing the lake: Simulations to promote gains in student knowledge and interest about climate change. *International Journal of Environmental and Science Education, 10*(4).

Nussbaum, E. M., Cordova, J. R., & Rehmat, A. P. (Feb, 2017) Refutation texts for effective climate change education. *Journal of Geoscience Education*.

Works in Progress

Bailey, J. M., Lombardi, D., Cordova, J. R., & Sinatra, G. M. Meeting students halfway: Increasing self-efficacy and promoting knowledge change in astronomy (pulled from JRST; under revision with intention to be submitted to IJSE)

Reports

Nussbaum, M. N., Sinatra, G. M., Harris, F. C., Ahmad, S., Dascalu, S. M., Crippen, K. J., Owens, M. C., Vesco, J. M., Dawadi, S., Cordova, J. R., Rehmat, A. P. (2012) *Losing the lake: Promoting sustainability awareness through educational computer-simulations of Lake Mead water levels and water supply to the Las Vegas Valley. Technical Report*. University of Nevada, Las Vegas. (supported by NSF EPSCoR grant EPS-0814372 and NSF grant CMMI-0846952)

Curriculum Materials

Nussbaum, E. M., Sinatra, G. M., Cordova, J. R., Owens, M. C., Rehmat, A. P. (2012*)* *Losing the Lake: A simulation guide on Lake Mead, water resources, and climate change. Facilitator's guide.* University of Nevada, Las Vegas.

Conference Presentations

Nussbaum, E. M., Cordova, J. R., & Rehmat, A. P. (April, 2016) *Refutation Texts for Effective Climate Change Education.* Paper presented at the annual meeting of the American Educational Researchers Association National Conference, Washington, D.C.

Nussbaum, E. M., Owens, M. A., & Cordova, J. R. (April, 2014). *When Science, Subject, and Politics Meet: Factors Affecting Professors' Beliefs About Climate Change.* Paper presented at the annual meeting of the American Educational Researchers Association National Conference, Philadelphia, PA.

Cordova, J. R., Nussbaum, E. M., Owens, M. A., & Rehmat, A.P. (August, 2013) *Fostering interest in learning more about climate change through a computer simulation game.* Paper presented at the biannual meeting of the European Association for Research in Learning and Instruction, Munich, Germany.

Bailey, J. M., Lombardi, D., Sinatra, G. M., & Cordova, J. R. (August, 2013). *The impact of self-efficacy on conceptual change: A study in astronomy.* Paper presented at the biannual meeting of the European Association for Research in Learning and Instruction, Munich, Germany.

Nussbaum, E. M., Owens, M. C., Rehmat, A. P., & Cordova, J. R. (June, 2013). *Toward collaborative argumentation in "Losing the Lake."* Paper presented at the annual International Conference on Computer Supported Collaborative Learning, Madison, WI.

Nussbaum, E. M., Owens, M.C., Cordova, J. R., Rehmat, A. P., & Sinatra, G. M. (March, 2013) *Simulations to promote student knowledge and interest gains in environmental science and climate change.* Paper presented at the International Conference for the Society for Information Technology and Teacher Education, New Orleans, LA.

Cordova, J., & Sinatra, G. (August, 2011). *Self-efficacy, prior knowledge, and confidence in prior knowledge on conceptual change learning.* Paper presented at the biannual meeting of the European Association for Research on Learning and Instruction, Conceptual Change Special Interest Group, Exeter, UK.

Cordova, J., Broughton, S.H., & Sinatra, G. M. (April, 2011). *Self-efficacy, confidence judgments, and accuracy in conceptual change learning.* Paper presented at the annual meeting of the American Educational Researchers Association, National Conference, New Orleans, Louisiana.

Sinatra, G. M., Cordova, J. R., Broughton, S. H., & Taasoobshirazi, G. (August, 2010). *Self-efficacy, emotions, and conceptual change*. Paper presented at the biannual meeting of the European Association for Research on Learning and Instruction, Motivation and Emotions Special Interest Group, Porto, Portugal.

Cordova, J., Broughton, S.H., & Sinatra, G. M. (May, 2010). *Self-efficacy, confidence in prior knowledge, and conceptual change*. Paper presented at the annual meeting of the American Educational Researchers Association, National Conference, Denver, Colorado.

Broughton, S. H., Cordova, J. & Sinatra, G. M. (2009). *Warming the culture of science learning: Investigating interest and emotions as factors of conceptual change.* Paper presented at the bi-annual meeting of the Southwest Consortium for Innovations in Psychology in Education Conference, University of Nevada, Las Vegas.

V. TEACHING

Graduate Courses

Descriptive and Inferential Statistics: An Introduction, Teaching Practicum, Spring, 2012.
Educational Research Methods, Instructor, Summer, 2011.
Educational Research Methods, Teaching Practicum, Fall, 2008.

Trainings

Wangberg, J. R. (2000) *Safe Nest Volunteer Domestic Violence Training Program.* Forty-hour domestic violence training program developed and facilitated semiannually from 2000-2004.

Wangberg, J. R. (2000) *Domestic Violence 101.* Six-hour domestic violence training developed and presented semiannually from 2000-2004.

Wangberg, J. R. (2000) *History of Women's Victimization.* One hour training developed and presented semiannually from 2000-2004.

Wangberg, J. R. (2000) *Vicarious Traumatization and Self-Care.* One hour training developed and presented semiannually from 2000-2004.

SERVICE

2015 *Ad hoc Student Reviewer,* Journal of Educational Psychology

2013 *Student Member,* Educational Psychology Faculty Search Committee, UNLV.

2012 *Ad hoc Student Reviewer*, Metacognition and Learning

2011 *Ad hoc Student Reviewer*, Contemporary Educational Psychology

2010 *Ad hoc Student Reviewer*, Journal of Experimental Psychology

2007 *Student Member*, Educational Psychology Faculty Search Committee, UNLV.

2006-2008 *Volunteer*, Safe Nest Domestic Violence Agency

2002-2006 *Member,* Colman Jaycees.

2003-2004 *Member,* DOVIA (Directors of Volunteers in Agencies) Steering Committee.

2003-2004 *Chair,* DOVIA (Directors of Volunteers in Agencies) Awards and Nominating Committee.

2002-2004 *Volunteer,* Las Vegas Metro Police Department Crisis Response Team.

VI. REFERENCES

Dr. CarolAnne Kardash
Department of Educational Psychology and Higher Education
College of Education
University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, NV 89154
P: 702-895-3839
E-mail: carolanne.kardash@unlv.edu

Dr. Gale Sinatra
Past VP, Division C, AERA
Professor
Rossier School of Education
University of Southern California
3470 Trousdale Parkway
Waite Phillips Hall
Los Angeles, CA 90089-4036
P: 702-303-4328

E-mail: gsinatra@usc.edu

Dr. Michael Nussbaum
Department of Educational Psychology and Higher Education
College of Education
University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, NV 89154
P: 702-895-2665
E-mail: nussbaum@unlv.nevada.edu