THE PSYCHOLOGICAL CONSTRUCTION OF CONFUSION AND ITS RELATIONSHIP TO COMPLEX INFERENTIAL REASONING PERFORMANCE IN A LEARNING ENVIRONMENT

by

TERRITA L. UPCHURCH-POOLE

STEPHEN J. THOMA, COMMITTEE CHAIR

CECIL ROBINSON
BEVERLY ROSKOS
JASON SCOFIELD
SARA TOMEK

A DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Educational Studies in
Psychology, Research Methodology & Counseling
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2017

ABSTRACT

A growing body of evidence suggests that meaningful learning is improved when students engage in tasks and activities that require complex thinking or inferential reasoning. In turn, many educationalists have responded to this finding by attempting to intensify the cognitive rigor of learning tasks given to students. But this strategy alone may prove ineffective because interdisciplinary investigations suggest that complex reasoning involves both cognitive and affective processes. In fact, the emotional experience of learning-related confusion, categorized as an epistemic emotion, is purported to foster or improve students' complex inferential reasoning, although specific mechanisms of action which underpin confusion's reported benefit have not been well studied and thus remain unclear. One hypothesis, proposed by this dissertation, is that confusion is a psychologically *constructed* emotion, where confusion concept knowledge and epistemological beliefs about the nature of knowledge and learning represent constitutive elements that are in turn associated with differences in how students perceive the feeling of, and respond to confusion in the context of performing complex reasoning tasks. To shed light on this phenomenon, the Theory of Constructed Emotion was utilized as a guiding framework, in conjunction with hierarchical regression analyses, to investigate how students might psychologically construct two different perceptions of confusion, as well as the ways in which different confusion constructions appear to either help or hinder complex inferential reasoning performance. Results suggest that there are differences in students' psychological constructions of confusion and that these differences are related to variation in their reasoning performance.

DEDICATION

This dissertation is dedicated to the most important people in my life. First to my parents, Dr. (Leo) and Mrs. (Louise) Upchurch. Over the course of my formative years living in Ann Arbor, you exposed me to music, art, food, sports, travelling, the great outdoors, and people from across the globe; and you never grew tired of me wanting to try everything—from playing the clarinet, to girl scouts, to ballet, gymnastics, choir, and more. I suspect that my many endeavors may have at times created a financial burden, but in giving me the space and the encouragement to explore, you fostered in me a deep love of learning that will forever be a part of who I am. I am eternally grateful for the example you set for me in all things, but in particular in terms of valuing education and striving to be a good human being.

And then to Leila and Kenny. You two are ultimately the reason that I decided to embark upon this foray into educational psychology; I refused to believe that three letters (and you know the ones I'm talking about) should define who you are and dictate what you are capable of achieving in life. I am prouder than you will ever know of the truly amazing people that you are and will continue to become; one of the greatest joys of my life has been watching you both grow up.

And finally, to my steadfast encouragers, cheerleaders, and all-around life lines—Aunt Zel, and my sisters, Terri, Terissa, Marita, and Terralyn. You always called at the right time, showed up at the right time, and generally made sure that I had whatever I needed (including an occasional batch of sweet potato cupcakes shipped from 700 miles away) at any given moment. It was (and is) a wonderful comfort to know that you believed in me from the start to the finish.

LIST OF ABBREVIATIONS AND SYMBOLS

PK	Climate Change Prior Knowledge: measure of participants' existing knowledge about climate change
VA	Verbal Ability: measure of participants' word comprehension
FOC-P	Feeling of Confusion Text Passage Priming: proxy measure for the level of confusion experienced during emotion priming
FOC-R	Feeling of Confusion Learning Verification Task Reactivation: proxy measure for the level of confusion experienced during learning verification task completion
EB	Epistemological Beliefs: measure of the sophistication of participants' beliefs about the nature of knowledge and learning
TK	SES-Q Confusion-Threat Concept Knowledge: rating measure of participants' agreement with confusion as a threat signal
CK	SES-Q Confusion-Challenge Concept Knowledge: rating measure of participants' agreement with confusion as a challenge signal
LVT	Learning Verification Task: measure of participants' complex inferential reasoning performance
df	Degrees of freedom: number of values free to vary after certain restrictions have been placed on the data
F	Fisher's *F* ratio: a ration of two variances
M	Mean: the sum of a set of measurements divided by the number of measurements in the set
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
r	Pearson product-moment correlation
t	Computed value of *t* test
X^2	Computed value of Chi square test of association

ACKNOWLEDGMENTS

I could not have succeeded in this endeavor without the kindness and support of a number of people, and I am pleased to have this opportunity to formally acknowledge them. My Dissertation Chair, Steve Thoma has been an incredible advisor, mentor, and friend. I appreciate the way that you simultaneously encouraged my autonomy but never left me feeling alone. You were truly invested in my success, and I am most grateful for your knowledge and insight. I was also fortunate to have an outstanding Dissertation Committee: Bev Roskos, Jason Scofield, Sara Tomek, and Cecil Robinson. The conceptual expertise and unique approach to the dissertation process that each of you contributed was invaluable. Your critique and insight have helped me to become a better researcher.

Along the way I made some truly awesome friends, Jean, Marsha, and Adriane. Not only were you ladies a phenomenal academic support system, but you also kept me going when 'life happened'. Additionally, I had the pleasure of working closely with Cori in the graduate school during the last year of my studies; you were a great boss, and an even better friend. And last but certainly not least, I want to acknowledge my SREB family—in particular, Dr. Abraham and Dr. Mohr. I don't know that I could have done this without you! Far more than just a check and a handshake, SREB provided an all-encompassing network for and access to mentoring, academic and personal development, and people who are truly committed to changing the landscape of the professoriate.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The 21st century represents an era of opportunity for more people than ever before; nevertheless, there are many complex issues—slowing climate change, reversing poverty, and improving healthcare—which cannot be ignored (Martin, 2007). Moreover, finding socially, morally, and economically workable solutions to these challenges will be heavily dependent upon the ability of the world's citizenry, in particular the students of today who will become the leaders and decision makers of tomorrow, to engage effectively in critical thinking and complex reasoning (Paul, 1984; Flores et al, 2012). Indeed, many educationalists concur with this assertion but have argued that more research and practical applications which address and support students' development of complex higher order reasoning competencies (e.g., scientific literacy) are needed (Flores et al, 2012); and this has led to an ongoing trend in education-related research where a great deal of emphasis has been placed upon identifying and dissecting the cognitive factors that appear to support and promote complex inferential reasoning.

Unarguably, studying relationships between cognitive factors and student learning is a valid and important aim; however, a number of interdisciplinary studies make the case that students' higher order reasoning capacities and meaningful learning cannot be improved by focusing on cognitive/thinking processes in isolation. According to this nascent line of inquiry, the most fruitful understanding of complex reasoning can only be derived by giving consideration to other mental concepts, constructs, or states that might also support the development of such thinking abilities (Barsalou, 2010; Pajares, 1992; Pekrun & Stephens, 2010; Muis et al, 2015). One such concept that has received significant attention in the literature is epistemological beliefs about the nature of knowledge and learning (Schommer,1990).

Over the past three decades, Schommer-Aikins has conducted research that examines what students believe about the nature of knowledge, knowing, and learning, and the role that such beliefs play in learning processes and outcomes. For example, across a number of studies, Schommer-Aikins has demonstrated that students who believe the speed of knowledge acquisition is slow, that knowledge is generated through a complex unorderly process, and that the ability to 'know' and learn is not innate or fixed, often exhibit greater use of higher-order, complex reasoning processes and are significantly more effective in monitoring their comprehension (Schommers, 1990; Ravindran, Greene & DeBacker, 2005). As evidenced by findings such as these, epistemological beliefs are now considered to be integral to our understanding of students' thinking and learning. But there is also a burgeoning stream of research which postulates that in addition to beliefs and cognitions, emotions and affective states are another potentially salient category of mental phenomena that could play a symbiotic role in the facilitation of complex inferential reasoning (Lipson, 1990, 1992; D'Mello & Graesser, 2014).

Indeed, achievement emotions, topic emotions, and social emotions now occupy a decisive space in the literature in terms of distinguishing and describing the affective states experienced by students in classroom settings (Pekrun, 2011; 2016); and even more intriguing is the intensified and growing interest in epistemic or 'knowledge' emotions—those which have been determined to accompany or occur in tandem with thinking and cognitive processing effort

(Pekrun, 2011; 2016). Among the handful of the epistemic emotions identified to date, the feeling of confusion is one which seems particularly fascinating, given both its paradoxical and inconsistent effects on cognitive processing and learning. For example, a number of studies have demonstrated that confusion is positively correlated with students' successful performance of complex reasoning tasks in an auto-tutor environment (D'Mello & Graesser, 2014), while other investigations have shown that confusion's benefits are largely time-bound and may quickly deteriorate (D'Mello & Graesser, 2014), or that its affective signature (e.g., activated displeasure) is altogether debilitating and detrimental for learning (Pekrun, 2011). Additionally, with the exception of engagement and enjoyment, other epistemic emotions—such as boredom and frustration—have not been shown to have a similarly positive impact on learning as does confusion (D'Mello, Lehman, Pekrun & Graesser, 2014). These curious and inconsistent findings suggest a need to delve deeper into the affective dimension of learning in general and the role of confusion in complex inferential reasoning in particular.

To this end, the present dissertation study sought to contribute to the understanding of the emotional nature of complex inferential reasoning, with an emphasis on confusion. The topic of confusion as an epistemic emotion has received relatively little investigative attention (D'Mello & Graesser, 2014), and no study to-date has examined variation in the subjective perception of confusion. This dissertation study blends insight from both the learning and affective sciences, and was undertaken with the purpose of exploring relationships between two different psychological constructions of confusion and complex inferential reasoning performance.

The intention of the chapters presented herein is to do the following: 1) offer an overview of the nature of the problem addressed by the research; 2) present a review of the relevant conceptual literature and the theoretical framework which supported the study;

3) provide an explanation of the study's methodological approach; 4) present relevant study results, and 5) discuss the implications of the study findings. The dissertation continues below with an in depth exposition of the problem.

Meaningful Learning: A New Charge for Students

While students in past decades could perhaps demonstrate academic excellence simply by reproducing a large cache of disconnected facts or thoughtlessly replicating a set of procedures without authentic conceptual understanding (Smith and Colby 2007), education policy makers' recalibration of desired learning outcomes now demands that academic tasks be configured to eclipse such rote learning. The charge is that students must now achieve the capacity for advanced hypothesis generation, sophisticated quantitative thinking, and other complex cognitive processes (e.g., inferential reasoning) deemed necessary to negotiate life's social complexities and support future industrial innovation (Grover and Pea, 2013). In this vein, a number of studies have examined the effect of higher order thinking tasks on achievement gains or have investigated correlations between complex reasoning and general learning outcomes (Chin & Chia, 2006; Chin & Osborne, 2008; Zohar & Dori, 2003; Haller, 1992; Newmann, 1991). The results of these investigations suggest that learning activities which involve complex reasoning processes (such as asking probing questions, generating hypotheses or identifying discrepancies in a problem situation to reach a valid conclusion) are associated with significantly greater learning gains for students, as compared to tasks which emphasize rote learning or offer students only minimal opportunity to work through problems or scenarios that feature multiple, equally probable, or unclear solutions.

The Emotional Cost of Meaningful Learning: Stuck and Confused

Unfortunately, some investigations have also concluded that many students never acquire or remain deficient in higher order thinking competence (Flores et al, 2012). But more troubling still is the frequent though perhaps short-sighted guidance which argues that the remedy for this situation is to simply provide students with an increased volume of problem-based learning exercises or teach them performance strategies for standardized test-taking. In contrast, studies from the affective computing and learning sciences have revealed that it is perhaps not simply the experience of engaging in problem-solving tasks that alone promotes meaningful learning. Instead, these studies have suggested that it is more likely the accompanying meta-experiences of getting cognitively stuck, of reaching impasses in understanding, or of experiencing a sense of 'not knowing'—a feeling that we often perceive and conventionally label as confusion (Lipson, 1990; Kort, Reilly, & Picard, 2004; D'Mello & Graesser, 2011, 2014)—that seems to purposefully link complex reasoning activities to meaningful learning. This is because confusion, categorized as an epistemic emotion (Pekrun, 2011), is an affective state which appears to offer both covert and overt insight into the level and quality of one's cognitive processing efforts and might in turn function as a prompt to seek additional information and/or change cognitive processing strategies (Lipson, 1990, 1992). At the same time, it is inappropriate to assume that there is a universal emotional perception of confusion linked to metacognitive awareness or that there are no other mental processes (e.g., beliefs) that might interfere with the desired and anticipated positive effects of confusion-facilitated metacognitive awareness.

Unsurprisingly, the feeling of confusion has historically borne a strong negative connotation. For many people, the emotional experience of confusion is often perceived as "a sign that something has gone shamefully wrong" (Lipson, 1992) during one's attempt to draw a reasoned conclusion or make sense of and formulate a rational response to an uncertain situation. In these instances, confusion may be perceived as something which should be avoided; it seems to function as a threat alert mechanism, providing an affective warning that perhaps one's self-determined intellectual adeptness could somehow be in jeopardy. To be clear, however, this interpretation stands in stark contrast to what research has begun to uncover about the potential benefit of confusion for learning. And given this state of affairs regarding the relationship between emotions and learning, it is essential that researchers seek novel explanations and consider neoteric theoretical approaches that expand our understanding of affective phenomena and lead to improvements in students' complex reasoning and meaningful learning.

A Theoretical Framework for Studying Confusion

In 2006, Barrett proposed a novel psychological constructionist perspective on affect and emotion which she has successfully applied as a mechanism to account for the neural processes, subjective appraisal, and cultural manifestations of emotion generation, emotion experience, and emotion expression. The then-new model was a significant turn in the field of affective science because, prior to its inception, the classical view of emotions—a more uncompromising orientation—predominated. The Theory of Constructed Emotion (Barrett, 2017), originally coined as the Conceptual Act Model/Theory of Emotion (Barrett, 2006), takes as its starting point the notion of core affect. According to Russell & Barrett, the concept of core affect reflects the idea that valence (measure of the experience of pleasant/unpleasantness) and arousal (measure of the experience of alertness/relaxation) are the physiologically irreducible elements which ground and link all affective phenomena. In contrast, other theoretical perspectives propose neural specific networks or discrete, pre-formed/hard-wired categories as the basis for emotional phenomena.

In elucidating her idea, Barrett (2006b) argued that emotion words are social conventions or folk terms which have been agreed upon and culturally transmitted across time, but do not in and of themselves serve as evolutionary evidence of natural kind/hard-wired emotions. She further posited that while emotional experience (and expression) are emergent situated conceptualizations which do rely in part on the brain's functional architecture, these situated conceptualizations are only made complete as emotions through an interaction between conscious perception of sensory input from the environment and interoceptive feedback (e.g., awareness of internal bodily sensations), along with the simultaneous retrieval and application of relevant mentally stored information and emotion concept knowledge (Barrett, 2006b).

Pointing to the major tenets of her theory, Barrett (2006b) has argued that the most meaningful analyses of emotional experience (e.g., perception and feeling) and expression (e.g., reactions and behavior) should include an attempt to account for subjective variation by considering core affect as well as differences in underlying cognitions and emotion concept knowledge (2006b). More specifically, Barrett (2017) and Barrett, Wilson-Mendenhall, & Barsalou (2014) have argued that the following four tenets comprise the Theory of Constructed Emotion: 1) Emotions are populations of instances tailored to the situational environment; 2) Each instance of emotion is *constructed* within the brain's functional architecture, involving domain-general core systems, to create situated conceptualizations; 3) Emotional episodes cannot be deconstructed or reduced down to these domain-general systems but instead emerge from their interaction. Therefore, the inner workings of individual systems are not ideal targets for meaningful investigation and should instead be holistically examined within momentary states of the brain and body; and 4) Emotional episodes, because they are emergent states, have functional features that physical states alone do not possess.

Barrett's (2017) theory had great relevance for the present dissertation study because it provided a flexible framework for better understanding how confusion might subjectively operate in the context of learning. While research suggests that confusion, an affective state hypothesized to signal the cognitive experience of 'not knowing' or a breach in understanding during information processing, might elicit and facilitate the use of complex/higher-order reasoning and in turn improve learning and performance on complex inferential reasoning tasks, the bulk of current confusion studies have tacitly employed a natural kinds theoretical perspective or seem to imply a universal experience of confusion (e.g., D'Mello & Graesser, 2014; D'Mello, Lehman, Pekrun, & Grasser, 2014). These studies have not sought to explicitly consider how individual difference factors might create variation in the subjective perceptual experience of confusion, and how such variation could render confusion as debilitating or facilitative.

The major argument advanced in this dissertation is that confusion, as an emotion, does not have a universal essence, but can instead be perceived or experienced in different ways. More specifically, it is my suggestion that for some students, feeling confused might be perceived as a sense of threat, or something to be avoided, and in turn lead them to abandon their cognitive effort; while for other students, feeling confused might instead be perceived as a sense of challenge, or something to be overcome, and in turn lead them to intensify their cognitive effort in order to achieve deeper understanding. In short, confusion has been called an epistemic emotion (Pekrun, 2014), and variation in its perceived meaning and feeling could be underpinned by differences in students' beliefs about knowledge and learning and linked to their cognitive processing habits in the context of problem solving or critical reasoning (Pekrun, 2011; Muis et al, 2015). Therefore, the present dissertation study sought to examine differences in students' feelings of confusion; the relationship between different psychological constructions of confusion and complex inferential reasoning performance; and the role of epistemological beliefs about knowledge and learning, along with emotion concept knowledge, in these relationships.

Deconstructing Confusion: The Role of Epistemological Beliefs

Epistemology is the study of knowledge and ways of knowing. It is concerned with the construction, revelation, and acquisition of knowledge, as well as its justification, legitimization, and dissemination. It seeks answers to questions such as these: What is knowledge? How do people know that they know—and what they know? Is knowledge universal? (Apple, 2006). Moreover, epistemology seeks to understand the ways in which varied conceptualizations of knowledge production influence everything from institutional discourses, to social policies and outcomes, to personal realities and everyday practices such as learning (Hofer, 2001).

Hofer and Pintrich (1997) describe three major streams of epistemological research which have come to the fore since the 1950's: one stream, led by Perry (1970), centers on how our beliefs about knowledge develop and change over time and shape the ways in which we make sense of our realities; a second stream, made notable by King & Kitchener (1981), emphasizes the global nature of beliefs about knowledge and their impact on reasoning processes in the context of reflective judgment and decision making; and the third stream, which argues that epistemological beliefs about knowledge operate as multidimensional contextualized systems, informs the premise that learning and reasoning are affected by beliefs about the nature of knowledge and knowing. It is the work of this latter group, in particular Schommer (1990) and Wood and Kardash (2004) and those who have followed in this stream (Jehng, Johnson, & Anderson, 1993; King & Jackson, 2009; Muis, Lajoie, Chevrier, 2015), which supports the epistemological beliefs construct applied in this dissertation study.

Understanding the impact of epistemological beliefs on cognitive processes continues to be a prominent area of study. And now, given what is known about the relationship between cognition and other mental processes, scientists in various disciplines have undertaken work which has sought to expand the application of epistemological theory. This includes research which attends to the relationship between epistemological beliefs, emotions, and learning. For example, Muis and colleagues (2015) have proposed a model which describes relationships between students' epistemic beliefs, epistemic emotions, cognitive learning strategies, and learning outcomes. Adopting a similar perspective, the present study sought to examine the role that epistemological beliefs play in students' psychological construction of confusion and their complex inferential reasoning performance.

Adding to the Confusion Literature

The foregoing discussion related to the nature of confusion and its role in complex reasoning has served to articulate a basis of support for its further investigation. This dissertation study was warranted because of two main clusters of findings: 1) there is evidence which implicates the experience of confusion as being potentially important for eliciting/developing complex reasoning abilities and fostering meaningful learning within students; and 2) current confusion studies have not sought to examine factors that may underlie potential subjective differences in the perception of confusion's meaning and function and the impact of such differences on complex inferential reasoning performance.

This dissertation study investigated whether two different constructions of confusion are related to successful complex inferential reasoning, and also sought to determine if it is possible to identify constitutive psychological elements that serve as building blocks for the different confusion constructions. The significance of this study lies in the fact that no research to-date has examined variation in the perception of confusion as a function of differences in its psychological construction; therefore, it has been unclear if confusion is consistently helpful and facilitative for complex reasoning performance, or if it renders a sense of helplessness and has a negative impact on reasoning performance, or if there are elements and conditions which make one outcome (facilitative or debilitative) more likely than the other.

Study Limitations

While this study offers a novel contribution to the literature on emotion and learning, there are nevertheless some limitations that should be made clear. First, affective scientists do not wholly agree on the origins and structure of emotions in general or how best to categorize emotions that occur in the context of academic settings (Pekrun, 2011); this complicates the selection of the most appropriate theoretical framework and methods for studying emotional phenomena (Lindquist & Barrett, 2011). In the same vein, the lack of agreement regarding theories and methods of study also means that some emotion researchers may feel inclined to challenge the findings drawn from this study. For instance, though Barrett (2004) has demonstrated that self-report remains the best method for capturing and studying emotional experience, and that retrospective judgments of emotions are, under directed circumstances, stable over distant periods in time, there is a population of researchers—perhaps committed to a different theoretical perspective—who might insist that self-report emotion data must necessarily be substantiated by psychophysiological measures or other secondary methods in order for research findings to be objective and valid.

Additionally, it should be noted that given the exploratory nature of this study, it is conceded that findings may lack wide-scale generalizability at the present time, particularly since the research has been undertaken at a single institution. Nevertheless, care was taken to employ recruitment strategies that tried to ensure a sample as culturally diverse as possible, even though it was not the intent of the study to examine variation in the perception of confusion attributed to and correlated with factors such as race/ethnicity, or institution-level social considerations (e.g., differences in the availability of courses for students that directly teach, use, or promote higher order reasoning). However, these are certainly important elements which could certainly receive attention in future investigations. It is also possible that there are yet other factors which may impact participants' perceptions of confusion which have not been identified here. For example, future studies might consider the developmental role of parents or parenting styles as factors in students' understanding of and response to confusion, as well as the potential effects of culture or other factors that influence learning ability (e.g., reading disabilities or Attention Deficit Disorder). Future work in the area of learning-related confusion could also seek to develop, implement, and evaluate interventions that help both educators and students adopt new behaviors and language associated with confusion.

Chapter Summary

By way of a general summary, this chapter has offered an introduction to and statement of the problem concerning confusion and complex inferential reasoning. The chapter also presented background discussion about the role that epistemological beliefs might play in the psychological construction and function of confusion. And finally, the chapter identified possible limitations of the study. The dissertation turns next to Chapter 2, which elaborates both on the components of the problem under investigation and on the theoretical framework employed in the study.

CHAPTER 2

REVIEW OF LITERATURE

The ability to learn is among the most vital of human capacities, and as a result of this faculty, researchers have spent decades attempting to identify and investigate the elements which account for and support successful learning, particularly in school settings. Historically, a substantial amount of attention has been paid to examining cognitive, motivational, and developmental processes; however, there is increasing interest in understanding the role of affect in learning. Along these lines, this dissertation study sought to expand the understanding of the relationship between affect and complex inferential reasoning by considering a specific emotional state—confusion—in conjunction with a well-studied theoretical construct, epistemological beliefs about the nature of knowledge and learning. More specifically, the study examined the psychological construction of the epistemic emotion, confusion, and the relationship between different subjective perceptions of confusion and complex inferential reasoning performance.

The purpose of this chapter is to describe the major conceptual ideas that provided the foundation for the study. The flow of topics proceeds as follows: 1) overview of meaningful learning and its relationship to complex inferential reasoning; 2) discussion of epistemological beliefs that shape and impact learning; 3) review of emotion theory and the role of emotions in learning; 4) summary of extant investigations into the role of confusion in learning; and 5) application of the Theory of Constructed Emotion to the present study.

Meaningful Learning and Complex Reasoning

The Theoretical Relationship

Meaningful learning refers to the acquisition and retention of factual and procedural knowledge, in conjunction with effective cognitive processing strategies, and the ability to flexibly transfer and utilize all of these elements in future situations or across variable contexts (Marton & Saljo, 1976; Biggs, 1987; Entwistle, 1981; Mayer, 2002; Ramsden, 2003; and Tagg, 2003). Unlike rote learning, which generally emphasizes low-level cognitive processes such as memorization and recall of facts or the replication of simple procedures, meaningful learning is in contrast characterized by a focus on the integration of new conceptual knowledge within existing or emerging cognitive schemas and the selective utilization of deep learning strategies (Biggs, 1987; Mayer, 2002; Tagg, 2003). When these elements are effectively deployed, researchers contend that the result is an expansion of what an individual knows and also what she/he is capable of doing in different learning situations (Mayer, 2002).

At the same time, researchers understand that meaningful learning and the development of the cognitive processing strategies which support desired learning outcomes are not wholly organic in nature; instead these capacities can be derived through intentional cognitive scaffolding, frequent opportunities to practice higher order thinking/reasoning, and the provision of metacognitively directive feedback (Mayer, 2002). Learning scientists have posited that meaningful learning is most likely to be achieved under the following conditions: 1) when teachers incorporate the use of desirable difficulties into their instructional methods, including spaced content delivery and frequent opportunities to retrieve information from memory (Bjork & Bjork, 2011; McDaniel & Butler, 2011); and 2) when there is the concurrent requirement that students must process information at varying levels of cognitive complexity (Mayer, 2002). Moreover, it has been argued that assessments of meaningful learning, both formative and summative, should challenge students to engage in higher order thinking processes such as inferring, comparing, explaining, differentiating, detecting patterns, critiquing, generating hypotheses, producing solutions, and planning task completion strategies (Mayer, 2002). By way of engaging in a broad range of higher order cognitive experiences students should be able to garner the capacity to thrive in a world where problems abound —big and small, in work, school, and relationships—and adaptability rules the day.

The claims above suggest that the promotion of complex, higher order reasoning is an imperative that should not be ignored given its significance for improving students' ability to negotiate every-day interactions and situations; and it is in the school setting where we can begin to see its burgeoning effects. Studies have demonstrated that complex reasoning is strongly correlated with achievement in variable learning contexts (Biggs, 1988; Arum & Roska, 2011) and also with higher rates of student engagement (Laird, Shoup and Kuh, 2005). Although engagement—defined by Kuh, Kinzie, Schuh, & Whitt (2011) as the amount of time and effort students willingly expend toward achieving meaningful learning—was not a central focus of this dissertation, it is nevertheless important to point out its relevance as a factor which flows from higher order thinking and that is facilitative for desirable achievement outcomes.

For example, Kuh and colleagues (2011) conducted a 2-year investigation among students, faculty, and administrators at 20 demographically, geographically, and academically diverse American universities (selected from a larger sample in a previous study) to identify and examine the conditions which seemed to account for their students' higher levels of engagement (as measured by questions on the National Survey of Student Engagement) and higher than average graduation rates. The researchers found, across disciplines and universities, a strong correlation between the use of cognitively complex learning activities and students' reports of higher levels of engagement and desirable academic performance outcomes.

Similarly, in the 2007 Australian Survey of Student Engagement (AUSSE), Coates (2008) found that higher levels of multiple aspects of engagement (e.g., social, emotional, and cognitive) were strongly positively correlated with students' use of "more advanced forms of reasoning such as analysis, synthesis, evaluation, and application". And in a study which explored conditions which appear to enhance or diminish student engagement, Hockings, Cooke, Yamashita, McGinty & Bowl (2008) showed that engagement was substantially increased when students completed learning tasks that required them to hypothesize, evaluate, and search for connections between concepts.

It is clear from the examples above that an added benefit of complex reasoning is its positive impact on engagement; but returning now to the main focus of this dissertation, there is also equally compelling evidence which demonstrates a critical relationship between higher order cognitive processing, deep meaningful learning, and achievement. For example, Chin and Brown (2002) found that middle school science students who engaged in deep approaches to learning (e.g., inferring, comprehension monitoring, hypothesis generation, prediction, anomaly detection, application, explaining and planning), as compared to surface/rote approaches (e.g., simple factual recall), developed deeper conceptual understanding and were more self-directed in their learning, compared to students who primarily engaged in superficial (e.g., re-reading) or rote learning strategies alone (e.g., rehearsing and memorizing). In their study, students received instruction through two pedagogical methods: teacher-centered (e.g., explicit presentation of known facts and explanations) or problem-solving activities (e.g., constructing and testing possible solutions to an ill-structured problem based upon general conceptual principles); in both conditions, students were encouraged to verbalize disconnects in understanding (e.g., getting cognitively stuck/not knowing) and were also allowed and encouraged to ask questions. Further, in addition to correct responses given, the study authors also recorded and analyzed the kinds of questions generated in each learning context.

In their findings, Chin & Brown (2002) noted that teacher-centered methods of instruction generally yielded what they referred to as “basic information questions”, where students simply asked for re-statement of factual information. In contrast, the researchers observed that problem-solving activities led to “wonderment questions”, where students wanted to know more, to understand why, or to obtain clarification (Chin & Brown, 2002). The study authors described wonderment questions as those which are typically associated with complex reasoning and deep learning approaches; such questions they argued are indicative of students’ engagement in cognitive processes such as comprehension monitoring, inferring conclusions, prediction, anomaly detection, application of principles, planning, and attempts to hypothesize and generate explanations (Chin & Brown, 2002).

The positive effects and correlations highlighted above have been found across a variety of disciplines, grade levels, school sizes, geographic locations, instructional delivery modalities (e.g., online versus in-person), socioeconomic statuses, and achievement levels. For instance, Haak, HilleRisLambers, Pitre & Freeman (2011) observed that the use of problem-solving, data comparison, and other higher-order cognitive processes, improved the performance of all students in a college-level introductory biology class and reduced the achievement gap between socioeconomically disadvantaged and nondisadvantaged students. Additionally, in a study of 225 undergraduate students (enrolled in an online computer coding course) who completed an online self-administered version of the National Survey of Student Engagement, Robinson and Hullinger (2008) found that the majority of students who earned a course grade of 'A' and rated their learning experience as satisfying, reported greater use of complex cognitive processes such as critiquing, analyzing, and synthesizing.

And finally, the results of Gordon & Debus's (2001) longitudinal quasi-experimental study among three cohorts of preservice teachers which attempted to examine the effects of learning context on participants' future use of deep learning strategies, transfer of learning, and teacher efficacy beliefs modification (e.g., emphasizing the constructed, rather than didactic nature of learning, de-emphasizing grades as evidence of competence, and utilizing learner-centered instructional practices that encouraged students to engage in deep cognitively complex approaches to learning), revealed that preservice teachers (Cohort 2 treatment group) who received greater exposure to learning context modifications demonstrated a statistically significant decline in their use of surface learning strategies and an equally significant increase in their reliance on deep approaches to learning, compared to preservice teachers in the control group (Cohort 1). Additionally, participants in the Treatment Cohort 2 also demonstrated statistically significant changes in their stated primary goal for learning (e.g., understanding, as opposed to earning a high grade), and in the reasons they articulated for their espoused teacher efficacy beliefs.

While the participants in all cohorts (control and treatment groups) began the study with a strong reliance on surface approaches to learning (e.g., attempts to simply memorize or replicate procedures, rather than construct a deep conceptual understanding), only those in Cohort 2 displayed a significant shift in their primary approach to learning—moving from high reliance on surface strategies to a near complete reliance on deep cognitive strategies. In contrast, participants in Cohort 3 and in Cohort 1 showed mixed and inconsistent use of deep approaches to learning (Gordon & Debus, 2001). In discussing the importance and ramifications of their study for preservice teacher learning and future practice, Gordon & Debus (2001) assert the following:

> [t]he learning approaches adopted…are of particular importance in teacher education, because [they] have been linked with students' conceptions of approaches to teaching. The approach adopted may…determine the learning environment they establish as future teachers, which would impact on the learning approach consequently adopted by their students.

As a result of research findings which support the utility of complex reasoning processes and activities for promoting meaningful learning and engagement, such as those which have been presented here, the National Governor's Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) developed and released a set of guidelines in 2009, called the *Common Core State Standards* (CCSS), aimed at identifying and defining the range of knowledge and skills that students in grades K-12 should acquire in order to be college and/or career ready upon completion of their secondary educational experiences (Conley, Drummond, de Gonzalez, Rooseboom & Stout, 2011). These guidelines, while not intended to be a mandate for a nationwide or universal curriculum, assert that in order for students to acquire 21st century skills—those which are most likely to enhance social engagement, economic productivity, and overall well-being—they must be presented with educational activities across every discipline that require the use of complex, higher-order thinking processes. At the same time, as previously argued, it is insufficient to provide students with these kinds of activities without also considering other mental factors that may play a role in their ability to navigate cognitively complex learning situations.

Potential Consequences of Epistemological Beliefs about Knowledge and Learning

Investigations into the relationship between epistemology, complex reasoning, and meaningful learning are of great importance, given that every theory of learning must begin with some underlying assumptions about the nature and process of knowing (Kelly, McDonald, & Wickman, 2012). For an extended period of time, however, epistemological theory was largely situated in the arena of development. Eventually, having grown dissatisfied with the limitations of more traditional theoretical conceptualizations of personal epistemology due to their intense focus on reifying a developmental sequence or their propensity to characterize the construct as a unidimensional phenomenon, Schommer (1990) set out to demonstrate that personal epistemologies are multidimensional in nature, that they operate as contextualized systems, and that they have specific implications for learning.

Combining theoretical elements from the work of Perry (1970), Dweck & Leggett (1988), and Schoenfeld (1983), Schommer initially developed a rudimentary five factor model of epistemological beliefs. She argued that beliefs about knowledge and knowing can be framed in terms of the following dimensions: 1) structure; 2) certainty; 3) source; 4) control; 5) and speed of acquisition. Using these dimensions, Schommer (1990) investigated how epistemological beliefs play a role in school learning and related processes such as deep comprehension. For example, in a study of college students, she demonstrated a relationship between beliefs about knowledge, use of particular cognitive learning strategies, and performance on a reading task. Students completed her epistemological beliefs questionnaire and weeks later were asked to complete a reading comprehension task, to rate the degree to which they believed they understood the text, and to make inferences based upon the text contents; students' comprehension scores were also documented. In analyzing the data, Schommer (1990) found that students who believed that the process of learning is quick earned lower comprehension scores, yet judged themselves as more certain of their comprehension, and also made the most unsophisticated inferences.

In another study (Schommer et al., 1992), subjects completed the epistemological beliefs questionnaire and later read a passage related to statistics. Then, prior to taking a performance test, subjects were asked to judge themselves on how well they thought they understood the material. The results of this experiment revealed that higher comprehension scores were negatively correlated with belief in simple knowledge. And secondary analyses indicated a possible relationship between epistemological beliefs, type of cognitive study strategies used, and academic performance. In later studies, Schommer determined that the control dimension previously identified failed to show predictive power; therefore, this dimension was removed from later iterations the questionnaire.

The studies described above represent only a few which have examined epistemological beliefs in the context of learning; and while Schommer's work has drawn critical feedback from some (Hofer & Pintrich, 1997) who argue that her conceptualization of personal epistemology is an overreach from traditional philosophical notions of the construct—in particular her dimensions of 'belief in innate ability to know' and 'speed of acquisition'—her epistemological framework has become the foundation for many contemporary models of epistemological beliefs used in education and learning-related research studies. For instance, Jehng, Johnson, & Anderson (1993) developed a modified version of Schommer's (1990) questionnaire, replacing the simple knowledge dimension with orderly process. These researchers conducted a study among 386 graduate and undergraduate students at three universities and across four academic disciplines to determine if field of study, academic level, and academic context played a role in students' epistemological beliefs. The results of this investigation showed support for the researchers' hypotheses; for example, the study revealed that graduate students, compared to undergraduates, reported stronger belief that knowledge acquisition is a slow process and is not orderly, and that knowledge itself is often uncertain.

More recently, Young (2005) completed a study that investigated the relationship between epistemological beliefs about knowledge and learning and students' choices of cognitive study strategies and perceived academic performance. A sample of 293 students enrolled in a college marketing course completed a 12-item epistemological beliefs questionnaire derived from Schommer's measure, a cognitive strategy use assessment which tapped students' propensity to use superficial (repetition/memorization), deep (concept mapping, summarizing, interpreting, applying), and/or metacognitive (comprehension monitoring/self-questioning, goal setting) learning strategies, and a course performance self-assessment. Data analysis revealed a significant negative correlation between the sophistication of students' epistemological beliefs and their use of particular learning strategies; that is, students who more strongly believed that the ability to know is not innate and that learning is a gradual process, reported greater use of deep learning and metacognitive strategies, as compared to students who believed that learning is quick and the ability to know is relatively fixed.

Additionally, Wood and Kardash (2002) conducted a factor analytic study to evaluate the dimensions of Schommer's personal epistemology construction. A central aim of their work was to confirm the factor loadings that Schommer had previously determined, given the concerns which had been raised regarding her theoretical justification for including certain dimensions, as well as the methodology she used to develop her instrument. To this end, Wood and Kardash (2002) developed an 80-item self-report survey that included 58 of Schommer's 63 original items and 22 items which had been developed by Jehng and his colleagues (Jehng, 1991; Jehng et aI., 1993), and the instrument was given to a sample of 793 students.

The results of their study revealed that while Schommer's claims regarding the multidimensional nature of epistemological beliefs was indeed supported, all of the individual items taken from her original instrument did not load as theorized. Instead, Wood and Kardash (2002) identified a slightly different five factor model of epistemological beliefs with the following dimensions: Speed of Knowledge Acquisition; Structure of Knowledge; Knowledge Construction and Modification; Characteristics of Successful Students; and Attainability of Objective Truth. Additionally, they were able to reduce the number of items from 80 in the combined instrument (and from 63 in Schommer's questionnaire) to a 38-item Likert scaled self-report inventory, which they called the Epistemological Beliefs Survey. They performed factor analyses and tests for internal consistency to obtain 38 items which represent the five independent dimensions identified above. In subsequent tests of this modified personal epistemology construction, Wood and Kardash (2002) found that their model in general had statistically significant predictive validity for academic performance (with highest validity demonstrated on the dimensions of Speed of Knowledge Acquisition and Characteristics of Successful Students) which exceeded that of ACT scores either alone or in combination with students' GPA. The present dissertation study utilized the Wood-Kardash (2002) Epistemological Beliefs Survey (EBS) because it appears to offer the soundest theoretical and methodological construction currently available for the purposes of this investigation.

Epistemological Beliefs Meet Epistemic Emotions

In an expansion of research on epistemology and learning, Pekrun (2011) and Pekrun & Stephens (2010) defined epistemic emotions as a subset of a broader category of academic emotions that are caused by "cognitive qualities of task information and of the processing of such information", such that epistemological (here forward called epistemic) beliefs are posited to be antecedents of epistemic emotions (Pekrun, 2011). Included in this group of epistemic emotions are the states of anxiety, boredom, frustration, surprise, enjoyment, curiosity, and confusion. It should be noted that while Pekrun (2000) had previously developed and tested a theory of academic emotions, called the Control-value theory, which elucidates the motivational nature of various affect states, it did not specifically address the idea of confusion as an epistemic emotion; thus this is a relatively new position, so Pekrun's (2011) work in the area is still somewhat emergent.

In a recent study, Muis et al (2015) employed the epistemological beliefs framework of Hofer & Pintrich (1997), which overlaps considerably with both Schommer's (1990) and Wood and Kardash's (2002) frameworks, to test the effect of epistemic beliefs and epistemic emotions on information comprehension. In the study, 439 college students from Canada, United States, and Germany were asked to self-report their epistemic beliefs about climate change before reading 2 versions of a complex text about the same subject. After reading each version of the text, subjects were asked to rate the degree to which they had experienced each of a set of 7 epistemic emotions. After the reading of the second version of the text, subjects answered 21 inferential learning verification questions and were also asked to select the type of cognitive strategies they had attempted to use to learn the material.

Data analysis revealed that students who believed knowledge and knowing are complex and uncertain reported lower levels of confusion, anxiety, and boredom. Moreover, stronger belief in the uncertainty of knowledge and the need to actively construct knowledge was predictive of lower levels of anxiety, frustration, and confusion. Epistemic emotions were significantly related to and were generally predictive of the types of learning strategies (e.g., higher order thinking versus rehearsal) students used to learn the material, and they also mediated the relationship between beliefs and strategy use. For example, pleasant, activating emotions (curiosity and enjoyment) were predictive of higher order thinking strategies; on the other hand, unpleasant, activating (frustration) and unpleasant deactivating (boredom) emotions were predictive of superficial cognitive strategy use.

The dissertation study presented herein sought to extend the work of Muis and colleagues (2015) by producing evidence to support two claims: the first claim is that students' (epistemological) beliefs about knowledge and learning are important elements in how they construct their perceptions of the feeling of confusion in academic settings (e.g., their implicit/subconscious or explicit/conscious interpretation of what the feeling means and how that perceived meaning influences their behavior); and the second claim is that there are relationships (positive or negative) between students' perceptions of confusion's meaning/function and their complex inferential reasoning performance.

The argument which underpins the first claim is multidimensional in nature and is based upon studies which confirm a relationship between one's deep cognitive engagement and learning, the level of sophistication of one's epistemological beliefs, and one's overarching motives for engaging in learning activities (Ravindran, Greene, & DeBacker, 2005). Researchers have suggested that the ability to employ deep cognitive processing strategies, to achieve meaningful learning, and to later transfer what has been previously learned, is most apparent when cognitive efforts are synergized with two key psychological affordances: a strong belief that genuine learning involves a deliberate process of moving from a mental state of 'knowing', to 'not knowing', and back again; and the ability to re-prioritize, suspend or effectively balance the need to view oneself as 'being smart' or 'always knowing', with the desire to improve and eventually achieve conceptual mastery.

The second claim is supported by recent research studies which posited that meaningful learning is facilitated when students encounter desirable difficulties (Bjork et al, 2012) during the course of navigating complex reasoning tasks. It has been argued that certain kinds of learning tasks propel students into a temporary state of cognitive discord and affective dis-ease (confusion), which in turn appears to encourage the use of deeper cognitive processing strategies (Muis et al, 2015) and more robust learning (D'Mello & Graesser, 2011). This is most certainly an intriguing idea; however, what extant studies have lacked is a direct attempt to identify and/or evaluate underlying factors which play a role in facilitating the positive benefits found to be associated with confusion. This presented an ideal opening for the present dissertation study which aimed to demonstrate that complex inferential reasoning performance can be influenced by the capacity to perceive the core affective hallmarks of confusion (feeling simultaneously unpleasant and activated) (D'Mello & Graesser, 2014) in one of two ways: 1) as a metacognitive 'challenge' signal indicative of the need to adjust one's learning strategies; or 2) as a metacognitive 'threat' signal indicative of potential goal failure (e.g., failure to be judged as 'smart' or receive a high grade). The newly distilled argument described above is rooted by the notion that epistemological beliefs are an underlying but important interacting variable which could potentially shape students' emotional/core affective feelings and perceptions of confusion, and in turn play a role in their complex inferential reasoning performance.

Emotion Theory and Emotions in Learning

The literature review continues here with a discussion of several of the major theoretical stances which presently frame the study of emotion, along with an elucidation of the role of emotions in learning. The section begins with a general historical recount, followed by a description of several contemporary emotion perspectives and a discussion of the relationship between emotions and learning, and concludes with the presentation of the Theory of Constructed Emotion, the framework for the present dissertation study.

Early Emotion Theory: A Possible Misunderstanding of Darwin

Published in 1872, Charles Darwin's treatise on emotion entitled, *The Expression of Emotion in Man and Animals*, set the stage for what has since been called the great emotion debate. Darwin's early theorizing on emotion, likely intended to support his work surrounding natural selection and the evolutionary trajectories of living species, has perhaps been the unfortunate victim of conflation and re-presentation. Indeed, Darwin's studies of emotion are often suggested to have provided the initial evidence in support of a set of basic emotions and the idea that experiential/feeling phenomena are natural kinds—that is, entities which exist in nature, apart from our ability to perceive or not perceive them (Darwin, 1872, 1965). But a closer read of his manuscript reveals that for Darwin, the study of emotion was not simply an exercise in discovering a set of emotions assumed to pre-exist in nature; instead, Darwin's early work with emotions was perhaps an attempt to understand the social-psychological processes which might have been involved in their manifestation (Barrett, 2011). For example, Darwin's observations across species prompted him to conclude that expressions were not necessarily the manifestation of innate emotions, but may have instead been habituated remnants of *voluntary* social systems that had once permitted species to cooperate, adapt, and thrive (Barrett, 2011).

Moreover, while Darwin did in fact note that emotions seemed to produce or were at least accompanied by changes in sensory, perceptual, motor, and physiological function, it is often falsely argued that he espoused the idea that there is a set of basic or discrete emotions which produces universal, highly coordinated sequences of expressive behavior (e.g., facial expressions) and are largely biological functional adaptations. Instead, Darwin suggested that "humans are active perceivers who do not passively decode expressions, implying that humans might not possess preserved, evolved mechanisms for extracting information from expressions" (Barrett, 2011). In other words, Darwin seemed to assert that it is not fully possible, through simple observation of facial expressions and bodily movements, to confirm the discrete existence of a particular emotion and subsequently draw conclusions about its meaning and function in the absence of contextual information.

Basic Emotions/Natural Kind Theories

Nevertheless, the natural kind view of emotions, initially attributed to Darwin, continues to be the basis for a number of modern theoretical positions. For example, Izard (2007) and Ekman (1992) have argued that anger, fear, disgust, happiness, sadness, and surprise represent a set of universal, basic emotions which are rooted in neurobiological brain structures and possess innate, evolutionary functionality (Izard, 2007). They contend that basic/natural kind emotions possess the following characteristics: they have features which identify them as being distinctly related to one another yet separate from other types of emotions; their feeling and expression occurs universally even in the absence of conscious awareness; and their presence is not dependent upon artificial naming conventions which are used by societies to create humanly-defined groupings (Ekman, 1992).

To support the idea of evolutionary neurobiological emotion correlates, basic emotions theorists began turning to neuroimaging data from animal studies. For instance, affective neuroscientist Jaak Pankseep (2007) contends that through experiments of systematic subcortical stimulation, scientists have been able to elicit emotional responses in animals. This in turn permitted him to claim that there is sufficient evidence to support the identification of at least seven innate emotional systems. Panksepp (2007) suggested that these systems have been embedded into the subcortical structures of the mammalian brain through processes of evolutionary genetic encoding. Panksepp (2007) further contended that there are specific brain regions which give rise to particular emotion processes, and argued that while emotional instincts and emotional feelings both arise from subcortical brain structures, each emotion is elicited by a distinct neural network and each has a different purpose. Emotional instincts, he concluded, evolved to serve as anticipatory physiological stabilizing cues, while emotional feelings emerged to act as advanced survival signals (Panksepp, 2007).

Despite apparent biological evidence however, Barrett (2011) has remained firm in her assertion that Darwin's words have been reinterpreted over time to fit the widely accepted narrative of basic emotions. She points again to Darwin's repeated statements regarding the uselessness of emotional expressions, in the sense that they have likely become habituated over time, yet show little consistent evidence of evolutionary functionality. For example, Darwin wrote: "whenever the same state of mind is induced, however feebly, there is a tendency through the force of habit and association for the same movements to be performed though they may not then be of the least use" (1872; in Barrett, 2005, p. 19). Barrett (2011) added that it is highly unlikely that each emotion emerged as its own mechanism, with its own selection pressures, along its own evolutionary path, as that would in fact be evolutionarily inefficient.

Appraisal Theories of Emotion

A second theoretical stance on emotion argues that while there are possibly evolutionary mechanisms which ground the ability to experience basic or discrete emotions, there are also cognitive processes which facilitate and regulate their expression (Lazarus, 1984). Cognitive appraisal theories of emotion assert that when a person encounters a new stimulus that cannot be spontaneously incorporated into an existing framework of understanding, the autonomic nervous system becomes highly aroused. Subsequently, higher order cognitive processes shift attention to this arousal which is interpreted as a signal to evaluate or appraise the situation as positive or negative, harmful or helpful. This appraisal is presumed to lead to a particular natural kind categorical emotional response, which is followed by a corresponding action that is complimentarily hard-wired into that natural kind category (Clore and Ortony, 2008). Like basic emotions theories, appraisal theories presume that emotions are housed in the brain, relatively intact, and are elicited upon encountering environmental triggers. These theories also seem to imply an underlying universality of emotion categories, suggesting for example that fear—or confusion—is similarly experienced and expressed across individuals.

Here again, while not denying that emotions do help us in determining how to function or respond to environmental conditions, Barrett (2011) has argued that emotions do not exist ready-made in nature, complete with pre-determined expressions and response patterns. Instead, she surmised it is more likely that humans evolved an underlying adaptive set of physiological mechanisms which become activated to produce a variety of emotional responses according to the particular environmental conditions and situations we encounter (Barrett, 2011). She has continued to assert that, unfortunately, due to the ongoing scientific misreading of Darwin, some studies have perhaps inadvertently used methodological manipulation to find support for a particular theoretical perspective; thus the great emotion debate is likely to continue (Barrett, 2011).

Constructionist Theories of Emotion

While both natural kind and appraisal theories have enjoyed a significant period of prominence and continue to be a strong basis for some strands of emotion research, other theorists have challenged their premises on the basis that they seem to require or at least promote an underlying essentialist viewpoint. To be clear, major proponents (Russell, 1991; Barrett, 2006a) of the psychological constructionist movement do not deny the involvement of neural substrates in the generation of emotion; yet they argue against the idea that there are *exclusive* systems and universal pathways of an evolutionary nature that are dedicated to the generation, experience, and expression of a specific set of basic emotions. Moreover, they contend that the feeling phenomena we label with socially agreed upon concept terminology are not at all natural kinds, but are instead psychological constructions built upon an innate physiological capacity to be aroused/activated and to perceive states of pleasure and displeasure; Russell and Barrett call this physiological capacity 'core cffect' (Barrett, 2006b).

Indeed, Barrett's work has put both the natural kind and appraisal theories on the proverbial ropes. Following more than 10 years of neuroscientific research of her own, Barrett (2007) argued that purported findings from animal studies which appear to favor the claim of neuroanatomical and neural circuit specificity, widely touted by Panksepp (2007), are inconsistent and ambiguous at best. She has suggested that these data are limited due to the fact that there is clear evolutionary superiority of the structural and functional capacity of the human brain over other mammals—making Panksepp's assumption of homologous cross-species brain structures questionable (Barrett, 2006a). She has asserted further that natural kind and appraisal theories have been hard pressed to account for either individual subjective or cultural variation in the experience and expression of emotion, referring to a recent study conducted among a remote tribal group in which Ekman (1992) and Izard's (2007) contention regarding the universality of facial expressions of emotion did not hold true (Gendron, Roberson, van der Vyver, & Barrett, 2014). In answer to these charges, Barrett has offered a new model for understanding and explaining emotion to be described in detail in the coming pages.

Emotions in Learning

A Brief Review of Research on Emotions in Learning

With a general overview of emotion theory completed, the discussion turns next to the presence of emotions in studies of learning. In terms of contemporary research into the role of emotions in learning, a review of the recent literature (studies undertaken since the 1990's), reveals that a great majority of such investigations appear to have emphasized emotion as a peripheral construct. For example, Graziano, Reavis, Keane, and Calkins (2007) investigated the role of children's emotion regulation skills and academic success in kindergarten; Ingleton (1999) studied the role of emotion in establishing and maintaining identity and self-esteem in learning situations; Pekrun, Goetz, Titz, & Perry (2002) explored the academic emotions (enjoyment, hope, pride, relief, anger, anxiety, shame, hopelessness, and boredom) experienced by students at school (but not specifically as epistemic emotions); Levin and Pizarro (2004) considered the effects of emotion on memory (but not directly in the performance of academic tasks); and Duncan et al (2007) examined the role of socioemotional development in school readiness and later achievement.

At the same time however, parallel streams of research into the relationship between emotions and learning have also emerged. Rather than focusing on affect as an entity outside of cognition, these programs of research have attempted to understand the emotional states, especially confusion, that arise during and in conjunction with cognitive processing effort. Such investigations emphasize the epistemic nature of learning and the possibility that there may be poorly understood mechanisms, such as affect dynamics, which may be more elusive to study but that could nevertheless play an equally important role in the relationship between emotions and learning. And while there are certainly differences in epistemic emotion studies, what appears to be a common theme in those which highlight confusion as a point of interest is that they are at least in part derived from Piaget's (1952) theorizing about disequilibrium.

The Origins of Confusion as Factor in Learning

To understand how confusion has become a relevant construct for learning research, we can begin by recalling Jean Piaget's (1952) theory of cognitive development. Piaget's (1952) theory posits that cognitive disequilibrium represents a state of mental imbalance that is experienced when we are faced with information that does not fit neatly into an existing schema or framework; and as a result of this imbalance, we are subsequently forced to develop new schema or modify the ones which currently exist. Disequilibrium, Piaget (1952) argued, produces a sense of discomfort and a desire to take some cognitive action that will, as quickly as possible, allow us to return to a state of comfort, or equilibrium.

While Piaget (1952) made no direct mention of feeling states, his theory suggests that the application of mental energy—perhaps deeper cognitive processing—is required in order to create or adapt schema; otherwise disequilibrium will remain, and we will be obliged to settle for an alternative (and likely unsatisfactory) course of action, whether it is allowing an ill-fitting schema to remain unchanged or altogether withdrawing our attention and mental energy from the task. Yet a question that appears to have been neither asked nor answered by Piaget is this: just what is it that serves as a cognitive prompt or signaling mechanism, indicating that an infusion or increase in mental energy is required in order to move from a state of cognitive disequilibrium back to a state of equilibrium? One potential answer, which has been proposed by a number of researchers and is the focus of this dissertation study, is that it is the feeling of confusion that may act as an important driver of the process Piaget (1952) called equilibration. Indeed, while interest in the relationship between confusion and learning seems to be a relatively recent phenomenon, it has in fact been a topic of interest for some time.

In 1910, John Dewey, writing in one of his most widely acclaimed collections of writings on learning and education, argued that confusion is a necessary and essential component of reflective thought. W.J. Pauli (1960) distills Dewey's contention in his statement that "confusion, the feeling of difficulty in a situation, is the stimulus as well as the origin of thinking. Without this *felt* [emphasis added] difficulty, appeals to an individual to think would be futile." In as much as Piaget (1952) stopped short of explicitly identifying confusion as an emotional catalyst of deep thought and complex reasoning, Pauli (1960) forthrightly articulates that claim.

Writing specifically and directly about the relationship between confusion, problem solving, and learning, Pauli (1960) asserted that while the terms 'problem-solving' and 'learning' are often used interchangeably, they are in fact not exactly the same; rather it is the engagement and practice of problem-solving (a form of complex reasoning) which leads to conceptual learning and the ability to transfer one's knowledge to new situations. At the same time, he also argued that some degree of the felt experience of confusion seems to be the unifying element which underpins nearly all instances of problem-solving and eventual learning. He states that "confusion is the catalytic agent that generates the problem-solving process, and thinking is the solvent" (Pauli, 1960).

To further clarify his theoretical suppositions, Pauli (1960) was careful to differentiate the context in which his ideas are cast. He achieved this by defining the kind of confusion experienced during problem solving and learning as a "sense of… discomfiture of mind, a state of being disconcerted, of experiencing perplexity, doubt, and uncertainty", as opposed to confusion in "the psychiatric sense…characterized by unstable attention, poor perception of reality, disorientation, and inability to act coherently" (Pauli, 1960). He added also that the affective state of confusion associated with learning "implies that the individual has the intelligence and experience to penetrate the confusion blocking his goal" (Pauli, 1960).

But Pauli (1960) went further still by suggesting a potential mechanism of action for confusion. He contended that "for any individual the key to successful problem solving lies in his *attitude* [emphasis added] toward confusion…and "we can learn to overcome confusion or we can be overcome by it." Moreover, he asserted that unless we are resigned to avoiding learning, we should not seek out or expend extraordinary amounts of time and energy trying to develop strategies that might permit us to altogether avoid confusion. Indeed, confusion should not be "regarded as an intrusion to make problem solving [and learning] needlessly difficult, but rather as an essential [affective] barrier to navigate" (Pauli, 1960). This suggests that such strategies as those which intend to eliminate confusion from problem-solving, complex reasoning, and learning are, as a matter of function, shortcuts to propel students toward what they hope will be a simple, unidimensional, or uncomplicated answer with little concern for the context or conceptual elements which surround and are intrinsic to the path which leads to understanding in a respective arena of knowledge.

Pauli (1960) clarified this argument by pointing out that “shortcuts through dense forests are sometimes necessary, but if the necessary is understanding of the forest, shortcuts will enable us to see the least.” In other words, if the objective of learning is to gain a useful depth of understanding about some idea or concept, then circumventing complex reasoning and confusion (e.g., by way of rote strategies) will profit the learner very little. Complex reasoning and the affective state of confusion have the potential to help students “attain understanding of the relationships which connect answers to questions” (Pauli, 1960), moving them beyond the goal of making a certain grade, or the ability to identify an answer in a text book, or the habit of simply recalling and uncritically advancing a bit of information that they have been told.

Extant investigations into confusion and learning: affective computing environments. In making an empirical case for a relationship between confusion and learning, some contemporary researchers appear to have embraced the insight of Pauli (1960) and Piaget (1952). For instance, D'Mello and Graesser (2012) agree that the underpinnings of the relationship between challenging cognitive tasks and meaningful learning can be traced back to Piaget's (1952) ideas regarding disequilibrium as the mechanism which facilities the development of new cognitive abilities through assimilation and accommodation. Their model of confusion as a factor in meaningful learning begins with the assertion that because human beings are motivated to reach and maintain a state of mental surety or balance, the introduction of uncertainty, impasses in understanding, contradictions, and negative feedback provokes a highly arousing and displeasing affect state (e.g., confusion), which in turn compels individuals to rigorously search for conceptual connections in order to quiet disequilibrium and facilitate a return to cognitive balance (D'Mello and Graesser, 2014).

If not fully apparent, the premise here is that there is an affective, physiologically-driven response to uncertainty which promotes an increase in reflective and critical thought as well as higher-order reasoning (e.g., problem solving); in turn this affective state and the subsequent alterations in one's depth of cognitive processing may ultimately lead to deeper learning and conceptual understanding. In short, complex thinking involves both cognitive and affective processes, with the latter succinctly represented by the emotion label, confusion (D'Mello and Graesser, 2014). To test the hypotheses described above, D'Mello, Taylor, and Graesser (2012) conducted a series of studies which tracked the dynamic path of affective states experienced during complex learning. The researchers were able to identify 6 affective states (flow, boredom, confusion, frustration, and delight) which were significantly related to learning outcomes for college students engaged in a course of study on computer literacy. However, although each of the six affect states was shown to have occurred during complex learning, their results indicated that confusion appeared to produce the greatest learning gains. On the other hand, the authors advised caution in interpreting these particular results, suggesting that the experience of confusion may have a limited temporal range for positive benefit, such that beyond this range, which they have termed the "zone of optimal confusion", the affective state may become overwhelming, leading to an emotion cascade that progresses from confusion, to frustration, to boredom, and finally disengagement (D'Mello and Graesser, 2014).

The confusion studies conducted by D'Mello and colleagues (2014) are significant in that they not only demonstrate a relationship between affective states and learning, but also show that the well-studied discrete or basic emotions--anger, fear, sadness, joy, disgust, and surprise--

described extensively in the literature by Ekman (1992) and Izard (1992)—do not appear to frequently occur during difficult learning tasks. At the same time, there are several limitations to many of these studies. For example, a substantial portion have been conducted in the context of machine learning, affective computing, or human-computer interaction studies and have typically employed auto-tutor interfaces under laboratory conditions. Moreover, none appear to be directly aligned with a specific framework or theory of emotion or have used, by default, a set of basic emotions, seemingly to avoid the fray of the great emotion debate.

Other shortcomings of the confusion studies discussed thus far are that none have sought to theorize about the psychological mechanisms of action which underpin confusion’s effect on learning, nor have they been concerned with developing interventions to improve teachers' ability to support students’ confusion during learning. In general, affective computing studies have as a primary goal, the development of 'smart' machines and programs—auto tutors—which have the capacity to facilitate or support affective states and the associated dynamics that occur during the performance of difficult learning tasks in *computerized* [emphasis added] environments. Thus, it is not surprising that such studies neither attempt to theorize about the conceptual composition or generative source of confusion, beyond acknowledging that valence and arousal are involved, nor attempt to account for subjective variation in the experience and expression of confusion or what such variation could mean for the successful performance of complex inferential reasoning tasks in non-technology oriented learning environments.

Extant investigations into confusion and learning: classroom environments. Although the findings from studies of confusion in affective computing and auto-tutor environments may not be readily generalizable to different settings, another stream of research fills this gap. Pekrun (2011) and colleagues have recently undertaken a program of research which investigated a group of emotions—identified as epistemic emotions—hypothesized to occur during classroom learning, with implications for cognitive processing in general, use of specific types of learning strategies (e.g., rote vs. higher-order), comprehension of complex texts, and inference generation capacity. These studies confirmed that in addition to boredom and frustration, confusion appears to play an important role in complex reasoning and meaningful learning.

For example, Muis et al (2015) examined the effect of a group of epistemic emotions, including confusion, on learning strategy use and complex learning. In this study they confirmed a relationship between anxiety and comprehension of a complex text; students who reported higher rates of the experience of anxiety demonstrated poorer levels of text comprehension. Additionally, they found that learning strategy use was predictive of test performance outcomes and also mediated the relationship between emotions and performance outcomes. But while students did report the experience of confusion, its effects on test performance were negative or inconsistently positive. This was an interesting finding because Muis et al (2015) hypothesized that confusion would lead to higher levels of performance achievement due to its theorized ability to positively stimulate metacognitive insight; however, this was not borne out by their results. Indeed, confusion did not follow the anticipated path to improved text comprehension as predicted, and the researchers subsequently explained this outcome by referencing an argument from previous work (Pekrun, 2011) in which it was posited that the experience of negative, activating emotions may lead to use of rigid rehearsal-type learning strategies which diminish or have a debilitating effect on learning for the average student. Thus confusion, previously identified as a negative, activating emotion, seemed to produce a cognitive dampening or shutting down, which in turn interfered with text comprehension and successful performance on an inference verification task.

While the results of the Muis et al (2015) study offer insight into the relationship between epistemic emotions and learning, the findings regarding confusion in particular were not as the researchers expected and were also inconsistent with the findings of other investigations which suggested that confusion can in fact be beneficial for learning (D'Mello & Graesser, 2014). I submit that Muis et al (2015) failed to consider the potential for variation in the experience of confusion—that is, the possibility that participants had different perceptions of the meaning and function of confusion. This is a possible explanation for why confusion did not function as they expected, and it provides evidence for the present dissertation study which sought to examine underlying mechanisms of action that may account for the power of confusion as a beneficial epistemic emotion. Indeed, confusion as an emotion may serve as a motivational force either prompting students to continue seeking a schematic bridge toward conceptual understanding or to disengage from the situation. However, I argue further that subjective responses to confusion are psychologically constructed by way of student's emotion concept knowledge about confusion as well as their epistemological beliefs about knowledge and learning, and that an examination of this construction is warranted.

The Psychological Construction of Confusion: Application of the Theory of Constructed Emotion.

The present dissertation study converges with and takes as a starting point several decades of research which point to a connection between confusion, complex reasoning and learning. At the same time, the study also diverges from previous investigations surrounding confusion in that it aims for theoretical alignment in a way that allows for a separating out of potential differences in subjective perceptions of the meaning and function of confusion; and this is something that has not been undertaken elsewhere heretofore. Work of this nature is paramount because a majority of extant confusion studies have not specified a particular theoretical framework. As a result of this absence, the affective state of confusion, like the more widely recognized ‘basic’ emotions (e.g., fear, anger, and sadness), has taken on an essentialized quality and is presumed to have a universal pattern of physiological and psychological perception, expression, semantic connotation, and behavioral response indicators.

As previously explained, the emotion label, ‘confusion’, appears to carry with it a highly negative connotation. It is suffused with folk emotion concept knowledge which, in some instances, may be interpreted as a signal of imminent harm and a warning to avoid or disengage from an offending source. Additionally, it is often implied that those who experience the feeling of confusion in settings where competence is highly valued (e.g., school) are in some way intellectually deficient or that one “has failed in his learning” (Lipson, 1992). Yet in spite of arguably common reports, both semantic and phenomenological, that confusion is a simultaneously activating and unpleasant affective state (Graesser and D'Mello, 2012) with characteristically ominous indications, science educator Abigail Lipson (1990), confirming Piaget’s (1952) ideas about equilibration and cognitive advancement, suggested that authentically meaningful learning involves a cycle of moving from “clarity to confusion and back again” (p. 10). In a qualitative study conducted among students in an introductory science course, she found that when students were supported and guided in managing their perceptions about the feeling and meaning of confusion, they began “to recognize confusion as a familiar and perhaps essential part of intellectual inquiry” (Lipson, 1995, p. 95).

Lipson’s early work certainly offers a promising entree for this dissertation study; however, an important limitation of her (1990, 1992) research is that she failed to identify or articulate a theoretical framework to aid in dissecting confusion as a learning-related emotion. Among any number of reasons, this paucity in her theorizing could be attributed to the fact that the widely accepted emotion theories contemporaneously in operation twenty-five years ago did not lend themselves to the kind of application permitted by current perspectives on emotion. Now however, nearly three decades later, Lipson's (1990, 1992) implicit contention regarding differences in students' subjective perceptions of confusion's meaning and function can be well-supported by the Theory of Constructed Emotion (Barrett, 2017).

The present study used as its framework, Barrett's (2017) Theory of Constructed Emotion, which asserts that emotions are conceptual categories populated with instances that are tailored to specific contexts; that instances of emotion are emergently constructed within the brain through parallel distributed processes involving domain-general core systems; and that psychologically constructed emotional episodes have functional features that physiological states, alone, do not possess. Thus, meaningful analysis of emotional feelings, including confusion, must attempt not only to account for physiological/perceptual variation, but do so by considering differences in factors such as emotion concept knowledge, as well as beliefs and dispositions. More precisely, to exam confusion through the lens of the Theory of Constructed Emotion is to suggest that there are indeed a number of factors which underpin, shape, and give rise to variation in how the emotional experience is generated, what it is perceived to mean, and what function it is perceived to serve.

Here it may be necessary to offer a reiteration that the Theory of Constructed Emotion offers a perspective that is very different from the more well-known, classical natural kind viewpoints. Indeed, natural kind theories strongly argue for universality across individuals and cultures in terms of emotional feeling experience, expression, response patterns and concept knowledge. In contrast, Barrett's (2006a) psychological constructionist framework rejects the premise that emotions are discretely bound neural entities exclusively correlated with specific brain regions and/or that they give rise to a limited range of perceptual experiences and responses, regardless of situational context. The Constructed Emotion model, broadly categorized as a dimensional approach (valence x arousal), asserts that emotions are in fact contextualized psychological constructions.

Barrett (2006a) has argued that emotions are manufactured when people momentarily experience (feel) interoceptive feedback about the body's current internal physiological state and cognitively interpret this information (rapidly and typically subconsciously) through a prism of culturally shared and idiosyncratic concept knowledge, memories, and subjective sense-making habits. There is communication between the body's internal sensory receptors and the brain, which is transcribed into meaningful perceptions by way of the simultaneous cognitive infusion of learned emotion knowledge, personal and/or shared beliefs, attitudes and opinions about a topic or idea, and memories of previous experiences of being in a similar situational context or physiological state (Barrett, 2014).

The psychological constructionist perspective is also consistent with Lipson's (1990, 1992) subtle argument that students have the capacity to perceive confusion in different ways. In Lipson's (1990, 1992) work, confusion appeared to differentially function as a metacognitive prompt, giving students insight about their cognitive processing strategies and level of effort. For some students, the feeling of confusion, though possibly unpleasant, served as an activating signal to challenge themselves to search for and apply a different cognitive processing strategy, such as identifying contradictions between pieces of information, in order to master the complex science problem. For other students, however, the feeling of confusion was not only activating but possibly even more unpleasant and seemed to elicit a sense of being threatened by the potential for appearing shamefully unintelligent or incompetent; therefore, instead of persisting in the task or seeking help in managing the cognitive load of organizing new information, these students disengaged from the complex science problem (Lipson, 1990, 1992).

Moreover, these perceptions of confusion, whether learned indirectly or taught, may have also contained appraisal heuristics (e.g., mental shortcuts) which students used to infer information about the demands of the learning situation or task and about the availability of resources; indeed, for some students, the heuristic for the feeling of confusion could be that any state of uncertainty is threatening and that the cognitive demand required for resolution necessarily outweighs available resources. Likewise, some students may apply a challenge heuristic in the face of uncertainty, in spite of experiencing a negatively-valenced affective state (Moore, Vine, Wilson, and Freeman, 2012). The notion of challenge and threat states and their ability to function as appraisal heuristics is the final hypothesized element that might underpin the psychological construction of confusion.

Conceptualizing the Function of Confusion: Threat State vs. Challenge State.

Previous studies have suggested that the limits of confusion's benefit are due to the negative affect cascade which ensues after some extended period of having experienced the emotion (D'Mello & Graesser, 2011); however, this argument does not fully explain the mechanisms of action or conditions which seem to support the utility of confusion. Indeed, this is a central question that the present dissertation study sought to answer: how can the function of confusion be further conceptualized in a way that helps to explain its positive benefit for complex inferential reasoning? And the answer can be found in further applying the constructed emotion framework.

It has already been hypothesized in earlier sections of this dissertation that during periods of cognitive disequilibrium in academic settings, a core affective response is elicited, which is met simultaneously with an infusion of emotion concept knowledge, external sensory information (e.g., awareness of the task environment) and other cognitive input (e.g., beliefs about learning and goals for learning). Such an episode could concisely be labeled with the emotion term, confusion. But beyond emotion terms and the dual process network phenomenon described by the Theory of Constructed Emotion, Blascovich (2013) has asserted that through biopsychosocial processes, emotional experiences function as an alert system, providing both cognitive and affect signals about the potential outcomes of the situations in which we find ourselves.

Blascovich (2013) offers a model of challenge and threat states which argues that prior to and/or during the performance of tasks, we subconsciously assess how demanding we perceive a task to be (demand evaluation) and whether or not we possess the appropriate competency, skills, and resources to meet the requirements necessary for successful task completion (resource evaluation). Additionally, Moore, Vine, Wilson, & Freeman (2012) have suggested that these demand-resource assessments frequently occur in situations where competence is often highly valued, where performance will be rated by others as positive or negative, and also when individuals are engaged in tasks requiring sustained cognitive attention and effort. They argued that when evaluations of task and resource demand are congruent, we typically experience a challenge state; in contrast however, when demand outweighs perceived availability of resources, we experience a threat state. Moreover, their research has revealed that demand-resource evaluations can often be impacted by the degree of task familiarity or unfamiliarity, information incongruity and uncertainty, and even feelings of psychological danger, such as the potential loss of status or fear of appearing incompetent (Moore, Vine, Wilson, & Freeman, 2012).

Bringing this line of argument closer to the realm of emotion, Jones, Meijen, McCarthy, & Sheffield (2009) and Skinner & Brewer (2004) have asserted further that challenge states are generally associated with both positive and negative affective states, where on the other hand, threat states are generally associated with negative affect only. They also posited that demand-resource assessments are often unconscious and occur automatically such that we may have little to no awareness of any challenge/threat evaluative processes. In terms of the experience of confusion, this suggests that while students may be unaware of challenge /threat processes, this mental phenomenon, which shares neural networks used by other mental processes, has the same potential to become infused into the conceptualization process which underpins the psychological construction of emotion; and students who are more sensitive to the valence dimension of the emotional state of confusion may be inclined to experience an increased sense of threat.

More specifically, confusion represents a conceptual category where particular instances are generated and experienced as a function of the immediate environment or situational context. Through parallel distributed brain networks, which reflect a domain general core affective system, and the cognitive infusion of conceptual beliefs, the emotional experience of confusion is created. Like other emotions, confusion signals something about the environment or a present stimulus—that there looms either a threat or a challenge—and prompts the individual to engage in behaviors which match the emotional signal. Where learning is concerned, confusion is likely to be helpful only to the extent that learners' beliefs about knowledge and about how learning happens (e.g., their epistemological beliefs about how people come 'to know') disposes them to conceptualize their core affect as a signal to approach the stimuli (learning tasks) as an adaptive challenge, rather than to withdraw cognitive effort to mitigate some manner of threat.

Chapter Summary

The preceding chapter has presented claims and evidence intended to support the argument that confusion is a misunderstood emotion that may nevertheless play an important role in complex inferential reasoning and meaningful learning. Indeed, in order to harness the potential power of confusion, studies such as the one presented in this dissertation are needed to investigate its underlying mechanisms of action. The methodology used for this investigation is presented next.

CHAPTER 3

RESEARCH METHODS

As previously articulated, this dissertation study sought to examine relationships between two different psychological constructions of the learning-related emotion, confusion, and complex inferential reasoning performance among a sample of college students. In probing variation in the psychological construction of confusion, the study considered differences in participants' perceptions of the meaning/function of confusion, their retrospectively judged feeling experiences of confusion, their confusion emotion concept knowledge preferences, and their epistemological beliefs about knowledge and learning. The most consequential assertions of the study were that 1) students construct their affective experiences of confusion through an integrative psychological process that involves physiological, cognitive and perceptual information, and that 2) there are relationships between different psychological constructions of confusion and complex inferential reasoning performance. This chapter describes the methodology used in carrying out the investigation.

Study Frameworks and Design

The overarching framework for this dissertation study was derived from Barrett's (2017) Theory of Constructed Emotion. It is a psychological constructionist theory of emotion which argues that emotions are situated conceptualizations of Core Affect (e.g., the ability to be aroused and to experience pleasure and displeasure) created from an interaction between many factors including the situational context in which the emotion occurs, an individual's emotion concept knowledge, their memories, personal beliefs, values, and other characteristics, in conjunction with their context-bound physiological states.

Additionally, there were several secondary frameworks used to support the study. The research of D'Mello and Graesser (2014) and Braten and Stromso (2010) guided both the priming of confusion and the manipulation confirmation check, while the work of Braten and Stromso (2009), D'Mello and Graesser (2011), and Muis et al (2015), informed the assessment of participants' epistemic emotion experience and complex inferential reasoning performance. For example, according to research by D'Mello and Graesser (2011), information that is novel and /or contradictory demonstrated the potential to induce confusion when individuals became aware of discontinuities in understanding. Moreover, their work revealed that learning-related emotions, such as frustration and confusion, are more frequently experienced than are basic emotions such as anger and fear, when students are engaged in problem-solving tasks, and also that emotion experience during exposure to novel/contradictory information is dynamic or shifting. Likewise, the research of Braten and Stromso (2010) contributed the finding that participants' understanding of multiple complex texts, under different instructional conditions, can be influenced by students' epistemological beliefs about knowledge and learning, and that asking participants to report their level of understanding and epistemic emotion states is an effective way verify successful emotion priming.

Thus, borrowing from these lines of research, the present dissertation study employed complex text passages comprised of novel, seemingly contradictory content, to elicit or prime the feeling of confusion and to also measure participants' inferential reasoning performance. Additionally, to confirm success of the emotion priming procedure, the study captured information about participants' feeling experiences of confusion during the completion of the inferential reasoning measure, relative to other emotion states, as well as evidence of affect dynamics or shifting. The design for the present investigation was that of an observational experiment, employing hierarchical linear regression as the primary analytic technique.

Participants

The population for this study was undergraduate college students (n = 305) enrolled at a large Southeastern university. Using the G*Power application (Faul, Erdfelder, Buchner, & Lang, 2009), it was determined that this sample size would be sufficient to conduct meaningful hierarchical regression analyses (effect size = 0.15; α= .05; power = 0.95) with 4 predictors of interest (feeling of confusion, both threat and challenge emotion concept knowledge preference, and epistemological beliefs) and 2 control predictors (prior knowledge and verbal ability). An effort was made to recruit participants from as many academic majors as possible. No compensation was offered to participants by the study investigator; however, some individual professors/instructors agreed to offer course-related incentives (e.g., 2 to 4 extra credit points) to their students.

Procedures

The study was administered in a large academic classroom to groups of 15 to 25 participants at a time. After providing informed consent, each participant was given a numbered folder containing correspondingly numbered study documents. The researcher began the study by explaining the procedure to the entire group, pointing out the study measures/questionnaires, the three text comprehension passages, and the learning verification exercise. Upon notification by the researcher, participants were then allowed to open their respective folders and subsequently to begin the study. Participants completed the study instruments/measures in a fixed, linear, and selfpaced order as follows: 1) Demographic Questionnaire; 2) Confusion Perception Scenario; 3) Climate Change Prior Knowledge test; 4) Climate Change Text Comprehension Passages; 5) Epistemological Beliefs Survey; 6) Learning Verification Task; and 7) Verbal Ability measure. The logic for the ordering of study instruments was to collect data in the manner that was most likely to elicit authentic responses (particularly as it related to the confusion perception scenario), allow sufficient time between reading of the text comprehension passages and completion of the learning verification task to optimize emotion induction potential, and also to minimize the potential for participant fatigue before completing the most important study measure (e.g., the learning verification task). There were no time restrictions for completion of the study tasks.

Data Collection

Data collection for the study was implemented through paper and pencil instrumentation. This procedure allowed for efficient and timely collection of data. Although similar studies have used computerized environments (Muis et al, 2015) for study administration and data collection, an important element of the present study was that the task environment should ensure, to the greatest degree possible, ecological validity (e.g., a realistic learning/school context). Moreover, the use of paper and pencil administration in a large lecture hall setting as implemented in this study was similar to the data collection procedures used by Braten & Stromso (2010) in their study of epistemological beliefs and complex text comprehension.

Measures

SES-Q (students' experiences in school question): confusion projection scenario. The SES-Q is a projection scenario that was created by the study investigator to assess participants' learning-related confusion emotion concept knowledge preferences (e.g., what they know and prefer to believe about the meaning and function of confusion) and their global or general perceptions of confusion. The SES-Q was pilot tested with two groups of undergraduate students (Pilot Study 1, n=33; Pilot Study 2, n=76), and the results confirm that students do in fact possess different kinds of knowledge about the meaning/function of confusion, and that their global perceptions of confusion are strongly correlated with their emotion concept knowledge preferences.

The SES-Q scenario describes a learning situation where a fictional student reports feeling confused after encountering a learning task for which she suddenly realizes she is unprepared; the scenario is then followed by a set of projective prompts to which study participants are asked to respond. The projective prompts are statements about what the fictional student believes about the meaning/function of learning-related confusion and what behavioral action she would be likely to take. One statement reflected conceptual knowledge of confusion as a state of disorientation and a signal of some manner of threat (e.g., This can't possibly make sense, I don't know where to begin; smart people don't get confused; my grade could be in jeopardy). In contrast, the other statement reflected conceptual knowledge of confusion as a state of wonderment and a signal of some manner of challenge (e.g., If this is supposed to make sense, what can I do to figure this out; there has to be a way; I'm going to try something different and continue on).

Projection tasks are widely used in psychological research because they allow individuals to project their own subject insights, knowledge, and beliefs onto an external stimulus (e.g., a fictional character), often revealing personal conflicts, motivations, coping styles, and other individual characteristics. Taglasi (2013) stated that "projection is about the influence of preexisting mental sets or schemas on current information processing…the aim of projective techniques is to gauge how individuals use their schemas to negotiate the performance demands set by the stimuli and instructions of a particular task."

After reading through the scenario, study participants were asked to rate their level of agreement (Likert scale 1 to 5; Strongly Disagree to Strongly Agree) with each of two projective statements, a threat knowledge agreement statement and a challenge knowledge agreement statement. These statements were designed to indicate participants' projected interpretations of the fictional character's feeling experience of confusion and her beliefs about its meaning/function. Participants received an emotion concept knowledge preference score for both the threat knowledge statement and the challenge knowledge statement. This exercise served as a projection task designed to tap into and provide insight about participants' implicit knowledge and beliefs about confusion and which of the two kinds of confusion emotion concept knowledge appeared to be most salient for them. These scores were used as independent variables of interest in hierarchical regression models.

A second part of the SES-Q asked students to select one of the two emotion concept knowledge preference categories (threat or challenge) which best reflected their overarching or global perceptions of confusion. The purpose of collecting this data was to demonstrate that there is no singular universal perception of confusion which characterizes how students understand its meaning and function. This was an important element of this investigation because previous studies (D'Mello & Graesser, 2011) that have investigated the effect of confusion on complex problem-solving have not explicitly considered the idea that confusion does not have a universally perceived feeling/meaning or that there are psychologically related constraints which could render confusion as either debilitative or facilitative for learning. This single statement was included as part of the task to reveal an overarching or global perception of confusion that participants might subconsciously apply as a stereotypical affective representation in their psychological construction of future episodes of confusion.

Climate change comprehension text passages: confusion priming task. A central aspect of the present study was the need to elicit or provoke within participants, the feeling of learning-related 'confusion' (FOC)—an emotion that reflects an awareness of 'not knowing' or of a discontinuity in understanding. The use of novel and/or conflicting information to elicit a range of epistemic emotions, including confusion, is consistent with Piaget's (1952) cognitive disequilibrium theory, and the effectiveness of this technique has been demonstrated in a number of studies which have examined factors such as affect dynamics in auto-tutor environments (D'Mello and Graesser, 2011). In a similar vein, Braten and Stromso (2009) employed a set of seven text comprehension passages which contained factually accurate information but are worded in such a way as to give the impression of potential discrepancies between the passages. These passages have been used in several recent studies (Braten and Stromso, 2010; Muis et al, 2015) to examine the effects of epistemological beliefs, learning strategy use, and a range of epistemic emotions, on the comprehension of complex texts.

To accomplish the goal of priming the experience of confusion, three of the seven text comprehension passages used by Braten and Stromso (2009) were used as a source for affect manipulation. The text passages were written in such a way that the content of each—though strongly related to one another—appeared incongruous to the others. This discontinuity was intended to elicit within participants, the feeling of 'not knowing' (otherwise defined as learning-related confusion), and in turn to potentially prompt a change in their level of cognitive processing (e.g., from superficial processing to deep processing). All passages contained information about the causes and effects of climate change and were presented to participants in a pre-determined order. The order of presentation was such that the second and third text passages contained information that appeared to be in contradiction to that which was presented in the first text passage. For example, the first text passage (314 words in length), originally published by scientists from the Center for International Climate and Environmental Research at the University of Oslo, presented information which discussed the relationship between environmental greenhouse gases and human production of climate gases and suggested that this interaction is responsible for extreme disruption in the climate system. In contrast, the second text passage (325 words in length), written by an astrophysicist and published in a scientific journal, explored the relationship between astronomical solar radiation, magnetism and observed historical variation in the earth's climate, and suggested that there is some doubt about the causes of climate change and also that human intervention to stop these changes may not be possible.

Each passage began with general introductory information (e.g., title and text source) as well as the respective author's (or authors') name(s) and credentials. As part of the instructions for the second and third text passages, information was included which subtly highlighted that the position taken by each author was in some manner different than the position taken by the others. Braten & Stromso (2009) suggested that this instruction be provided in order to aid participants' awareness of information incongruity and to stimulate the elicitation of emotion. In the present study, the instructions included informative statements such as the following: "The second text passage presented below also discusses the causes of climate change and is written by a science expert. However, the expert who wrote the first passage appears to claim that humans are responsible for climate change, whereas this expert appears to claim that changes in the climate are basically natural." Although the information contained in the two respective passages seemed incongruent or contradictory on the surface, the use of complex reasoning strategies should have guided readers to infer that while climate change is indeed a natural phenomenon, scientific studies also suggest that it has been dramatically exacerbated by humans. In general, the three complex text passages about climate change were intended to present factual content in an accurate but increasingly cognitively cryptic manner, as compared to the first passage, in order to evoke a sense of not knowing or an awareness of failure to understand. Before participants began reading the passages, they also received the instruction that they were permitted and encouraged to make notes and to study the text comprehension passages as much as desired in order to facilitate their later performance on a subsequent study measure of learning (learning verification task).

Adjective word sets: emotion (confusion) self-report. The emotion self-report procedure used in the present study was essentially a remembered moments retrospective judgment protocol designed to simultaneously tap participants' core affect and mental representations of emotion concept knowledge, without biasing their thinking via the provision of specific/conventional emotion word labels. Participants were asked to report a remembered affective state at two points in the study: First, after reading each of the three confusion priming text passages; and subsequently after answering each of 3 groups of conclusion statements on the learning verification task, the proxy measure for complex inferential reasoning performance. At each of the above identified study intervals, the following instructions appeared: "Now, circle the letter next to the <u>one</u> group of words below that best describes how you were feeling *while* reading the passage above (or *while* answering the previous group of learning verification task conclusion statements)."

To respond to these self-report prompts, participants selected from an adjective substitution list that contained word sets (4 words/set) which reflected the valence (2 words) and arousal (2 words) dimensions associated with six emotions (Fear, Anger, Frustration, Confusion, Boredom, and Enjoyment) and a neutral affect state. Four of the six emotions (Enjoyment, Boredom, Confusion, and Frustration) have been classified as epistemic emotions and have been shown to occur in learning-related settings (D'Mello & Graesser, 2014; Muis et al, 2015). Additionally, four of the six emotions (Fear, Anger, Frustration, and Confusion) are believed to share similar theoretical valence and arousal conditions (highly negative valence and moderate to high arousal). The instructions associated with the complex text passages and learning verification task directed participants to retrospectively judge and report the *feeling* they experienced *while* reading each passage or answering each set of learning verification task; they were instructed to choose from among a set of 7 descriptive adjective tetrads (e.g., muddled, thrown-off, tense, alert) which served as word substitutions for classical emotion labels (e.g., 'fear', 'confusion'). As previously described, two words in the tetrad were intended to tap participants' current level of activation (calm vs. aroused), while the other two were intended to serve as indicators of their valence state (pleasant vs. unpleasant).

It should be noted that while classical emotion word labels (e.g., 'anger', 'boredom') are used here in this description, participants were not shown these labels at any time during study implementation, but instead saw only the tetrads of adjective substitutes. This was a strategically necessary procedure to enhance theoretical alignment with the affect framework which undergirds this study. Specifically, Barrett's (2017) Theory of Constructed Emotion asserts that all emotions are manufactured from common underlying physiological or core affective elements (e.g., valence and arousal), and that what differentiates one emotion category from another, as well as psychologically creates individual emotion experience, is the presenting context in which these physiological sensations occur (e.g., a classroom), along with individuals' simultaneous cognitive activation of emotion concept knowledge and their memories of prior experiences and/or learned beliefs and information about the current situation.

Additionally, Barrett (2006a) has demonstrated through research that the presentation of classical emotion labels (e.g., ‘anger’, ‘fear’, ‘boredom’) has the potential to inadvertently influence or bias study participants’ ability to objectively judge and characterize their core affective states, which in turn interferes with researchers’ ability to accurately assess emotion-related phenomena. Therefore, because some emotions, such as ‘fear’ and ‘confusion’ for example, have been shown to share a similar core affective signature or pattern of physiological valence and activation (Barrett, 2006a), a goal of the present study was to ensure, to the greatest extent possible, that participants’ self-reported affective responses would reflect a meaningful characterization of their physiological states, which were expected to be derived from the subconscious application of their emotion concept knowledge preferences, remembered experiences, and situational/contextual beliefs and awareness.

In conjunction with the use of the adjective word-set (emotion) reports, participants were also asked to rate how well they comprehended each of the three text passages using a scale ranging from 0 points (I did not understand the passage at all), to 5 points (I understood the passage extremely well). These comprehension ratings served as a proxy for the feeling of confusion and allowed the experience of this specific affective state to be confirmed and isolated from other emotions (e.g., ‘fear’) that were potentially experienced by participants. The three individual rating scores provided by each participant were then combined to create a confusion composite score (with a range of 0 to 15 total points), where lower scores indicated less understanding and therefore higher confusion.

The adjective tetrad measure used to document participants’ self-report of emotional feeling was derived from Yik, Russell, and Steiger’s (2011) 12 Point Affect Circumplex (12-PAC). The 12-PAC is an emotion measure which provides 3 formats (adjective word lists; agree-disagree statements; describes me statements) for verbal self-report of core affect states (e.g, varying degrees of valence and arousal) for both current and remembered moments in time. The 12-PAC is an integration of the most prominent dimensional models of mood and emotion, including Russell's (1980) pleasure and arousal, Watson and Tellegen's (1985) positive and negative affect (PANAS), Larsen and Diener's (1992) multi-combinations of pleasantness and activation, and Thayer's (1996) tense and energetic arousal. Additionally, it has the capacity to operate in a manner similar to Mehrabian and Russell's (1974) semantic differential scales and Quirin, Kaze´n, Rohrmann, and Kuhl's (2009) implicit affect construct.

To develop the 12-PAC, Yik, Russell, and Steiger (2011) conducted four studies: Study 1 (n= 535), which sampled affect felt during a single remembered moment, presented the initial integration of 4 structural models of affect to create the circumplex and examined its relation to 10 existing mood scales; Study 2 (n = 190), which sampled affect felt during a current moment, performed an initial cross-validation of the 12-PAC subscales; Study 3 (n=234), which sampled affect felt during a current moment, presented a second cross-validation of the 12-PAC and examined its relation to 20 mood scales and 13 personality scales; and Study 4 (n=395), which sampled affect felt during two remembered moments, presented a cross-validation and examined the relation of the 12-PAC to 25 additional personality features/scales. Across all of the studies, the 12-PAC demonstrated good model fit.

To reiterate, in spite of good model fit however, Barrett (2013) has suggested that, although self-report continues to be the most reliable method for assessing emotion states, care must be taken since some studies show that individuals may actually become inadvertently primed to experience emotion states simply by reading or being presented with common emotion label terms such as 'Fear'. Therefore, for the present study, a modified version of 12-PAC measure was employed as an alternative but acceptable measure. The adjective word sets that were included in the measure represented each of 7 emotions categories that were either chosen directly from the Yik, Russell, and Steiger's (2011) 12-PAC list or that are synonyms chosen from Merriam-Webster's Collegiate Dictionary (Eleventh Edition). The word sets were constructed to reflect the underlying emotion concept knowledge which has been customarily agreed upon in American society and abbreviated using conventional emotion word labels. For example, the adjective word set associated with 'Fear' is a) apprehensive, on-edge, tense, up-tight, where 'apprehensive' and 'on-edge' are valence words conceptually related to fear, and where 'tense' and 'up-tight' are activation words also conceptually related to fear.

For the purpose of analyses, a frequency count for each of the emotions that participants reported during the priming procedure and completion of the learning verification task was generated to provide evidence of statistically significant differences in participants' experience of epistemic versus basic emotions.

support for fidelity of priming. The text procedure described above and used for the priming of confusion in the present study has been widely used employed and validated (e.g., Muis et al, 2015). In previous studies, the following claims were made: 1) that a general awareness of cognitive incongruity would occur during the reading of the second text passage due to the presentation of information which appeared to conflict with information presented in the first text; 2) that cognitive incongruity would not be likely to occur after reading the first text passage; and 3) that different emotions would be reported after the reading of the second text passage than those which had been reported after reading the first text passage. In a study conducted by Muis et al (2015), they expected to observe a particular pattern of emotional shifting between the reading of the first, second, and third text passages, where participants should have been more likely to go from reports of boredom, enjoyment, or neutral affect after reading the first passage, to reports of confusion, frustration, or anxiety after reading the second text passage; however, they did not expect the reverse to be true. Moreover, they argued that reports of confusion should remain relatively stable after reading the third text passage. After analyzing their data, Muis et al (2015) found that all of their hypotheses were in fact supported, suggesting that the incongruity priming manipulation had been successful.

These results provided support for the use of this priming technique in the present study; however, one point of clarification is offered. Muis et al (2015) used actual emotion word labels (e.g., Fear, Anxiety, etc.) in their study; in contrast, the present investigation used adjective word sets (as substitutions for conventional word labels) to identify the emotions. This was justified because the aims of the Muis et al (2015) investigation were not identical to those of the present study, which sought in part to demonstrate the constructed nature of confusion. Thus, despite this difference, it was nevertheless reasonable to expect that the incongruity priming task would be effective in evoking the feeling of confusion. For the purposes of measurement and to further ensure priming fidelity, the degree to which participant experienced the feeling of confusion was quantified by having them provide a retrospective rating of their certainty of understanding/ knowing (e.g., degree of comprehension) for each passage, using a Likert scale of 0 to 5 points. The rating question read as follows: "How well did you understand the passage you just read? Response indicators ranged from 0 – not all, to 5 – extremely well. The ratings for the three passages were combined (summed) to create a priming confusion composite score which was used later (as a basis for comparison) to help confirm the re-activation of confusion within participants while they had been completing the learning verification task. This was accomplished by determining if there were statistically significant differences between participants' priming confusion composite scores and their learning verification task confusion composite scores. It was expected that participants' learning verification task confusion composite scores (reactivated confusion) would be at least as high as their priming confusion composite scores. This finding would provide evidence in support of the successful (re)activation of learning-related confusion.

Epistemological beliefs survey. An element of the Theory of Constructed Emotion asserts that individuals hold conceptual beliefs that are associated with particular situations, contexts, and even the nature of how the world 'works', and that such beliefs play a role as interpretive cues in the process of our psychological construction of emotion (Barrett, 2017). Moreover, the cognitive infusion of these beliefs as an overlay for physiological core affective sensations often occurs outside of our awareness. As it relates to learning, research suggests that students hold ideas about the nature of knowledge and learning (e.g., what constitutes knowledge; from where does it come; how is knowledge acquired, and who is more adept at its acquisition), and that these ideas, called epistemological beliefs, can impact how students perform in the classroom, depending upon the sophistication or quality of their beliefs. For example, students who believe that the acquisition of knowledge is a process that could require both time and effort, tend to be more persistent in modifying their approaches to learning when confronted with complex problem solving tasks, compared to students who believe that learning is a quick, straightforward process that largely involves rote memorization.

In the present study, it is argued that there is a predictive relationship between students' epistemological beliefs and their complex inferential reasoning performance, and more importantly that these beliefs play a role in students' psychological constructions of confusion. To measure participants' epistemological beliefs about the nature of knowledge and learning, Wood and Kardash's (2002) Epistemological Beliefs Survey was employed. This instrument (and theoretical perspective) was selected because it was determined to have the best fit when subjected to CFA, compared to two other measures of epistemological beliefs (the Epistemological Questionnaire and the Epistemic Beliefs Inventory). Debacker et al (2008) have suggested that all 3 measures of epistemological beliefs show problems with consistency; however, they nevertheless confirmed that "the majority of items on the EBS appear to be fairly good indicators of the factors that Wood and Kardash (2002) have described." In general, it has been argued that epistemological beliefs is a construct which has long defied simple and precise measurement; thus, it is unlikely that there exists any instrument that would be without shortcomings.

The Wood-Kardash (2002) Epistemological Beliefs Survey is a 38-item instrument consisting of five subscales that are used to assess 5 independent dimensions of epistemic beliefs: 1) The Speed of Knowledge Acquisition (8 items); 2) Structure of Knowledge (11 items); 3) Knowledge Construction and Modification (11 items); 4) Characteristics of Successful Students (5 items); and 5) Attainability of Objective Truth (3 items). Responses to survey items are scored on a five point Likert scale: 1= strongly disagree, 2= disagree, 3= unsure, 4= agree, 5= strongly agree, and higher scores reflect more sophisticated epistemological beliefs. According to Wood & Kardash (2002), the subscales can be used separately or combined in a composite fashion. Wood and Kardash (2002) reported good internal consistency alpha coefficients for each of the five subscales. In the present study, participants were asked to rate their agreement with each of the 38 statements using a scale ranging from 1 point (I strongly disagree with this statement) to 5 points (I strongly agree with this statement). While it is acceptable to employ and score the subscales as separate entities, it is also acceptable to calculate an overall survey score as was done in this dissertation study. Thus, participants' rating values for the 38 items were summed to create an epistemological beliefs composite score with a possible range of 38 to 190 points, where higher scores reflected an overall more sophisticated view of the nature of knowledge and learning. The subscales are described in detail below:

- Speed of Knowledge Acquisition (8 items) – This dimension reveals beliefs about the speed of learning. Low scores reflect the belief that learning is a quick, relatively straightforward process, whereas high scores reflect the belief that learning is a more gradual process that takes time and effort.
- Structure of Knowledge (11 items) – This dimension taps into the understanding that meaningful information and knowledge does not always exist as neatly arranged, simple to understand ideas and concept. Low scores reflect the belief that knowledge is discrete and unambiguous and its meaning should be clear/obvious, whereas high scores reflect the belief that knowledge is complex and multifaceted and its meaning isn't always immediately apparent.
- Knowledge Construction and Modification (11 items) – This dimension uncovers participants' beliefs that knowledge is not 'ready-made' but can be obtained by combining and reconfiguring information from multiple sources. Higher scores on this subscale indicate an awareness that knowledge evolves and changes; on the other hand, low scores indicate the belief that knowledge is fixed and should not be questioned
- Characteristics of Successful Students (5 items) – This dimension reveals beliefs about the nature of learning success (e.g., is successful learning the product of innate ability or hard work). Low scores reflect the belief that successful students are 'smart' so it takes minimal effort for them to accomplish learning tasks, whereas high scores reflect the belief

that successful students expend time and effort to be good learners (even if their effort is unnoticed by others).

- Attainability of Objective Truth (3 items) – This dimension taps belief in the ability to uncover a single truth or answer, and that knowledge belongs to a designated authority. Low scores on this subscale reflect participants' beliefs in the certainty and objectivity of knowledge, while high scores indicate an awareness that knowledge is not always neutral but can be instead be subjective and uncertain.

Learning verification task (complex inferential reasoning performance): inference verification test. To assess participants' complex inferential reasoning performance, a learning verification task, modified from Braten and Strømsø's (2010) Inference Verification Test measure (IVT), was used in the present study. The test procedure was initially constructed by Royer, Carlo, Dufresne, and Mestre (1996), but was subsequently adapted by Strømsø et al. (2010). The purpose of these original measures was to assess individuals' ability to use complex inferential reasoning processes in order to acquire deep-level understanding of texts, draw reasoned conclusions, and identify accurate problem solutions. Each question on the task was presented as a single sentence which reflected the integration of two pieces of information drawn from related complex text passages. The sentences on the verification test represented inferences which were either valid (e.g., accurate inference) or invalid (inaccurate inference). Participants were instructed to indicate, by circling either "Yes" or "No", whether each respective item represented an inference that could reasonably be made based upon the text passages previously read. Braten & Stromso (2010) indicated that participants' evaluation of the appropriateness of each inference should ideally be made based upon the readers' ability to comprehend the passages and to reason in a complex manner. As stated by Muis et al (2015), "to reliably judge whether an inference is valid or not requires that the reader has constructed a mental model of the text that represents its deep structure (or meaning). Surface level representations (those that focus on surface structure or sentence wording) would result in chance level performance."

Similarly, in the present study, an inference verification test, here called learning verification task, was designed to measure how much participants had understood and learned from reading and studying the set of complex text passages, and more specifically, to gauge their ability to employ higher order, complex inferential reasoning strategies in order to detect and report the accuracy or inaccuracy of hypothetical conclusions derived from the presence or absence of information contained in the text passages. Nine of the 21 items used in the Braten & Stromso (2010) study comprised the present learning verification task; the 9 items were divided into 3 groups of 3 questions each. The decision to reduce the number of task items from 21 to 9 was done in order to decrease the potential for participant fatigue given the number of instruments included in the study. Participants received the instruction that each group of conclusion statements corresponded directly to at least two of the three complex text passages they had previously read and studied. Participants were directed to read each conclusion and to determine if the information it contained could or could not be accurately inferred based upon their reading and understanding of the complex text passages. Participants were asked to select from two answer choices when responding to the conclusion statements: 'Yes', the information in the statement can be accurately inferred from the texts; or 'No', the information in the statement cannot be accurately inferred from the texts. The learning verification task was scored by awarding to participants, one point for each correct response given; this resulted in a possible score range of 0 to 9 points. The earned scores for each participant were recorded as the total number of items correct (score out of 9 points). These scores served as a proxy measure of participants' complex inferential reasoning performance and were used as a continuous dependent variable for hierarchical regression analyses.

A second part of the learning verification task involved re-activating and capturing participants' retrospective judgments of the degree to which they had experienced the feeling of confusion they had experienced *while* completing the learning verification task. To accomplish this emotion (re)activation, the conclusion statements on the learning verification task were manipulated such that none of them reflected accurate inferences that could be made when based solely upon the information contained in the complex text passages. In short, the correct response to all nine inference verification task items was 'no'; participants received 1 point for providing this response, and 0 points if they answered 'yes' to any of the items. This scoring was consistent with the method previously described for the calculation of total number of items correctly answered; what is described here simply reflects further detail about the use of a manipulation that was intended to either provoke or reactivate an affective signal of discontinuity in understanding, otherwise known as the feeling of confusion.

A two-part procedure was used to capture information about participants' affective experiences and in turn confirm fidelity of the emotion (re)activation manipulation. After completing each learning verification task item, participants were asked to use the emotion adjective tetrads to indicate, via retrospective judgement, the emotion they had experienced while completing the respective task item. This was done in order to document the subjective affective states that participants had experienced across the completion of the learning verification task. In conjunction with participants' item-level emotion self-reports, after completing each 3-item set of questions on the learning verification task, participants were asked to retrospectively rate and report how well they had understood that respective group of items.

Participants performed this rating by applying the same scale they had previously used to rate their understanding of the complex text passages they had read earlier in the study; the scale ranged from '0' points, I did not understand this set of items at all, to '5' points, I understood this set of items extremely well. The rating scores from the 3 sets of items were summed to create an objective learning verification task confusion composite score with a possible range of 0 to 15 total points. These learning verification task confusion composite scores were used in hierarchical regression analyses as a continuous dependent proxy measure of the degree to which participants had experienced the feeling of learning-related confusion during the completion of the learning verification task.

Control Measures

Prior knowledge task. In terms of the comprehension quality of the text passages used in the present study, the content was intended to be novel and to be perceived by participants as incongruous; however, it is nevertheless possible that participants may have had some prior knowledge about the topic (climate change) presented in the text passages. To account for the potential effect of participants' prior knowledge about the topic, they completed a prior knowledge test, and those scores were treated as a covariate (of non-interest) during analyses.

Participants' prior knowledge of climate change was assessed with a 17-item multiple-choice test adopted from studies conducted by Bråten and Stromso (2008). The test included items whose content made reference to information that was contained in the confusion priming text passages. For example, one item asked: "The greenhouse effect is due to…" with the following five answer options from which to choose: "(a) holes in the ozone layer, (b) increased use of nuclear energy, (c) increased occurrence of acidic precipitation, (d) streams of heat that do not get out of the atmosphere, or (d) the pollution of the oceans." One point for each correct answer was awarded to participants, which resulted in a possible prior knowledge score range of 0 to 17 points. These scores were used in statistical analyses to control for the effect of prior knowledge on complex inferential reasoning performance.

Shipley-hartford verbal ability scale. The Shipley-Hartford (1940) Scale is a brief, self-administered instrument initially designed to test mental deterioration. The test was created to evaluate any existing degree of difference between vocabulary understanding and abstract thinking, as an index of changes in mental functioning. According to Shipley (1940), in clinical settings it had been observed that individuals who were experiencing mental deterioration often showed only slight changes in vocabulary comprehension while demonstrating more marked changes in abstract thinking capacity. The original instrument consisted of a vocabulary test and an abstract thinking test and was used in combination for clinical mental status evaluations. More recently, studies have used only the vocabulary scale to assess and control for differences in verbal ability in psychological studies (Tidwell, Sadowski, and Pate, 2000).

In the present study, the verbal ability test was a 40-item multiple choice instrument that measured participants' vocabulary knowledge. Each of the 40 items consisted of a target vocabulary word, in upper-case bold letters, and three secondary words, one of which was similar in meaning to the original target word. Participants were asked to select the secondary word that was closest in meaning to the original target word. Examples of scale items include the following: **PARDON:** forgive, pound, divide (correct response is forgive); **ORIFICE**: brush, hole, building (correct response is hole). Studies have demonstrated correlations between the Shipley-Hartford Verbal Ability Scale and other instruments such as the Weschler Adult Intelligence Scale (.78) (Tidwell, Sadowski, and Pate, 2000). In the present study, participants completed the Shipley-Hartford scale to control for potential mean differences in participants' verbal ability.

Demographic questionnaire. In the present study, participants provided the following demographic information: Academic Major, Year in College, Gender, and Race/Ethnicity. Because the study sample was drawn from a largely homogeneous population (e.g., White Females), gender and race/ethnicity were collected only to help document the characteristics of participants who enrolled in the study; however, these variables were not intended to be used in statistical analyses as variables of interest, since no prior research has shown them to be of consequence. Nevertheless, to ensure that these demographic factors should not be included as independent variables of interest, a preliminary factorial ANCOVA was performed, after confirming that the data reasonably met the major assumptions of this procedure, including Levene's test for equality of variances [F(102, 202)=.891, p=.741], to determine if there was any significant variation in participants' learning verification task scores across year in college, academic major, gender, race/ethnicity, while controlling for the potential effect of prior knowledge of climate change and verbal ability. The results of the ANCOVA revealed no statistically significant variation in participants' learning verification task scores in relation to their Year in College, $F(4, 244)=.457$, $p=.767$; Major, $F(7, 244)=.600$, $p=.756$; Gender, $F(1, 244)=.026$, $p=.872$; or race/ethnicity, $F(6, 244)=.279$, $p=.946$. Additionally, there was no main effect of either prior knowledge, $F(1, 244)=.101$, $p=.751$, or verbal ability, $F(1, 244)=.822$, $p=.365$ on learning verification task scores, nor interactions between the demographic factors and either prior knowledge or verbal ability. These results confirmed that it was acceptable to exclude these demographic factors as variables of interest.

Research Questions, Hypotheses, and Statistical Analyses

The primary research questions and hypotheses for the study were as follows:

RQ1a) Do students experience learning-related confusion while studying complex texts?

$H1_0$**:** Students do not experience feelings of learning-related confusion while studying complex texts.

$H1_1$**:** Students experience feelings of learning-related confusion while studying complex texts.

Statistical Analysis.

A frequency analysis of participants' retrospective emotion self-reports was conducted. Counts and percentages for seven emotions were generated; a Chi-square test was performed to determine if confusion was more frequently reported than other emotions, and a t-test was performed to determine the statistical significance. Additionally, participants provided retrospective ratings of their level of text comprehension in conjunction with both the initial emotion priming and their completion of the learning verification task. Composite scores were created for both sets of ratings; these ratings were used as independent variables in subsequent analyses.

RQ1b) Is there a relationship between students' feelings of learning-related confusion and their complex reasoning performance?

$H1_0$**:** Students feelings of learning-related confusion are not a statistically significant predictor of their complex inferential reasoning performance.

$H1_a$**:** Students' feelings of learning-related confusion are a statistically significant predictor of their complex inferential reasoning performance.

While demographic factors did not offer any statistically significant explanations for variation in participants' inferential reasoning performance, a central assertion of this dissertation study was that there are psychologically derived affective processes that might serve as complimentary, if not better explanatory components. Therefore, the first study hypothesis ($H1_a$) sought to initiate the establishment of this claim by modelling the predictive relationship between participants' feelings of confusion and their complex reasoning performance, while controlling for prior knowledge of climate change and verbal ability.

Statistical Analysis.

This research question was tested in two ways. First, a Chi square test of association was performed for each learning verification task item to determine if there was a significant association between the affective states experienced by participants during the completion of the respective item and the accuracy of their task responses. Additionally, for statistically significant item-level omnibus Chi square tests, a post hoc contingency table analysis was conducted following the Beasley & Schumacker (1995) procedure; this analysis was performed to determine if there was a statistically significantly greater number of correct inference responses associated with any of the 7 affective states than would be expected. Adjusted *z*-score residual values for each of the 14 cells of the contingency table were used to calculate the Chi square statistic; in turn, a *p*-value was conducted for each cell. A comparison *p*-value of .0036 was established by dividing .05 by the number of cells (14) in the contingency table.

Later, a hierarchical linear regression analysis was conducted where participants' learning verification task confusion composite scores served as the independent variable of interest and their scores (total number of correct responses) on the learning verification task served as the dependent variable. Prior knowledge and verbal ability scores were entered in the model to control for their effects. Before conducting the hierarchical regression, the major assumptions associated with this statistical analysis were tested. It was determined that a sample size of 305 subjects was acceptable based upon the number of independent variables. The singularity assumption was also met since prior knowledge, verbal ability, and feeling of confusion were not a combination of other independent variables. Additionally, an examination of intercorrelations indicated that none of the independent variables were meaningfully correlated, and collinearity statistics (both Tolerance and VIF) further confirmed that the multicollinearity assumption was met. Residual and scatter plots showed that normality, linearity and homoscedasticity assumptions were reasonably satisfied.

In the first step of the regression analysis, prior knowledge score and verbal ability score were entered together into the model to control for their potential effects; then, in the second step, (learning verification task) confusion composite score, the proxy measure of feeling of confusion, was entered as the main independent variable of interest.

RQ2a) Do students have a preference for one of two types of confusion emotion concept knowledge that might be mentally activated in a school learning environment?

$H2a_0$**:** Students do not have a preference for one type of confusion emotion concept knowledge over another; there are no statistically significant differences in the agreement rating scores that students give for confusion threat concept knowledge compared to confusion challenge concept knowledge.

$H2a_a$**:** Students have a preference for one type of confusion emotion concept knowledge over the other; there are statistically significant differences in the agreement rating scores that students give for confusion threat concept knowledge compared to confusion challenge concept knowledge.

The first part of the second study hypothesis ($H2a_a$) was that students have acquired and act upon preferred concept knowledge about the learning-related emotion, confusion. The assertion here was that while students may be aware of more than one conceptual meaning and/or signaling function of confusion (e.g., disorientation vs. wonderment and/or threat signal vs, challenge signal), they are likely to have developed an nonconscious preference for one kind of confusion emotion concept knowledge over the other. Thus, posing this research question and evaluating the related hypothesis offered a way to explore and garner a more nuanced understanding of the kind of emotion concept knowledge surrounding confusion that is most cognitively accessible to students as they psychologically construct their feeling experiences of confusion in school learning environments.

Statistical Analysis.

Chi square tests of proportions, correlation, and t-test analyses were performed. Using participants' responses on the SES-Q, frequencies were generated for their threat concept knowledge agreement ratings and challenge concept knowledge agreement ratings to establish the proportion of participants who reported 'agree' and 'strongly agree', as well as 'disagree' and 'strongly disagree', for both types of confusion emotion concept knowledge. Additionally, a Pearson's correlation analysis and paired samples t-test were performed to determine, first, if there was a statistically significant correlation between participants' threat knowledge agreement ratings and their challenge knowledge agreement ratings, and then to evaluate if there were statistically significant differences between the agreement ratings that participants gave for the challenge concept knowledge statement versus the threat concept knowledge statement. These results helped to demonstrate that participants do have preferences for either threat emotion concept knowledge or challenge emotion concept knowledge.

RQ2b) Do most students have a global perception of confusion as challenging?

$H1_0$**:** A majority of students (90%) will report a global perception of the learning-related emotion, confusion, as challenging.

$H1_a$**:** A statistically significant majority (90%) of students will not report a global perception of the learning-related emotion, confusion, as challenging.

The work of D'Mello & Graesser (2011), which demonstrated a positive link between the epistemic emotion, confusion and complex problem-solving performance (for some participants in their sample), appears to tacitly espouse the classical view of emotion which argues in favor of the universal perception and experience of emotions. But if it is in fact the case that emotions are universal, in terms of how they are perceived and the functions they are believed to serve, then one might have expected to see a positive correlation between confusion and problem-solving performance for most, if not all participants in their sample—which was not the case. Therefore, it was hypothesized here that students have not only acquired preferences for different types of confusion emotion concept knowledge, but also that they have formed global perceptions of confusion that are consistent with their emotion concept knowledge preferences, and that the proportion of participants who have a global perception of confusion as challenging is likely to be significantly less that what might be expected, given the results of studies (e.g., D'Mello & Graesser, 2011) that appear to suggest a wholly facilitative benefit. Understanding students' global perceptions of confusion is important because they may ultimately use these perceptions as heuristic information as they construct their experience of confusion across different learning contexts in school as well as in other aspects of their daily lives.

Statistical Analysis.

A nonparametric one-sample binomial test was conducted to determine whether the proportion of participants who hold a global perception of confusion as challenging is greater than or equal to a theoretically expected proportion of 90% ($\alpha = .05$). This test was employed to evaluate potential differences between the observed proportion and a hypothesized expected proportion of participants (≥ 0.90) who reported their global perception of confusion as a challenge signal. Then, to further explore the potential genesis of participants' global perceptions of confusion as either a challenge signal or threat signal, two chi-square tests of association were performed to evaluate if students' preference for either of the two kinds of emotion concept knowledge about confusion (threat concept knowledge vs. challenge concept knowledge), as measured by their agreement with the defining features of each, was significantly associated with their global perception of confusion.

RQ3) Is there a relationship between students' confusion emotion concept knowledge preferences and their complex inferential reasoning performance?

$H3_0$**:** Students' confusion emotion concept knowledge preferences are not a statistically significant predictor of their complex inferential reasoning performance.

$H3_a$**:** Students' confusion emotion concept knowledge preferences are a statistically significant predictor of their complex inferential reasoning performance.

Statistical Analysis.

A 2-step hierarchical regression analysis was performed with participants' threat knowledge agreement ratings and challenge knowledge agreement ratings as the independent variables, and learning verification task score as the dependent variable. Prior knowledge and verbal ability were included to control for their potential effects. Before performing the analysis, the major assumptions of the statistical procedure were tested and all were met. An examination of intercorrelations indicated that neither of the independent variables of interest were significantly correlated, and collinearity statistics (both Tolerance and VIF) further confirmed that the multicollinearity assumption was met. Residual and scatter plots showed that normality, linearity and homoscedasticity assumptions were reasonably satisfied.

Subsequently, in the first step of the regression analysis, the two continuous independent variables, prior knowledge score and verbal ability score, were entered together into the model to control for their potential effects; then, in the second step, threat concept knowledge agreement rating and challenge concept knowledge agreement rating were entered as the main independent variables of interest.

RQ4) Is there a relationship between students' epistemological beliefs sophistication and their complex inferential reasoning performance?

$H4_0$**:** Students' epistemological beliefs about the nature of knowledge and learning is not a statistically significant predictor of their complex inferential reasoning performance.

$H4_a$**:** Students' epistemological beliefs about the nature of knowledge and learning is a statistically significant predictor of their complex inferential reasoning performance.

The researcher hypothesizes that students who demonstrate more sophisticated epistemological beliefs about the nature of knowledge and learning, as measured by the Wood-Kardash Epistemological Beliefs Survey (EBS) will also demonstrate more advanced inferential reasoning, as measured by scores on the learning verification task. Previous studies suggest that students with more sophisticated epistemological beliefs are less likely to rely on rote cognitive strategies when they encounter novel, complex learning activities, and are instead more likely to rely on higher order thinking strategies.

Statistical Analysis.

A hierarchical linear regression analysis was performed where epistemological beliefs composite scores served as the independent variable and scores on the learning verification task was the dependent variable. This hypothesis sought to explore whether participants' epistemological beliefs sophistication could account for variation in their complex inferential reasoning performance over and beyond prior knowledge and verbal ability. Before beginning the analysis, it was confirmed that the data met the principle assumptions associated with this statistical test: Linearity was checked using scatter plots; the Q-Q plot showed that normality was reasonable; a Durbin-Watson value of 1.53 suggests that the assumption of independence of errors was met; and an examination of residual plots confirmed no serious violation of homoscedasticity. In the first step of the regression analysis, the two continuous independent variables, prior knowledge score and verbal ability score, were entered together into the model to control for their potential effects; then, in the second step, epistemological beliefs score was entered as the independent variable of interest.

RQ5) Is the interaction between students' confusion emotion concept knowledge preferences and the sophistication of their epistemological beliefs about learning, controlling for the effects of prior knowledge, verbal ability, and feelings of confusion, a better predictor of their inferential reasoning performance than their feelings of confusion or emotion concept knowledge preferences and epistemological beliefs alone?

$H5_0$**:** The interaction between participants' emotion concept knowledge preferences and their epistemological beliefs sophistication is not a more statistically significant predictor of their inferential reasoning performance than their feelings of confusion or emotion concept knowledge preferences and epistemological beliefs alone.

H5$_a$**:** The interaction between participants' emotion concept knowledge preferences and epistemological beliefs sophistication is a more statistically significant predictor of their inferential reasoning performance than their feelings of confusion or emotion concept knowledge preferences and epistemological beliefs alone.

It has been previously hypothesized that there are relationships between students' inferential reasoning performance and their feeling experience of confusion, their emotion concept knowledge preferences, and their epistemological beliefs sophistication. Here, I primarily sought to consider if the relationship between students' reported feelings of confusion, as measured by their self-report learning verification task confusion scores, would be significantly diminished by the interaction between their confusion emotion concept knowledge preferences, as measured by SES-Q emotion concept knowledge agreement ratings, and the sophistication of their epistemological beliefs about learning, as measured by composite scores on the epistemological beliefs survey. The argument is that because the feeling of confusion is believed to be a constructed emotional state, when variables that are hypothesized to reflect the constitutive components of confusion (confusion emotion concept knowledge and epistemological beliefs) are modelled together, the interaction of the components will be a more significant predictor of inferential reasoning performance than any of the individual constitutive elements alone.

Statistical Analysis.

A hierarchical multiple regression analysis was performed with (learning verification task) confusion composite scores, challenge concept knowledge agreement rating scores, threat concept knowledge agreement rating scores, and epistemological beliefs composite scores as the independent variables, and learning verification task scores as the dependent variable. Prior to performing the analysis, the major assumptions were tested and all were reasonably met. Although an examination of intercorrelation statistics revealed significant correlations between several independent variables, the large sample size of the study helped to overcome serious problems with multicollinearity. An assessment of collinearity statistics showed tolerance values greater than .20 for all independent variables; Menard (1995) suggests .20 as the recommended minimum tolerance value, while Tabachnick & Fidell (2001) suggest .10, and Huber & Stephens (1993) have recommended .25. Additionally, VIF values for all independent variables were greater than 1.00, but less than 10 as suggested by both Menard (1995) and Tabachnick & Fidell (2001). Residual and scatter plots showed that normality, linearity and homoscedasticity assumptions were also satisfied. As an additional precaution, all independent variables were centered by subtracting each variable's mean from each individual observation associated with the respective variable.

Subsequently, in the first step of the regression analysis, prior knowledge score, verbal ability score, and (learning verification task) confusion score were entered into the model to control for their potential effects; in the second step, threat concept knowledge agreement rating, challenge concept knowledge agreement rating, and epistemological beliefs score were entered; and finally, in the last step, 2-way, and 3-way interaction terms for threat concept knowledge agreement rating, challenge concept knowledge agreement rating, and epistemological beliefs were entered.
Interaction effects were graphed to facilitate interpretation of the data.

This chapter has presented the details of the methodology used in the dissertation study. It described the participants, study instrumentation, research questions, and statistical analysis plan. The dissertation now turns to chapter 4 which presents the results.

CHAPTER 4

RESULTS

This chapter begins with a brief review of the study objectives and a restatement of the research questions. Subsequently, the chapter moves forward to present respondent demographics, the outcome of the emotion (confusion) manipulation procedures, and a description of participants' performance on the complex inferential reasoning task and re-activation of confusion. Next the chapter presents statistical evidence from the first study hypothesis which helps to establish the case for further investigating the psychological construction of confusion and its relationship to complex inferential reasoning performance; and finally, the chapter concludes by reporting the results of data analyses which address and support the remainder of the study's research questions and hypotheses. These findings pertain to the elements which are argued to be the psychological building blocks of learning-related confusion. The hypotheses and results are arranged and presented in a manner that is intended to sketch a path which logically connects several theoretical/conceptual elements to arrive at a cogent picture of how students psychologically construct their feelings of learning-related confusion, differences in these psychological constructions, and their relationship to complex inferential reasoning performance.

Study Objectives and Research Questions

As it has been previously described, the objective of the present study was to explore how students psychologically construct emotional experiences of learning-related confusion and the relationship between two potentially different confusion constructions and students' complex inferential reasoning performance. In exploring these different psychological constructions of confusion, this dissertation specifically sought to consider differences in confusion emotion concept knowledge, differences in the sophistication of students' epistemological beliefs about the nature of knowledge and learning, and differences in the degree to which students experience situational feelings of learning-related confusion. Through the use of several statistical techniques, the study sought to answer the following research questions: 1) Do students feel confused while completing complex reasoning task, and is there a relationship between these feelings and their complex inferential reasoning performance?; 2) Do students show a preference for one of two types of confusion emotion concept knowledge that might be mentally activated in a learning environment?; 3) Is there a relationship between students' confusion emotion concept knowledge preferences and their complex inferential reasoning performance?; 4) Is there a relationship between students' epistemological beliefs sophistication and their complex inferential reasoning performance?; and finally, 5) Is there an interaction between students' confusion emotion concept knowledge preferences and the sophistication of their epistemological beliefs about learning? The chapter continues below with a demographic characterization of study participants.

Response Rate and Demographic Data

Approximately 800 undergraduate students from 10 academic colleges were invited to participate in this IRB-approved study. After a 4-week recruitment period, 305 students enrolled in and completed the study. The study response rate was 38.1%. Enrolled participants represented at least 8 academic majors; an 'Other' major category and a STEM major category were created to combine majors where enrollment was low. Participants who completed the study (n=305), were fairly evenly spread across the first three years in college, with a few indicating they were in their fourth year and beyond. In terms of academic major, 29.8% were from education; 26.2% were from business/computer science; and 12.5% were from nursing. The remaining five academic major categories each contributed less than 10% to the participant total. Roughly 78% of participants identified as White or Caucasian, and 12 % identified as African American; the remaining participants represented other racial/ethnic groups. Seventy three percent of participants identified as female. Participant demographics are summarized in Table1 and summary of the major study variables is shown in Table 2.

Table 1

Demographics of the Sample of 305 College Students.

Demographic Factor	n	%	Demographic Factor	n	%
Year in College			**Gender**		
First Year	97	31.8	Other	2	.7
Second Year	100	32.8	Female	223	73.1
Third Year	71	23.3	Male	80	26.2
Fourth Year	26	8.5	**Race/Ethnicity/Citizenship**		
Fifth Year/Beyond	11	3.6	African-American	37	12.1
Major			Hispanic/Latino American	4	1.3
Education	91	29.8	White/Caucasian	238	78.0
Business/Computer Science	80	26.2	Asian-American	7	2.3
Psychology	9	3.0	Native American	1	.3
Human Development	29	9.5	Asian Native/Immigrant	6	2.0
Other	19	6.2	Hispanic/Latino Immigrant	1	.3
Stem	29	9.5	Other (Non-White) Race	6	2.0
Nursing	38	12.5	Other Ethnicity/Citizenship	5	1.6
Communications	10	3.3			

Table 2

Summary of Main Study Variables (n=305).

Variable	*M*	*SD*
Climate Change Prior Knowledge Test (PK) • 17-item measure of participants' existing knowledge about climate change	5.55	2.38
Verbal Ability Test (VA) • 40-item measure of participants' word comprehension	26.76	4.30
Feeling of Confusion-P: Text Passage Priming (FOC-P) • Self-report of participants' level of text passage comprehension; proxy measure for the level of confusion experienced during emotion priming. • Composite score derived from 3 ratings of comprehension using a 0 to 5-point scale. • Higher scores = greater comprehension and less feeling of confusion.	9.91	1.93
Feeling of Confusion-R: Learning Verification Task Reactivation (FOC-R) • Self-report of participants' level of text passage comprehension; proxy measure for the level of confusion experienced during learning verification task completion. • Composite score derived from 3 ratings of comprehension using a 0 to 5-point scale. • Higher scores = greater comprehension and less feeling of confusion.	9.24	2.61
Epistemological Beliefs Survey (EB) • 38-item measure of participants' knowledge and learning beliefs sophistication • 5-point Likert scaled used to rate agreement with statements. • Higher scores = more sophisticated beliefs	125.65	9.02
SES-Q: Confusion-Threat Concept Knowledge Preference (TK) • Agreement rating measure for confusion as threat statement using a 1 to 5-point Likert scale. • Higher scores= stronger preference.	2.34	1.34
SES-Q: Confusion Challenge Concept Knowledge Preference (CK) • Agreement rating measure for confusion as challenge statement using a 1 to 5-point Likert scale. • Higher scores= stronger preference	3.59	1.10
Learning Verification Task (LVT) • 9-item measure of participants' inferential reasoning performance	5.81	1.56

Experience of Confusion while Studying Complex Texts: Priming and Fidelity Check

To begin evaluating part one of the first study hypothesis ($H1_a$) regarding participants' experience of confusion while studying complex texts, and to confirm the effectiveness of the emotion manipulation procedure and intended affect dynamics described in the study methods, a frequency distribution was generated, along with descriptive statistics, which provided data about participants' experience of confusion. It was expected that participants would experience and report a particular pattern of affective information in the following manner: 1) more learning-related emotions than basic emotions (e.g., fear, anger) across all three text passages; 2) an increase in learning-related emotions with the core affective hallmark of moderate arousal and negative valence (e.g., frustration, confusion), compared to the emotions reported after the first text passage; and 3) a continuance of high rates of moderately arousing/negatively-valenced learning-related emotions after the third text passage, compared to the emotions reported after the second text passage. The confusion composite scores for participants observed during the priming manipulation ranged from a minimum of 1 point (very confused across all 3 passages), to a maximum of 15 points (not confused at all across all 3 passages), and the mean score was 9.91 (*SD*,1.94). Lower (priming) confusion composite scores reflect less understanding of the complex text passages and therefore higher confusion. The priming results for each passage are presented next.

Passage 1 Results. Frequency data revealed that after having read the first emotion priming text passage, the following emotion response rates were observed among participants: 3.9% fear, .7% anger, 4.2% boredom, 22.0% confusion, 32.4% enjoyment, 2.0% frustration, and 34.8% neutral. Compared to the basic emotion, fear, participants reported statistically significantly more of two learning-related emotions, confusion X^2 $(1, N = 305) = 44.25$, $p <$

.0001, and enjoyment X^2 (1, N = 305) = 83.24, p < .0001; and compared to the basic emotion, anger, participants also reported statistically significantly more of the learning-related emotions, confusion X^2 (1, N = 305) = 68.65, p < .0001, and enjoyment X^2 (1, N = 305) = 110.78, p < .0001.

Additionally, a one-way analysis of variance revealed that there were significant differences, F(6, 298)= 17.91, p< .001, in the self-reported level of text understanding across some of the emotion categories selected by participants. Subsequently, a Tukey HSD post-hoc analysis of pairwise comparisons was conducted. Results showed significant differences between the following emotion pairs: confusion and enjoyment; confusion and frustration; and confusion and neutral state. In each instance, participants who reported the affective state of confusion also reported significantly lower ratings of their text understanding compared to enjoyment (p<.001), frustration (p=.002), and neutral (p<.001) affective states. The difference in self-report ratings of text understanding ranged from .97 to 1.3 points lower for participants who reported feeling confused/experiencing a sense of not knowing. Means and Standard Deviations for passage 1 self-report of text understanding by emotion category are presented in Table 3.

Passage 2 Results. After having read the second emotion priming text passage, the following emotion response rates were observed among participants: 4.6% fear, 1.3% anger, 8.9% boredom, 42.3% confusion, 15.4% enjoyment, 4.9% frustration, and 22.6% neutral. Compared to the first text passage, there was a statistically significant increase in the rate of the moderately arousing/negatively-valenced learning-related emotion, confusion X^2 (1, N = 305) = 28.76, p < .0001; however, this was not the case for frustration, X^2 (1, N = 305) = 3.84, p =.05.

Additionally, a one-way analysis of variance revealed that, just as with passage 1, there were significant differences, F(6, 297)= 14.51, p< .001, in the self-reported level of text understanding across some of the emotion categories selected by participants. Subsequently, a Tukey HSD post-hoc analysis of pairwise comparisons was again conducted. Results showed significant differences between the same emotion pairs as those identified in passage 1: confusion and enjoyment; confusion and frustration; and confusion and neutral state. In each instance, participants who reported the affective state of confusion also reported significantly lower ratings of their text understanding compared to enjoyment (p<.001), frustration (p=.003), and neutral (p=.001) affective states. The difference in self-report ratings of text understanding ranged from .78 to 1.3 points lower for participants who reported feeling confused/experiencing a sense of not knowing. Means and Standard Deviations for passage 2 self-report of text understanding by emotion category are presented in Table 3.

Passage 3 Results. After having read the third emotion priming text passage, the following emotion response rates occurred: 2.6% anger, .3% fear, 7.9% boredom, 33.8% confusion, 19.3%, enjoyment, 4.6%, frustration, and 31.5% neutral. Here, the reported rate of the learning-related emotion, confusion, statistically significantly exceeded the rate observed after the first text passage, X^2 (1, N = 305) = 10.54, p = .0012 and second text passage, X^2 (2, N = 305) = 250.65, p < .001. However, while the observed rate of confusion after the third text passage was statistically significantly greater than the rate of enjoyment, X^2 (1, N = 305) = 16.42, p < .0001, there was a modest but statistically significant decline in the rate of confusion after the third text passage, X^2 (1, N = 305) = 4.67, p = .031.

Additionally, a one-way analysis of variance revealed that, just as with passages 1 and 2, there were significant differences, F(6, 298)= 14.49, p< .001, in the self-reported level of text understanding across some of the emotion categories selected by participants. Subsequently, a Tukey HSD post-hoc analysis of pairwise comparisons was conducted. Results showed significant differences between the following categories: confusion and enjoyment; and confusion and neutral state. In each instance, participants who reported the affective state of confusion also reported significantly lower ratings of their text understanding compared to enjoyment (p<.001) and neutral (p=.003) affective states. The difference in self-report ratings of text understanding ranged from .94 to 1.14 points lower for participants who reported feeling confused/experiencing a sense of not knowing. Means and Standard Deviations for passage 3 self-report of text understanding by emotion category are presented in Table 3.

Summary of Priming Manipulation. As expected, participants experienced more of two learning related emotions, confusion and enjoyment, compared to the basic emotions, anger and fear. Out of 915 total emotion reports made by participants, the difference between the percentage of confusion reports (32.7) and the percentage of enjoyment reports (22.4) was statistically significant, X^2 (1, N = 915) = 24.30, p < .0001. Most participants were likely to have experienced the expected affect dynamics (e.g., a general decline in text understanding over the three passages) in that there appeared to be a shift in the number of pleasant de/activating feelings reported after reading the first text passage, to an increase in the number of unpleasant activating feelings (which included confusion) reported after reading the second text passage. Further, the number of unpleasant activating feelings remained high after participants had read the third text passage.

In the same vein, there appeared to be consistency between participants' reported affective states and their self-reported levels of text understanding where, for example, those who reported feeling confused reported significantly lower levels of text understanding compared to participants who reported enjoyment or a neutral affective state. In general, participants' self-reported level of text understanding appeared to be a good indicator of the degree to which they experienced feelings of confusion; thus, the findings presented here suggest that the emotion priming manipulation was adequate for inducing a sense of not knowing among many participants. Frequency data are presented in Table 3.

Table 3

Frequencies of Emotion Feeling Responses and Mean Self-report Ratings of Text Understanding (n=305)

Emotion	Passage 1				Passage 2				Passage 3			
	n	%	*M*	*SD*	*n*	%	*M*	*SD*	*n*	%	*M*	*SD*
Fear	12	3.9	3.33	1.07	14	4.6	3.38	1.30	8	2.6	3.50	1.02
Anger	2	.7	3.00	.001	4	1.3	3.00	.816	1	.3	3.00	--
Boredom	13	4.2	3.11	.908	27	8.9	2.92	.974	24	7.9	2.82	.964
Confusion	67	22.0	2.92	.760	129	42.3	2.86	1.12	103	33.8	2.81	1.04
Enjoyment	99	32.4	4.25	.704	47	15.4	4.17	.620	59	19.3	3.96	.690
Frustration	6	2.0	4.17	.408	15	4.9	3.86	.864	14	4.6	3.47	1.06
Neutral	106	34.8	3.91	.784	69	22.6	3.64	.873	96	31.5	3.27	1.02

Evaluation of Participants' Prior Knowledge, Verbal Ability, Complex Inferential Reasoning Performance, and Re-activation of Confusion

Before proceeding with the results of the remaining analyses that pertain to the first hypothesis, it is necessary to present data related to participants' prior knowledge of climate change, their verbal ability, their learning verification task performance, and their (re)experiencing of confusion during the learning verification task. The inclusion of these results at this point in the chapter are essential because they provide the context or foundation for the remaining results. As indicated in the study methods, participants were evaluated for their prior knowledge of climate change and their verbal ability, as well as for their performance on the learning verification task and their emotional experience of confusion while completing the learning verification task. The mean score for each of these variables was determined by examining descriptive statistics, and the results are as follows: Mean PK score was 5.55 (*SD*, 2.38); mean VA score was 26.76 (*SD*, 4.30); mean LVT score was 5.81 (*SD*, 1.56), and the mean FOC-R score was 9.24 (*SD*, 2.61), with an observed ranged of 1 to 15 points. Lower confusion composite scores reflect less understanding of the complex text passages and therefore higher confusion.

An independent samples t-test revealed that there was a small but statistically significant difference between the feeling of confusion that participants reported experiencing during the priming manipulation and that which they reported experienced during the completion of the LVT, $t(304) = 3.67$, $p=.001$. In general, participants appeared to experience slightly less confusion (discontinuity in understanding) as they attempted to solve the LVT problems, compared to the confusion they experienced during the priming manipulation. However, this decrease was not meaningful in a practical sense, and the results suggest that confusion was sufficiently (re)activated. With the foregoing results in mind, the presentation of findings continues below with hypothesis $H1_b$.

Is there a relationship between students' learning-related feelings of confusion and their complex inferential reasoning performance?

The next part of the first study hypothesis ($H1_b$) was that there would be a statistically significant relationship between students' feelings of learning-related confusion and their complex inferential reasoning performance. As an initial step in evaluating this claim, a Chi square test of association was performed for each of the 9 items on the learning verification task to examine the relationship between participants' self-reported affective state and their success in being able to use complex reasoning to make judgements about the accuracy of a potential inference (e.g., yes, the inference is accurate; versus no, the inference is not accurate), based upon content from the complex text passages they had previously studied. For significant findings, a post hoc contingency table analysis (Beasley & Schumacker, 1995) using adjusted *z*-

scores for both yes and no responses was subsequently performed, with a significance test level of .0036. This level was calculated by dividing 0.5 by the number of cells (14) in the table.

The results of the analysis revealed that there was a statistically significant association between participants' self-reported affective state and their judgements of inference accuracy for 6 of the 9 learning verification task items as follows: Item number 1), X^2 (6, N = 305) = 34.11, p < .0001; Item number 2), X^2 (6, N = 305) = 46.74, p < .0001; Item number 3), X^2 (6, N = 305) = 37.65, p < .0001; Item number 4), X^2 (6, N = 305) = 36.58, p < .0001; Item number 8), X^2 (6, N = 305) = 39.77, p < .0001; and Item number 9), X^2 (6, N = 305) = 28.16, p < .0001. There was no significant association between affective state and judgement of inference accuracy for learning verification task item numbers 5, 6, and 7. The post hoc contingency table analysis showed that for the 6 significant task items described above, the association between participants' self-reported experience of confusion and their judgements of inference accuracy was the most statistically significant, compared to the associations between judgements of inference accuracy and fear, anger, boredeom, frustration, enjoyment and neutral affect states. Participants who reported the affective experience of confusion made a significantly greater number of 'No' judgements (the correct response) and a significantly lower number of 'Yes' judgements (the incorrect response) than would be expected, compared to the number of 'Yes' and 'No' judgements made by participants who reported any of the other affective states. Contingency table analysis data are presented in Table 4.

Table 4

Post hoc Contingency Table Analysis of the Association between Affective State and Learning Verification Task Inference Accuracy Judgement (n=305).

Affective State	Accuracy Judgement Response	LVT Question 1		LVT Question 2		LVT Question 3		LVT Question 4		LVT Question 8		LVT Question 9	
		X^2	p	X^2	p	X^2	p	X^2	p	X^2	p	X^2	p
Fear	YES	2.89	.823	.49	.998	.09	1.00	.81	.992	.01	1.00	1.00	.986
	NO	2.89	.823	.49	.998	.04	1.00	.81	.992	.01	1.00	1.00	.986
Anger	YES	.00	1.00	2.56	.862	1.69	.946	.25	1.00	.49	.998	.16	1.00
	NO	.00	1.00	2.56	.862	1.69	.946	.25	1.00	.49	.998	.16	1.00
Boredom	YES	.36	.999	.09	1.00	5.29	.507	11.56	.073	1.69	.946	2.89	.823
	NO	.36	.999	.09	1.00	4.84	.564	11.56	.073	1.69	.946	2.89	.823
Confusion	YES	31.36	.001*	38.44	.001*	29.16	.001*	30.25	.001*	32.49	.001*	22.09	.001*
	NO	31.36	.001*	38.44	.001*	27.04	.001*	30.25	.001*	33.64	.001*	22.09	.001*
Frustration	YES	1.44	.963	4.41	.621	.04	1.00	1.44	.963	.04	1.00	.04	1.00
	NO	1.44	.963	4.41	.621	.04	1.00	1.44	.963	.09	1.00	.04	1.00
Enjoyment	YES	.16	1.00	.01	1.00	.00	1.00	.04	1.00	3.24	.778	.09	1.00
	NO	.16	1.00	.01	1.00	.00	1.00	.04	1.00	3.24	.778	.09	1.00
Neutral	YES	10.24	.115	18.49	.005	12.25	.057	2.25	.895	7.29	.295	7.84	.250
	NO	10.24	.115	18.49	.005	11.56	.073	2.25	.895	8.41	.210	7.84	.250

Note: *p<.0036

Subsequently, to further evaluate the claim that there would be a significant relationship between the level of learning-related confusion and reasoning performance, a 2-step hierarchical regression analysis was performed. The results of the analysis first revealed that there was no statistically significant correlation between PK and LVT performance, or between VA and LVT performance; PA and VA made no significant contribution to the regression model, F (2,302) = 1.09, p= .337, accounting for less than 1% of the variation in LVT scores. This suggests that PA and VA were not significant predictors of LVT performance.

At the same time, there was a statistically significant moderately negative correlation between FOC-R and LVT score, r= -.419, p<.001, indicating that participants who reported greater understanding of the learning verification task questions (interpreted as being less confused), demonstrated diminished LVT performance (lower scores on the task); in contrast, participants who reported less understanding of the LVT questions (interpreted as being more confused), demonstrated higher LVT performance scores. Moreover, when FOC-R was added to the model, F (3,301) = 22.00, p < .001 (Cohen's f^2= .21), an additional 17.3% of the variation in LVT scores was explained, compared to the initial model, and this change in R^2 was significant, F (3,301) = 63.34, p < .001. The level of participants' confusion was demonstrated to be a better predictor of learning verification task performance than both prior knowledge of climate change and verbal ability, uniquely explaining more than 17% of the variation in learning verification task scores. Looking at the standardized beta coefficients in the second step of the model, the results showed that as participants' self-reported level of LVT understanding (β = .417) increased (e.g., less confused), their learning verification task performance scores decreased, when verbal ability and prior knowledge were held constant. This finding establishes that there is a meaningful relationship between students' feelings of learning-related confusion and their inferential reasoning performance, and that students' level of confusion was a stronger predictor of performance scores than verbal ability and prior knowledge. In general, the increase in confusion appeared to be positively related increases in reasoning performance. Intercorrelations for prior knowledge, verbal ability, learning verification task score, and feeling of confusion are presented in Table 5; regression statistics are presented in Table 6.

Table 5

Intercorrelations for Prior Knowledge, Verbal Ability, Feeling of Confusion, and Learning Verification Task

Variable	PK	VA	FOC-R	LVT
Prior Knowledge	--	.293	.068	-.006
Verbal Ability	.293	--	.068	-.076
Feeling of Confusion	.068	.068	--	-.419*
Learning Verification Task	-.006	-.076	-.419*	--

Note, n= 305; * p < .001

Table 6

Summary of Hierarchical Regression Analysis of Feeling of Confusion as a Predictor of Inferential Reasoning Performance (n=305).

Variable	*B*	*SE B*	β	*t*	*R*	R^2	ΔR^2
Step 1					.085	.007	.007
Prior Knowledge	.034	.039	.053	.877			
Verbal Ability	.019	.022	.053	.880			
Step 2					.424	.180	.173*
Prior Knowledge	.039	.036	.060	1.097			
Verbal Ability	.007	.020	.019	.349			
Feeling of Confusion	-.249	.031	-.417	-7.959*			

Note, n= 305; *p< .001

Do students show a preference for one of two types of confusion emotion concept knowledge that might be mentally activated in an academic environment?

The first part of the second study hypothesis ($H2a_a$) was that students have nonconscious preferred conceptual understandings of the learning-related emotion, confusion. The results of the frequency analysis revealed that a combined 63.6% (n=194) of participants disagreed or strongly disagreed with threat concept knowledge of confusion, while only a combined 31.5% (n=96) of participants agreed or strongly agreed with threat concept knowledge. In contrast, a combined 63.3% (193) of participants agreed or strongly agreed with challenge concept knowledge of confusion, while a combined 22.3 % (n=68) of participants disagreed or strongly disagreed with challenge concept knowledge.

As for the correlation and paired samples test, the results of the respective analyses showed that there was a statistically significant, strongly negative correlation, $r(305) = -.797$, between the agreement ratings for the two types of emotion concept knowledge, and that there was a statistically significant difference, $t(304) = -9.447$, $p < .001$, between the Mean of participants' threat concept knowledge agreement ratings, M=2.34 (*SD*, 1.338), and challenge concept knowledge agreement ratings, M=3.59 (*SD*, 1.103). These findings suggest that participants who have a strong preference (e.g., high agreement ratings) for one kind of concept knowledge are likely to have a weak or non-preference (e.g., low agreement ratings) for the other kind of concept knowledge. Frequency data are presented in Table 7 and Table 8.

Table 7

Frequencies of Challenge Concept Knowledge Agreement (n=305)

	n	%
Strongly Disagree	116	38.0
Disagree	78	25.6
Somewhat Agree/Somewhat Disagree	15	4.9
Agree	83	27.2
Strongly Agree	13	4.3

Table 8

Frequencies of Challenge Concept Knowledge Agreement (n=305)

	n	%
Strongly Disagree	8	2.6
Disagree	60	19.7
Somewhat Agree/Somewhat Disagree	44	14.4
Agree	129	42.3
Strongly Agree	64	21.0

As a secondary aspect of the preceding hypothesis, ($H2b_a$), two additional analyses were performed. A non-parametric one-sample binomial test was first performed to establish that students may have a global perception of confusion as either challenging or threatening; then two chi-square tests of association were performed to evaluate the relationship between participants' emotion concept knowledge agreement ratings (for both threat and challenge knowledge) and their global perception of confusion. The results of the binomial test revealed that the observed proportion of students in the challenge group was 0.60; this was statistically significantly lower than the hypothesized proportion of students (≥ 0.90) expected to report confusion as a challenge signal ($p < .001$).

The chi square analyses revealed that there are statistically significant relationships between global perceptions of confusion and both threat concept knowledge agreement, X^2 (2, N = 305) = 250.65, p < .001 as well as challenge concept knowledge agreement, X^2 (2, N = 305) = 283.86, p < .001. Participants who had higher agreement with confusion emotion concept knowledge as threatening were more likely to have had a global perception of confusion as a threat signal; and conversely, students who had higher agreement with confusion emotion concept knowledge as challenging were more likely to have had a global perception of confusion as a challenge signal. Additionally, there were differences in the feeling of confusion (FOC-R) observed for participants who reported a global perception of confusion as threatening (M=10.82, SD=2.30), compared to those who reported a global perception as challenging (M=8.34, SD=2.34), and these differences were statistically significant, F (1, 301) = 80.40, p< .001.

Is there a relationship between students' confusion emotion concept knowledge preferences and their complex inferential reasoning performance?

The third study hypothesis ($H3_a$) was that there is a statistically significant predictive relationship between students' emotion concept knowledge preferences and their complex inferential reasoning performance, controlling for the effect of their prior knowledge about climate change and verbal ability. The results of the analysis first revealed that there was no statistically significant correlation between prior knowledge and LVT performance, or between verbal ability and LVT performance. However, there was a statistically significant strongly negative correlation between threat concept knowledge agreement and LVT scores, r= -.741, p<.001, and a statistically significant moderately positive correlation between challenge concept knowledge agreement and LVT scores, r= .689, p<.001. These correlations indicated that as participants' challenge knowledge agreement increased, their LVT scores also increased; in contrast, as participants' threat knowledge agreement increased, their LVT scores decreased.

Intercorrelations for prior knowledge, verbal ability, threat concept knowledge agreement, challenge concept knowledge agreement, and LVT score are presented in Table 9.

Table 9

Intercorrelations for Prior Knowledge, Verbal Ability, Threat Concept Knowledge, Challenge Concept Knowledge, and Learning Verification Task.

Variable	Prior Knowledge	Verbal Ability	Threat Concept Knowledge	Challenge Concept Knowledge	Learning Verification Task
Prior Knowledge	--	.293	.028	-.009	.068
Verbal Ability	.293	--	.119	-.086	.068
Threat Concept Knowledge	.028	.116	--	-.797*	-.741*
Challenge Concept Knowledge	-.009	-.086	-.797*	--	.689*
Learning Verification Task	.068	.068	-.741	.689	--

Note, n= 305; * $p < .001$

Subsequently, the hierarchical regression analysis revealed that at the first stage, prior knowledge and verbal ability made no significant contribution to the regression model, $F(2, 302) = 1.09$, $p = .337$, accounting for less than 1% of the variation in LVT scores. This suggests that prior knowledge and verbal ability again were not significant predictors of inferential reasoning performance. However, threat concept knowledge agreement and challenge concept knowledge agreement together made a significant contribution, $F(4, 300)=112.67$, $p<.001$, (Cohen's $f^2 =$ 1.48). When these variables were added to the model, an additional 59.3% of the variation in LVT scores was explained, and this change in R^2 was significant, F (2, 300) = 222.65, $p < .001$. An examination of the standardized betas showed that, when verbal ability and prior knowledge were held constant, as participants' threat knowledge agreement ratings increased ($\beta = -.547$), their learning verification task performance scores decreased; but when challenge knowledge agreement ratings increased (β = .265), learning verification task scores increased. This suggests that while threat concept knowledge and challenge concept knowledge together appear to be important predictors of complex inferential reasoning performance, uniquely explaining approximately 60% of the variation in LVT scores, students' level of threat knowledge agreement is a stronger predictor of reasoning performance scores. Regression statistics are shown in Table 10.

Table 10

Summary of Hierarchical Regression Analysis for Threat Concept Knowledge and Challenge Concept Knowledge as Predictors of Learning Verification Task Performance (n=305).

Variable	*B*	*SE B*	β	*t*	*R*	R^2	ΔR^2
Step 1					.085	.007	.007
Prior Knowledge	.034	.039	.053	.877			
Verbal Ability	.019	.022	.053	.880			
Step 2					.775	.600	.593
Prior Knowledge	.029	.025	.044	1.157			
Verbal Ability	.051	.014	.142	3.684			
Threat Knowledge Agreement	-.636	.071	-.547	-9.015*			
Challenge Knowledge Agreement	.374	.085	.265	4.382*			

Note, n= 305; *p<.001

Is there a relationship between students' epistemological beliefs sophistication and their complex inferential reasoning performance?

The fourth study hypothesis ($H4_a$) was that there is a predictive relationship between the sophistication of students' epistemological beliefs about the nature of knowledge and learning and their inferential reasoning performance. Participants completed the epistemological beliefs survey and the mean score was 125.65 (*SD*= 9.02), where higher scores indicated greater sophistication of learning beliefs.

The results of the analysis revealed first that there was no statistically significant correlation between prior knowledge and LVT performance, or between verbal ability and LVT performance. However, there was a statistically significant moderately positive correlation between epistemological beliefs and LVT score, $r = .622$, $p < .001$. These correlations indicate that as the sophistication of participants' epistemological beliefs increased, their learning verification task scores were also likely to increase.

Subsequently, the hierarchical multiple regression analysis revealed that at the first stage, prior knowledge and verbal ability made no significant contribution to the regression model, F (2, 302) = 1.09, $p = .337$, accounting for less than 1% of the variation in LVT scores. This suggests that prior knowledge and verbal ability were again not significant predictors of LVT performance. However, epistemological beliefs made a significant contribution, $F(3, 301) = 66.19$, $p < .001$, (Cohen's $f^2 = 1.48$). When this variable was added to the model, an additional 39% of the variation in learning verification scores was explained, and this change in R^2 was significant, F (1, 301) = 194.98, $p < .001$. Epistemological beliefs uniquely explained nearly 40% of the variation in learning verification task scores; an examination of standardized beta coefficients indicated that as participants' epistemological beliefs sophistication increased ($\beta = .625$), their reasoning performance scores increased, when verbal ability and prior knowledge were held constant. Intercorrelations for prior knowledge, verbal ability, epistemological beliefs, and learning verification task score are presented in Table 11 and regression statistics are shown in Table 12.

Table 11

Intercorrelations for Prior Knowledge, Verbal Ability, Epistemological Beliefs about Knowledge and Learning, and Learning Verification Task.

Variable	Prior Knowledge	Verbal Ability	Epistemological Beliefs	Learning Verification Task
Prior Knowledge	--	.293	.002	.068
Verbal Ability	.293	--	-.041	.068
Epistemological Beliefs	.002	-.041	--	.622*
Learning Verification Task	.068	.068	.622*	--

Note, n= 305; *Correlation is significant at the 0.01 level (2-tailed).

Table 12

Summary of Hierarchical Regression Analysis for Epistemological Beliefs as a Predictor of Inferential Reasoning Performance (n=305).

Variable	B	SE B	β	t	R	R^2	ΔR^2
Step 1					.085	.007	.007
Prior Knowledge	.034	.039	.053	.877			
Verbal Ability	.019	.022	.053	.880			
Step 2					.775	.600	.593
Prior Knowledge	.028	.031	.043	.918			
Verbal Ability	.029	.017	.082	1.740			
Epistemological Beliefs	.108	.008	.625	13.964*			

Note, n= 305; *p < .001

Is there an interaction between students' confusion emotion concept knowledge preferences and their epistemological beliefs?

While the results of the analyses associated with hypotheses $H1_b$, H3, and H4 demonstrated that participants' feeling of confusion, emotion concept knowledge preferences, and epistemological beliefs sophistication were statistically significant predictors of LVT scores, the fifth and final study hypothesis ($H5_a$) was that there is an interaction between students' confusion emotion concept knowledge preferences and their epistemological beliefs about the nature of knowledge and learning, such that the addition of this interaction will statistically significantly improve the explained variation in learning verification scores, controlling for prior knowledge, verbal ability, and feeling of confusion.

The results of the analysis first revealed that there was no statistically significant correlation between prior knowledge and LVT performance, or between verbal ability and LVT performance. However, just as expected, given the results of previously discussed regression analyses, there were statistically significant correlations between confusion and learning verification task scores, $r= -.419$, $p<.001$; between threat concept knowledge agreement and learning verification task scores, $r= -.741$, $p<.001$; between challenge concept knowledge and learning verification task scores, $r= .689$, $p<.001$, and between epistemological beliefs and learning verification task scores, $r= .622$, $p<.001$. Likewise, there were also statistically significant correlations between learning verification task scores and each of the two-way and three-way interaction terms. Intercorrelations for prior knowledge, verbal ability, threat concept knowledge agreement, challenge concept knowledge agreement, and learning verification task score are presented in Table 13.

Table 13

Simple Intercorrelations and Semi-partial Correlations for Learning Verification Task, Prior Knowledge, Verbal Ability, Feeling of Confusion, Threat Knowledge, Challenge Knowledge, and Epistemological Beliefs (n=305).

Variable	LVT	PK	VA	FOC	CHALL	THREAT	EPIB	CHALL-THREAT	EPIB CHALL	EPIB THREAT	EPIB* CHALL* THREAT
Learning Verification Task	--	.068	.068	-.419*	.689*	-.741*	.622*	.419*	-.288*	.315*	-.427*
Prior Knowledge	.068	---	.293	-.006	-.009	.028	.002	.019	.008	-.013	-.006
Verbal Ability	.068	.293	--	-.076	-.086	.116	-.041	-.184	.122	-.132	.098
Feeling of Confusion	-.419*	-.006	-.076	--	-.390*	.430*	-.298*	-.179*	.059	-.159*	.186*
Challenge Knowledge	.689*	-.009	-.086	-.390*	---	-.797*	.651*	.528*	-.336*	.367*	-.622*
Threat Knowledge	-.741*	.028	.116	.430*	-.797*	--	-.675*	-.518*	.357*	-.428*	.608*
Epistemological Beliefs	.622*	.002	-.041	-.298*	.651*	-.675*	--	.392*	-.434*	.534*	-.745*
Challenge Knowledge* Threat Knowledge	.419*	.019	-.184	-.179*	.528*	-.518*	.392*	--	.455*	-.495*	-.575*
Epistemological Beliefs* Challenge Knowledge	-.288*	.008	.122	.059	-.336*	.357*	-.434*	.455*	---	-.776*	.679*
Epistemological Beliefs* Threat Knowledge	.315*	-.013	-.132	-.159*	.367*	-.428*	.534*	-.495*	-.776*	--	-.665*
Epistemological Beliefs* Challenge knowledge* Threat Knowledge	-.427*	-.006	.098	.186*	-.622*	.608*	-.745*	-.575*	.679*	-.665*	--

n=305; *p<.001

Subsequently, the hierarchical multiple regression analysis revealed that the first model was a statistically significant predictor of learning verification task scores, $F(3, 301) = 22.00$ $p < .001$, (Cohen's $f^2 = .21$), with feeling of confusion making a statistically significant contribution as confirmed by standardized beta values. The change in R^2 was .180, which was statistically significant, $F(3, 301) = 21.99$, $p < .001$, indicating that the model was able to account for approximately 18% of the variation in learning verification task scores. Prior knowledge and verbal ability made no significant contribution to the model. An examination of standardized beta coefficients revealed that as participants' self-reported task understanding (e.g., less confused) increased ($\beta = .417$), learning verification task scores decreased. In general, an increase in confusion appeared to cause increases in reasoning performance.

The second model, which included threat concept knowledge agreement rating, challenge concept knowledge agreement rating, and epistemological beliefs score, was also a statistically significant predictor of learning verification task scores, $F(6, 298) = 81.49$, $p < .001$. The R^2 was .621, (Cohen's $f^2 = 1.08$), indicating that the model was able to account for 62.1% of the variation in learning verification task scores. The change in R^2 was .442, indicating that the model was able to account for approximately 44.2% more of the variation in learning verification task scores than the first model; this change was statistically significant, $F(3, 298)=115.82$, $p < .001$. As with the first model, prior knowledge of climate change and verbal ability made no meaningful contribution.

An assessment of standardized beta values showed that threat concept knowledge, epistemological beliefs, challenge concept knowledge, and feeling of confusion were all statistically significant predictors in the model, with epistemological beliefs [(t(304)=3.430, p<.001] and challenge concept knowledge [t(304)=3.28, p<.001] contributing the most toward explaining the variation in learning verification task scores, followed by the feeling of confusion and threat concept knowledge. As participants reported greater understanding (β =.089) —or less confusion, their learning verification scores decreased, and as their threat concept knowledge agreement increased (β =.442), performance scores also decreased. In contrast, as participants' challenge concept knowledge agreement increased (β =.201), performance scores increased, and as epistemological beliefs sophistication increased (β =.172), performance scores also increased.

Finally, the third model, which included threat concept knowledge agreement rating, challenge concept knowledge agreement rating, epistemological beliefs score, and their 2-way and 3-way interactions (threat concept knowledge x challenge concept knowledge; threat concept knowledge x epistemological beliefs; challenge concept knowledge x epistemological beliefs; and threat concept knowledge x challenge concept knowledge x epistemological beliefs) was also shown to be a statistically significant predictor of learning verification task scores. It was the most superior of the three models, explaining 66.5% of the variation in learning verification task scores, $F(10, 294)=58.48$, $p<.001$, (Cohen's $f^2 = 1.92$). The R^2 change of 4.44% over model 2 was relatively small, but nevertheless statistically significant, $F(4, 294)=9.70$, $p<.001$. Additionally, neither feelings of confusion, nor the two-way interaction between epistemological beliefs and threat concept knowledge agreement made significant contributions to the model.

In terms of evaluating variable contributions, regression statistics revealed that prior knowledge of climate change and verbal ability made no meaningful contribution to the model. In contrast, challenge concept knowledge alone [$t(304)=3.93$, $p<.001$], threat concept knowledge alone [$t(304)$, 7.11, $p<.001$], and epistemological beliefs alone [$t(304)=6.30$, $p<.001$] all made significant contributions. An examination of the standardized beta values for these variables revealed that, when holding verbal ability and prior knowledge constant, as participants' challenge concept knowledge agreement increased (*β* =.239), their learning verification task performance scores increased, and as their epistemological beliefs sophistication increased (*β* =.370), performance scores also increased; but as threat concept knowledge agreement increased (*β* =.443), performance scores decreased. Here threat concept knowledge agreement appears to be the strongest predictor of reasoning performance scores.

Likewise the two-way interaction between challenge concept knowledge and threat concept knowledge [$t(304)=2.26$, $p<.001$] and between challenge concept knowledge and epistemological beliefs [t(304)=2.95, p<.001], made significant contributions to the model, as did the three-way interaction between challenge concept knowledge, threat concept knowledge, and epistemological beliefs [$t(304)=5.88$, $p<.001$], as was hypothesized. The interaction between threat concept knowledge and epistemological beliefs did not make a significant contribution. An examination of the standardized beta coefficients for these interactions suggests that, when verbal ability and prior knowledge were held constant, the two-way interaction between challenge concept knowledge agreement and threat concept knowledge (*β* =.103), and the three-way interaction between challenge concept knowledge agreement, threat concept knowledge agreement, and epistemological beliefs sophistication (*β* =.398) yielded increases in participants' reasoning performance scores. However, the interaction between challenge concept knowledge agreement and epistemological beliefs (*β* =.176) yielded a decrease in participants' performance scores. As with previous analyses, the increase in confusion appeared to cause increases in reasoning performance.

These findings suggest a complex relationship between emotion concept knowledge preferences and epistemological beliefs sophistication. Learning verification task scores appeared to be highest for participants who reported low threat knowledge agreement, highly sophisticated epistemological beliefs, and moderate to high challenge knowledge agreement. The second highest learning verification task scores were demonstrated for participants who reported low threat knowledge agreement, less sophisticated epistemological beliefs, and high challenge knowledge agreement; and similar learning verification task scores were demonstrated for participants who reported high threat knowledge agreement, highly sophisticated epistemological beliefs, and high challenge knowledge agreement. The lowest learning verification task scores were found among participants who reported high threat knowledge agreement, less sophisticated epistemological beliefs, and low challenge knowledge agreement. Nevertheless, in spite of the complex interactions in this third model, it should be noted that participants' feelings of confusion no longer made a significant contribution when the two-way and three-way interactions between challenge concept knowledge agreement, threat concept knowledge agreement, and epistemological beliefs were added. Interaction effects are presented in Figure 1 and regression statistics are shown in Table 14.

Figure 1:

Three-way Interaction effects of Challenge-Knowledge Agreement, Threat-Knowledge Agreement, and Epistemological Beliefs Sophistication on Learning Verification Task Scores (n=305).

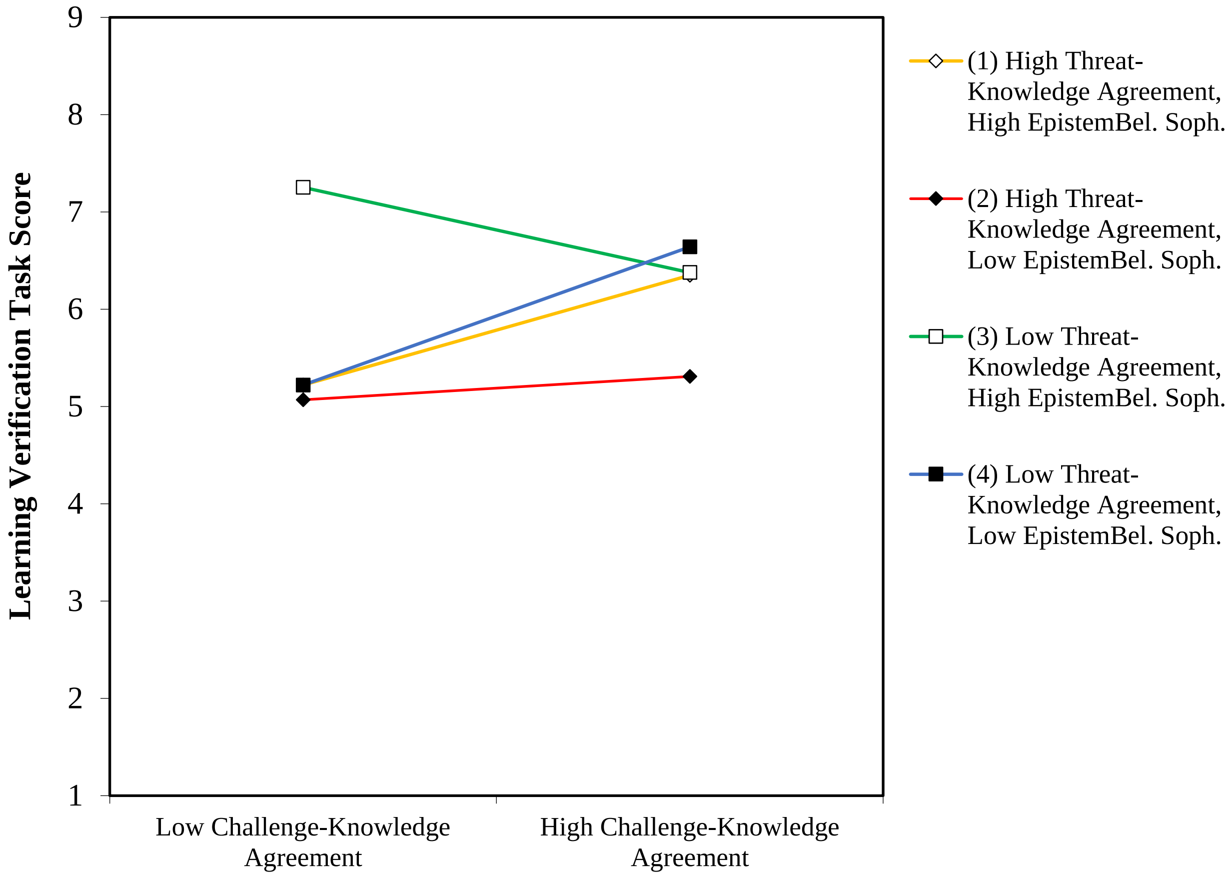


Table 14

Summary of Hierarchical Regression Analysis for Variables Predicting Inferential Reasoning Performance (n=305).

	Step 1 (Model 1)				Step 2 (Model 2)				Step (Model 3)			
Variable	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*
Prior Knowledge	.039	.036	.060	1.097	.029	.024	.045	1.205	.029	.023	.044	1.251
Verbal Ability	.007	.020	.019	.349	.045	.014	.124	3.267	.047	.013	.129	3.536
Feeling of Confusion	-.249	.031	-.417	-7.959*	-.053	.024	-.089	-2.230*	-.043	.023	-.071	-1.853
Challenge Concept Knowledge					.284	.087	.201	3.280*	.338	.086	.239	3.931*
Threat Concept Knowledge					-.514	.075	-.442	-6.834*	-.515	.072	-.443	-7.108*
Epistemological Beliefs					.030	.009	.172	3.430*	.064	.010	.370	6.300*
Challenge Knowledge* Threat Knowledge									.131	.058	.103	2.264*
Epistemological Beliefs* Challenge Knowledge									-.030	.010	-.176	-2.949*
Epistemological Beliefs* Threat Knowledge									-.010	.008	-.072	-1.244
Epistemological Beliefs* Challenge knowledge* Threat Knowledge									.032	.006	.398	5.877*
R^2	.180				.621				.660			
R^2 change	.180				.442				.044			
F for change in R^2	22.00*				115.82*				9.70*			

*$p < .001$.

Summary

It was the goal of the preceding chapter to review the study questions and hypotheses, and in turn present the analytical results of the dissertation study. The study hypotheses were largely supported by the analytical findings and begin to paint a provocative picture of how students may psychologically construct their emotional experiences of learning-related confusion, as well as how different constructions of confusion might be related to complex inferential reasoning. The dissertation continues next with a discussion of the study's findings, implications, limitations, and thoughts on potential directions for future research.

CHAPTER 5

DISSCUSION

The Quagmire that is Confusion

Dictionaries offer several definitions for the word quagmire; however, there is one representation which seems particularly suitable for application to confusion. The study of confusion as a learning-related emotion is a quagmire in the sense that it necessarily involves delving psychologically into “an area of miry or boggy ground whose surface may yield under tread” (Dictionary.com; Unabridged, 2016). This is true especially given the discomfort and resistance that is frequently provoked by mere mention of the word confusion. Moreover, this quagmire is intensified in light of evidence which implicates confusion as an affective state that may actually be a precursor to deepened cognitive processing (Muis et al, 2015) and that may also facilitate successful complex inferential reasoning performance and meaningful learning (D’Mello & Graesser, 2014). Cast in these terms, it seems clear that more research is needed about the nature and utility of confusion, including its underlying mechanisms of action and any factors that may potentially shape not only students’ understanding of its meaning and function, but also their behavioral responses to the affective feeling experience. It was the goal of this dissertation study, as it has been presented in the foregoing chapters, to add to the literature in this regard.

A Brief Methodological Recapitulation

The major hypothesis put forth in this work is that while the epistemic emotion, confusion, might be able to promote positive change in students' level of cognitive processing such that their complex inferential reasoning and problem-solving performance are in turn improved, there could actually be differences in how students psychologically construct their perceptions of the meaning and function of confusion, leading it to be an affective state that, for some, is debilitative rather than facilitative for performance. The study used an observational research design with an experimental manipulation, in conjunction with hierarchical regression analyses as the primary method of statistical testing, to demonstrate that there are relationships between two different psychological constructions of confusion and students' complex inferential reasoning performance; additionally, the study considered confusion emotion concept knowledge preferences and epistemological beliefs as two constitutive elements of students' perceptions of confusion.

In regard to the experimental manipulation, it should be noted that while participants' experience of confusion may have varied across the three complex text passages or perhaps was never evoked, the general goal of the manipulation procedure was to confirm that the complex text passages were at all able to induce confusion and that there was an overall decrease in the global levels of self-reported understanding across the three text passages. Moreover, the self-report measure of text understanding served as a proxy for the degree to which participants experienced the feeling of confusion such that it is not unreasonable to infer that a participant who reported a high level of text understanding is likely to have experienced a low degree of confusion (if any).

Summary of Major Findings

While the statistical analyses for the vast majority of the study's research questions and hypotheses yielded significant results, there are four overarching findings which encapsulate the essence of this investigation. First, students do indeed feel confused during the performance of complex reasoning tasks; second, students' feelings of confusion are related to their complex inferential reasoning performance; third, students' confusion emotion concept knowledge preferences are related to their complex inferential reasoning performance**;** and fourth, epistemological beliefs about the nature of knowledge learning and emotion concept knowledge preferences appear to be constitutive elements in students' psychological construction of confusion, and the interaction between these elements is related to their complex reasoning performance.

The final point above is of particular interest because a primary purpose of the dissertation study was to show that students' learning-related confusion is a psychologically constructed affective phenomenon. This means that while students may experience the feeling of confusion as a unified emotion, there are in fact underlying components which together create or constitute their emotional experience. Barrett (2017) suggests that the elements of emotion construction include physiological phenomena (e.g., core affect) as well as beliefs/cognition, and memories. In the present study, it was hypothesized that students' epistemological beliefs sophistication and their preferences for challenge or threat emotion concept knowledge are two constitutive elements in their psychological construction of confusion. This was demonstrated in the results of the fifth study hypothesis (H5) where the feeling of confusion—shown in an earlier analysis to be a significant predictor of inferential reasoning performance—became insignificant when epistemological beliefs and emotion concept knowledge preferences were added to the regression model. In general, increases in the feeling of confusion appeared to be positively related to increases in reasoning performance. Each of these constitutive elements was shown to have uniquely significant predictive power for inferential reasoning performance beyond that of the feeling of confusion; however, the interaction between these factors further strengthened their relationship to participants' reasoning performance. The next section elaborates further on each of the findings identified above.

The Essence of the Investigation

Students feel confused during the performance of complex reasoning tasks.

There is little question that human beings are cognitive misers. We use heuristics and any number of strategies to efficiently simplify the mental route to understanding and reduce our need for effortful processing (Aronson, 2008); and today's technology-rich culture has made it both attractive and easy to become habituated to this cognitive state of affairs (Fiske & Taylor, 2013). But the world is far from simple, and although we have become highly adept at superficial thinking and rote learning, there is nevertheless a need to be able to solve complex problems and use inferential reasoning to draw valid conclusions, even when information is unclear or not straightforward. Unfortunately (for some), the route along which such complex reasoning often travels has, as its gateway, the affective experience of confusion. In fact, Graesser & D'Mello (2012a, 2012b) argue that impasses in understanding are often accompanied by the feeling of confusion; yet this moderately arousing and highly displeasing affective state, argued in the present dissertation study to be a signpost for cognitive disequilibrium, appears to promote a deepening of cognitive processing, even if only to restore cognitive balance. Here, the specific reason for the change in level of cognitive processing is relatively inconsequential, since the result of this deepening is likely to be growth in conceptual understanding and an increase in meaningful learning.

In the present investigation, the data reveal that while participants reported experiencing emotions across seven affective categories, the most prevalently reported emotions were epistemic in nature, defined by Pekrun (2011) as those which occur in tandem or conjunction with cognitive processing effort, as opposed to what Ekman (1992) and Izard (2007) have called basic emotions, such as fear and anger. For example, of the 915 total emotion reports that participants made across the reading of the three complex text passages, 32.7% were confusion reports, while 22.4% were enjoyment reports. Yet beyond the significant differences between confusion and enjoyment reports presented in the results, what is particularly impressive about this finding is that participants were never shown any of the classical emotion labels (e.g, the words 'confusion' or 'fear'). Instead, they used a modified form of Yik et al's (2011) affect circumplex which required them to characterize their core affective states using adjective substitutes because Barrett (2004, 2005) has cautioned that the use of common emotion labels in self-report measures may inject a degree of bias. Thus, it is appropriate to suggest that participants' emotion reports were reasonably accurate, and that students do indeed experience feelings of confusion in the context of complex reasoning tasks.

Students' feelings of confusion are related to their complex reasoning performance.

Researchers have long argued that complex inferential reasoning and scientific thinking are crucial skills that people must master in order to navigate life's varied experiential terrain (Zimmerman, 2005). For this reason, much effort has been expended on studying the cognitive factors and identifying interventions to improve inferential reasoning and problem-solving performance, particularly since our capacity for such deep processing does not necessarily mean that it develops unaided (Zimmerman, 2005). At the same time, evidence suggests there is an affective component involved in complex thinking, including the epistemic, learning-related emotion confusion (Dewey, 1910; Pauli, 1960; Lipson, 1990, 1992; Pekrun, 2011; D'Mello & Graesser, 2011; Muis et al, 2015).

To-date however, in comparison to studies which attend heavily to cognitive and/or individual traits and dispositions as the explanatory source of differences in complex reasoning performance, there are a relative few which have investigated the role of confusion in complex inferential performance (D'Mello & Graesser, 2011, 2012, 2014; Muis et al, 2015), and even fewer—if any—that have sought to understand the mechanisms of action that explain confusions purported benefit. For example, in a series of studies which tracked the dynamic path of affective states experienced by a sample of college students during a complex learning task, D'Mello & Graesser (2011) identified 6 affective states (flow, boredom, confusion, frustration, and delight) which were statistically significantly related to students' successful task performance, and they noted that confusion appeared to produce the greatest learning gains.

Likewise, the findings from the hierarchical regression analysis associated with hypothesis H1 in the present study revealed that nearly 20% of the difference in participants' inferential reasoning performance scores was related to their feelings of confusion, measured by proxy as how well they understood the learning task. Specifically, participants who reported lower levels of understanding (and thus higher levels of confusion), achieved significantly better scores than participants who reported higher levels of understanding (and thus lower levels of confusion). Yet while this result is consistent with the findings described by D'Mello & Graesser (2011), the present study goes a step further by seeking to understand the mechanism of action that accounted for the benefit associated with confusion, where D'Mello & Graesser (2011) did not make a similar effort. This leads to the next finding.

Students' confusion emotion concept knowledge preferences are related to their inferential reasoning performance.

Although the results of the present study do strengthen the general argument that there is a facilitative benefit of learning-related confusion, the study also demonstrates that this benefit appears to be related to differences in the kind of emotion concept knowledge that is most perceptually salient for students. Far from obvious (and perhaps far from our conscious awareness), people know something about emotions as concepts. Indeed, regardless of whether we have acquired such knowledge through intentional instruction or passive learning, we possess conceptual knowledge about what it means to feel happy, to feel afraid, and even to feel confused; and we use this knowledge in myriad situations as a predictive signal to not only help us make sense of our physiological states, but also to afford us with anticipatory insight about whether something good or bad is currently happening or will happen, and what actions—mental and/or physical—will produce the best outcomes or lead to a desired goal.

But emotion concept knowledge is not static or universal (Barrett, 2017), and differences in what people know about an emotion can influence their emotional feeling experiences, expressions, and responses. Barrett (2017) argues that emotions are psychological constructions, and that the content of these constructions includes both core affect (bodily sensations) and concept knowledge about the meaning of an emotion and the function that it serves. Moreover, while the meaning and function of an emotion can become stereotyped, Barrett (2017) suggests that these features are generally bound to contexts so that when we eventually become aware of an emotion, we interpret it as a signal about how things are going in the mind, in the body, and in the environment.

Two types of confusion emotion concept knowledge were examined in the present study; threat knowledge and challenge knowledge. Although there is no specific literature which characterizes the knowledge surrounding confusion in this particular way, there are theories which permit such a characterization. Blascovich's (2013) model of challenge and threat states asserts that emotional experiences function as an alert system that is driven in part by a nonconscious process of demand/resource evaluation. He contends that prior to and/or during the performance of tasks we subliminally assess how demanding we perceive a task to be (demand evaluation) and whether or not we possess the appropriate competency, skills, and resources to meet the requirements necessary for successful task completion (resource evaluation).

In the context of the present study with its emphasis on inferential reasoning performance, it is quite possible that students do make these kinds of task demand/resource evaluations and that this information in turn becomes infused into their psychological constructions of confusion. For example, students who determine a discrepancy or mismatch between task demand and resource availability may interpret confusion as a threat signal and subsequently act to conserve mental energy or choose to disengage from the task; on the other hand, students who determine a match or at least some consistency between task demand and resource availability may interpret confusion as a challenge signal and subsequently persist in the task while deepening their cognitive processing. It was hypothesized that students are likely to have encountered both kinds of emotion concept knowledge about confusion, but that one is more perceptually salient than the other. Perhaps one knowledge category reflects conceptual content that goes something like this: confusion is a signal of cognitive resource deficiency (or perhaps that you are not smart enough), given its feeling of moderate arousal and strong displeasure, and that one's environment, bodily systems, or psyche are not safe such that there is an impending threat (e.g., goal failure) from which one should withdraw (physically or mentally); in contrast, the other knowledge category might reflect conceptual content that sounds something like this: while the affective quality of confusion is undeniably arousing and strongly displeasing, it is nevertheless a signal that more resources are needed to make sense of the task at hand—yet there is an assumption that no apparent deficiency exists and the challenge therefore is to simply persist until an appropriate end-state is achieved or a desired goal is secured.

When study participants were asked to rate their agreement with both types of concept knowledge, represented in the SES-Q projection task scenario by two brief thought/behavior statements, there were significant differences in the agreement ratings given for each kind of confusion concept knowledge. Additionally, nearly all participants reported agreement or very strong agreement with one kind of confusion concept knowledge over the other; and not unexpectedly, they also reported disagreement or strong disagreement with the opposing kind of confusion concept knowledge. Indeed, participants acknowledged their familiarity with or at least the existence of both kinds of confusion emotion concept knowledge; but results show that they had a clear preference for one kind of concept knowledge over the other, as measured by their agreement ratings.

Additionally, in spite of a similar core affective feeling experience of confusion among participants, there was a strong relationship between the kind of emotion concept knowledge that participants more readily endorsed and their complex inferential reasoning performance scores. Participants who more strongly endorsed emotion concept knowledge of confusion as challenging scored significantly higher on the learning verification task, compared to students who more strongly endorsed emotion concept knowledge of confusion as threatening. This suggests that it is perhaps not simply the feeling experience of confusion that itself facilitates reasoning performance, but that there is instead something about the quality of confusion—perhaps its constitutive elements—that determines whether confusion is debilitative or facilitative for performance. This leads to the last category of study findings.

Epistemological beliefs about the nature of knowledge learning and emotion concept knowledge preferences are constitutive elements in students' psychological construction of confusion, and the interaction between these elements is strongly related to their complex reasoning performance.

The chapter has previously described the argument put forth by Barrett (2017) regarding the psychologically constructed nature of emotions and the role that emotion concept knowledge plays in such constructions. Additionally, results from the current study which support the assertion that students' perceptions of confusion are in part constructed by different kinds of emotion concept knowledge have been presented. But according to Barrett (2017), emotion construction could potentially involve not only emotion concept knowledge, but many other categories of cognitive information as well, including beliefs that are tied to particular situational contexts. In the present investigation, this important supposition was addressed by including epistemological beliefs about the nature of knowledge and learning as a factor that could potentially act as a constitutive element in students' psychological construction of confusion and in turn influence their inferential reasoning performance.

The inclusion of epistemological beliefs was not done in a random or arbitrary fashion. Instead, this construct was included because research by Perry (1970), Schoenfield (1983), Dweck & Leggett (1988), Jehng (1991), Jehng et al (1993), Hofer & Pintrich (2007), Schommer (1990), and Schommer et al (1992)—among others—suggests that epistemological beliefs—

what we believe about how knowledge is acquired and transmitted, and how learning happens—have a powerful influence on motivation, cognitive processing, and learning. For example, in examining how epistemological beliefs play a role in school learning and related processes such as deep comprehension, Schommer (1990) demonstrated a relationship between beliefs about knowledge, use of cognitive learning strategies, and performance on a reading task. The results of her study revealed that students who reported the belief that the process of learning is rapid achieved lower comprehension scores and made the most unsophisticated inferences, compared to students who expressed the belief that learning can be slow and take time; additionally, lower performing students judged themselves as more certain of their comprehension.

In a second study, Schommer and colleagues (1992) asked subjects to complete the epistemological beliefs questionnaire, read a complex text passage, take a comprehension performance test, and rate themselves on how well they thought they understood the material. The results of this investigation revealed that higher comprehension scores were negatively correlated with the belief in quick learning, where students who were less inclined to believe that learning is a quick process achieved higher comprehension scores. Additionally, students who expressed a belief in simple knowledge were also more likely to judge themselves as having understood the material very well, compared to students who reported the belief in the complexity of knowledge and also achieved higher comprehension scores.

And finally, Young (2005) completed a study, using Schommer's (1992) epistemological beliefs survey, that investigated the relationship between epistemological beliefs, choice of study strategies, and perceived academic performance. The data demonstrated a significant negative correlation between the sophistication of epistemological beliefs and use of complex learning strategies, such as elaboration. Students who more strongly believed that the ability to know is not fixed and that learning happens gradually, reported greater use of metacognitive strategies, compared to students who believed that learning is a fixed ability that should require little time and effort.

The results from the preceding examples align well with the results from the present study where it was found that participants' epistemological beliefs accounted for substantially more of the variation in their inferential reasoning scores than did their feelings of confusion; at the same time, epistemological beliefs accounted for nearly the same amount of variation in participants' complex reasoning scores as did their emotion concept knowledge preferences. In fact, participants for whom the most sophisticated epistemological beliefs were observed, as measured by Schommer's (1992) epistemological beliefs survey, achieved higher scores on the learning verification task, compared to students who expressed less sophisticated epistemological beliefs. And just as Schommer (1992) and Young (2005) found in their investigations, participants in the present study who reported higher levels of understanding (and thus less confusion) actually achieved lower inferential reasoning performance scores. The sum of these findings suggest that what students believe about the complexity (or lack-there-of) of knowledge and about the processes by which learning happens are both related to their complex inferential reasoning performance, but perhaps also that the lack of sophistication of epistemological beliefs interferes with students' ability to accurately judge their level of understanding or leads students to interpret core affective signals in a different way than what might be expected.

But given that epistemological beliefs accounted for nearly the same amount of variation in complex reasoning scores as did emotion concept knowledge preferences, a natural curiosity arises; is there an interaction between confusion emotion concept knowledge preferences and epistemological beliefs that might increase the explained variation in performance scores?

Further, if these two factors (concept knowledge preferences and epistemological beliefs), already demonstrated individually to be statistically significant predictors of inferential reasoning performance, are indeed constitutive elements in participants' psychological constructions of confusion, will the relationship between feelings of confusion and inferential reasoning performance diminish, when all factors (feeling of confusion, emotion concept knowledge preferences, and epistemological beliefs) are modeled together? This leads to the last—and unarguably on of the most critical—components of the study results.

The final research question of the study sought to address the speculation posed above. It was hypothesized that there would be a significant 3-way interaction between confusion threat concept knowledge, confusion challenge concept knowledge, and epistemological beliefs sophistication, such that this interaction would increase the explained variation in inferential reasoning performance scores beyond the amount of variation explained by either kind of concept knowledge or epistemological beliefs alone. Moreover, the hypothesis went further in suggesting that, as potentially constitutive elements of confusion, the variation explained by feelings of confusion would decrease in significance due to the interaction of concept knowledge preferences and epistemological beliefs.

Because a hypothesis of this nature regarding learning-related confusion has yet to be advanced in other studies, there is no specific literature which supports modelling threat concept knowledge and epistemological beliefs in the manner previously described, other than the tenets represented in Barrett's (2017) Theory of Constructed Emotion. Therefore, the results of this hierarchical regression analysis represent a small, but important contribution to the literature on emotions and learning. Indeed, the data revealed a statistically significant 3-way interaction between confusion threat concept knowledge, confusion challenge concept knowledge, and epistemological beliefs. This interaction accounted for approximately 66% of the variation in participants' learning verification task scores, which is significantly more than the amount variation explained by each factor alone or their 2-way interactions, as shown in regression models 1 and 2. But, as it was noted in the presentation of results in Chapter 4, the interpretation of this 3-way interaction requires an element of nuance.

What seems to stand out about the 3-way interaction is that for the most part, participants' learning verification task scores appear to increase as a function of the increase in the level of one or both of challenge concept knowledge agreement and sophistication of epistemological beliefs, regardless of their level of threat concept knowledge agreement. Indeed, it was rather curious to observe that learning verification task scores were highest for participants who reported low threat concept knowledge agreement, low challenge concept knowledge agreement, and high sophistication of epistemological beliefs sophistication; in fact, for participants who followed this independent variable pattern, their task performance scores were likely to decrease as a function of increases in their challenge concept knowledge agreement. This suggests that while threat knowledge, challenge knowledge, and epistemological beliefs might reflect constitutive elements which underpin or construct students' feelings of learning-related confusion, and while the significance of the 3-way interaction between these factors was such that the variation in reasoning task performance explained by the feeling of confusion alone became nonsignificant, it is nevertheless likely that there are other factors which influence or play a role in students' confusion constructions and in turn have an impact on their reasoning performance. A few such factors are considered later in this chapter.

It was not expected that the variation in learning verification task performance accounted for by participants' feelings of confusion would disappear, yet this finding does offer some evidence of the constructed nature of learning-related confusion. Unarguably, feeling confused is likely to be cognitively, physiologically, and psychologically uncomfortable for many students who are asked to engage in complex, higher-order reasoning and difficult problem-solving tasks, as demonstrated in this study and in the work of other researchers (e.g., Graesser & D'Mello, 2014). However, as this expanding line of inquiry suggests, confusion can in fact be beneficial for students' complex reasoning and problem-solving, and the findings from the present study provide insight that may help to explain the mechanism by which confusion functions as a facilitator of deep cognitive processing and learning. As reported here, an important key to the benefit of learning-related confusion could very well lie in the constitutive elements that infuse students' psychological constructions of their affective experiences, including their confusion emotion concept knowledge preferences and their epistemological beliefs sophistication.

Additional Constitutive Elements

The results described above present solid evidence in support of epistemological beliefs and confusion concept knowledge preferences as significant elements in the psychological construction of learning-related confusion; however, there are bound to be other factors which supply additional cognitive information in students' confusion constructions, given the complex interactions noted in the discussion of study results. Moreover, the involvement of other factors in students' confusion constructions would also make sense because the Theory of Constructed Emotion implies that there could be an unquantified assortment of both cognitive and non-cognitive information that is able to act as an overlay for the interpretation of physiological states. For example, human beings generally strive to act with intention and often consciously set or implicitly formulate corresponding goals. However, when goal pathways or outcomes appear to be blocked or seem jeopardized, the psychological construction of confusion about the situation, about any relevant inputs, and about how to proceed, could very well ensue. Thus, when students experience the feeling of confusion, it might be important to consider their underlying goals as factors in their psychological constructions of the affective state. Indeed, in the context of higher order reasoning and learning, the focus of the present study, academic goal orientation might be a potentially salient element in students' psychological constructions of confusion; this factor is further examined below.

This dissertation study presumes that the general function of confusion is to facilitate a change in a person's level of comprehension or understanding via the deepening of cognitive processing; however, it is certainly possible that confusion is an affective state that involves some target or goal at which the feeling and/or expression is directed. Indeed, tied to the general goal of understanding that seems to accompany learning-related confusion could be other, less consciously evident goals such as whether a student desires to perform well for the sake of some extrinsic reward (e.g., status or approval), whether she/he seeks to achieve competence for its own sake, and whether the desired end-result provokes either an active pursuit of or distancing from the imagined end-result.

In the early 1980's, Carol Dweck (1987) identified patterns of behavior demonstrated by children in response to failure or encountering setbacks while attempting challenging tasks; and through several series of interviews, she later determined that children's responses could be largely attributed to the goals they had set for performing these tasks or to the outcomes they expected to occur. Dweck's (1987) research suggests that students' learning and willingness to participate in academic tasks is often guided by the underlying goals they desire to achieve. Indeed, studies show that regardless of whether students approach academic tasks as a quest for conceptual mastery or as a mechanism for receiving affirmation from others, both dispositions are linked to achievement outcomes (Pintrich, 2000). Moreover, these dispositions also appear to impact students' willingness to persist at tasks—in spite of the perceived or real degree of task ease or difficulty (Elliot and Dweck, 1988).

Indeed, students whose academic goals are psychologically connected to a desire for continual personal improvement and ultimate mastery, as opposed to goals which disregard the value of process and effort and instead attend primarily to obtaining a certain score or avoiding failure, typically demonstrate higher rates of achievement (Dweck, 1986). Likewise, students who are able to sustain effortful action, even when previous task attempts have not resulted in successfully meeting a pre-determined measure of success, also demonstrate higher rates of achievement (Elliot and Dweck, 1988). However, in spite of a vast amount of research, the factors that permit students to think and act in these ways are still not altogether clear or agreed upon and are certain to include other elements such as the learning environment created by teachers and mental phenomena such as affective states.

To be clear, the intent of invoking the idea of goal orientation as a potential factor in the psychological construction of confusion is not to suggest that confusion and goal orientation are the same phenomena with different names. Instead, as is the case with many complex concepts, it is possible that the two factors share a componential relationship where goal orientation is subsumed within learning-related confusion in much the same way as epistemological beliefs and confusion concept knowledge preferences have been described in this investigation. And rather than this being a point of contention or a reason to diminish the findings of the present study, it instead opens the door for further investigation of learning-related confusion as well as the psychological construction of confusion in other contexts which are not necessarily related to learning. This would indeed be consistent with the notion that emotions are tailored phenomena.

The Impact of this Work

As with any research study, including those that yield statistically significant findings, the issue of practical meaning is one that must be addressed in order to lend credence to its true value. Or, in other words, the question of 'now what' must be asked and answered. For the present study, there are two important responses to the question of 'now what'. The first one deals with how we might be able to use these findings to help students, and the second one attends to how this work impacts or advances the field of educational psychology. Each is briefly discussed in turn.

In chapter one of the dissertation, a substantial amount of space was devoted to explaining the importance of strong complex inferential reasoning and higher order thinking skills for current and future students. Without relitigating that argument or digressing into redundancy, it is important to underscore the fact that those are and will continue to be critical capacities for the 21st century and beyond. And while researchers continue to look for clues that explain differences in reasoning performance and to develop interventions based upon those clues, it would be a disservice to students to allow them to remain uninformed, ill-informed, or misinformed about the affective nature of deep cognitive processing, or—for lack of a better description—thinking hard. To this end, the results of the present study have the power to inform students about the normalcy of feeling confused during the performance of complex reasoning and complex problem-solving tasks. Far too often students seem to believe that confusion is bad because it is presumed to reflect cognitive inadequacy at its worst, or a generally undesirable state of disarray at its best.

The good news, though, is that epistemological beliefs are malleable, and students can in fact acquire new ways of thinking about knowledge and learning such that this change in epistemology helps them academically as well as developmentally. But, there is also bad news. From parents, to teachers, and even the media, students are constantly confronted by competing conceptualizations of confusion, which—even when unrelated to the context of learning—become affective heuristics. One solution to this problem could be to extend what teachers learn about epistemic emotions—confusion in particular—during their pre-service (and in-service) training, and educate them about why and how to explicitly help their students anticipate and navigate the affective experience of confusion during complex learning activities. This is not to suggest that there are currently no teachers who provide such guidance; however, I would argue that most educational psychology textbooks today spend little if any ink specifically discussing the relationship between confusion and learning and offering practical information about the utility of confusion and the conditions under which it is likely to yield a facilitative benefit. To be fair of course, there is still very little research that specifically addresses confusion. Moreover, it would be difficult to broach the subject of confusion with educators when we actually know very little about their own perceptions of confusion and emotion concept knowledge preferences! Indeed, understanding the sources of students' emotion concept knowledge preferences could provide valuable information.

In terms of the second response to the question of 'what now', a triad of characteristics related to the broader field of educational psychology affords stature to this dissertation study: 1) it takes a theoretically interdisciplinary approach; 2) it is simultaneously translational and applied in nature; and 3) it expands the evidence that supports epistemic emotions as a special class of affective states related to learning environments. A brief discussion of each is offered.

It is becoming increasingly uncommon to approach the dissertation in the field of educational psychology by identifying a research stream, narrowing the topic of study, and a then selecting one (or a very few) well established discipline-specific theories around and through which to neatly situate a study. Instead, just as in many branches of psychology and in research in general, educational psychologists are crossing disciplinary boundaries, incorporating diverse theories, and using them as central investigative scaffolding; in the present study, such an approach was taken. The purpose of this study was to examine relationships between the epistemic emotion, confusion, and complex inferential reasoning performance; but rather than choosing to operate within the confines of emotion theories from the field of educational psychology (and there are number of them), the investigation instead employs a constructivist theory emotion (Barrett's Theory of Constructed Emotion) that is in part grounded in affective neuroscience. Additionally, the study draws heavily from research in cognitive/learning science, the affective computing sciences (Graesser & D'Mello's affect dynamics in auto-tutor environments), and from the biophysical/biopsychosocial model of challenge and threat states (Blascovich's reconceptualization of Dientsbier's physiological toughness construct).

While some may lament that the expectancy value theory of emotions and learning (Pekrun, 2011) should have served a more prominent role in the investigation, I would argue in return that the present study effectively used a variety of theoretical propositions to successfully dispatch the idea that educational psychology does not belong in the domain of psychological science. Studies in educational psychology which take an interdisciplinary tack, such as the one presented in this dissertation, are critical because they demonstrate the reach and interconnectedness of the field to other areas of psychology (and beyond), which in turn increases the value of our discipline.

In addition to a bent toward interdisciplinarity, the present study is also simultaneously translational and applied in nature. A common complaint among many outside the academic arena is that psychological science research has very little obvious connection to their everyday lives and thus has little value. To overcome this misconception, it is imperative that contemporary researchers look for ways to explicitly bridge the gap between basic psychological science research and everyday practicality by looking for opportunities to take a simultaneously translational and applied approach to their work. In the present study, this mandate was accomplished by using Barrett's (2017) Theory of Constructed Emotion, which is rooted in basic research and includes evidence drawn from systematic investigations in the areas of neuroscience, psychophysiology, and cross-cultural affective experience. In choosing this theory as a guiding framework, this dissertation not only demonstrated how basic psychological science research can be translated for use in the field of education, but also showed that there are concrete implications and application for both student learning and pedagogical practice. This kind of work is critical if research in the field of educational psychology is to keep pace with the broad and growing trend in research as a whole.

Finally, the last characteristic of this dissertation as it relates to implications for the field of educational psychology is that it helps to advance the conversation surrounding the role of affect states in thinking and learning and supports the supposition that epistemic emotions—those which occur in conjunction or in tandem with cognitive processing and learning mechanisms in general—are a special category of affective phenomena which deserve ongoing attention in the field of educational psychology. At the same time, the present study also demonstrates that there is room to expand the current discourse on the relationship between affective states and learning—in particular, the ways in which we conceptualize, understand, and talk about learning-related emotions. Currently the field of educational psychology seems to have a somewhat closed system in terms of what is deemed to be an acceptable approach and language for studying and talking about learning-related emotions. However, if we want our field to be valued as a vanguard in research, it is important that the proverbial tent under which we all stand as educational psychologists create space for—and welcome—theoretical intersectionality.

Study Limitations

Although the results of this study are largely positive in terms of the evidence that was generated in support of the research questions and hypotheses, there are nevertheless some limitations of the investigation that must be acknowledged. First, this investigation included only two factors, epistemological beliefs and confusion concept knowledge preferences, that were considered as constitutive elements of confusion; and in light of the complex interaction effects between these factors, it is highly possible that there are other elements, such as self-efficacy beliefs, need for cognition, and goal orientation, as was discussed at length in an earlier section, that might play a role in students' psychological constructions of confusion. On the other hand, it is possible that there are altogether different explanations, not tied to affective states, for the observed variation in participants' reasoning performance scores, such as time of day of study completion or interest in the topic.

Second, in the present study there was no comparison offered between other affective states, such as enjoyment or boredom, and participants' complex reasoning scores. It is possible that confusion may have had a weaker predictive relationship to reasoning performance scores, compared to enjoyment or even boredom; but given the prevalence of confusion reports and that the goal of the study was to explore confusion, this may not be quite so problematic in terms of the value of the study's findings. Along the same lines, the method of emotion self-report used in the study may have introduced concern about the interpretation of findings. This is because there are differences in the degree to which people are capable of sensing granular differences in core affective states. More plainly, some people are biologically less able to recognize the internal physiological signals associated with valence and arousal; this means that a person could have difficulty detecting fine differences between general affective states and particular emotions, such as confusion, making their retrospective emotion self- reports less reliable. Additionally, the modified adjective word tetrads used in the study may not have adequately or fully reflected the valence, arousal, and classical emotion label definitions for which they were intended as substitutes.

Finally, the sample of students who participated in the study was largely homogenous: most were females, less than 20% were minority students, and the investigation was conducted at a single predominantly white institution. These demographic limitations are important because to some degree, they impact upon the generalizability of the study findings.

Future Directions

Although there are a number of study limitations described above, rather than framing them as detrimental to the overall value of the investigation, they can instead be viewed as opportunities to hone and expand this line of inquiry. For example, future studies could seek to explore differences in the psychological construction of confusion across population groups and cultures by specifically recruiting a more diverse sample and conducting studies at more diverse institutions. Additionally, future research might also consider a number of other variables, such as self- efficacy beliefs, need for cognition, and especially goal orientation, as constitutive elements in the construction of confusion. Goal orientation is highlighted here given the argument established earlier in the chapter which emphasized the idea that the manner in which the affective experience of confusion is constructed—and perhaps even the degree to which it is helpful—is potentially shaped by the outcome (whether expected, uncertain, desired, or dreaded) to which an evocative situation or task is connected.

In yet another vein of research, new confusion studies could take an experimental tack by including both a manipulation and control group, or by employing confusing (e.g., nonsensical or syntactically erroneous) statements/sentences and exploring the relationship between confusion and complex reasoning performance. Additionally, new studies might also include psychophysiological measures, such as skin conductance or heart rate variability, to explore the degree to which students notice changes in their bodily states during the completion of complex reasoning tasks and in turn apply confusion substitute words (such as those used in the present study) to interpret their physiological states. Or, a psychophysiological study might investigate if awareness of changes in bodily states moderates the relationship between epistemological beliefs sophistication and self-report ratings of complex task comprehension. Studies of this nature could accomplish two things: First, they might shed light on whether differences in students' experience and reporting of confusion are related to their core affect (valence and arousal) granularity—that is, the degree to which they are aware of their internal bodily states, and whether differences in valence and arousal moderate the relationship between level of confusion and reasoning performance; and second, they might provide insight into underlying factors that explain why students with epistemological beliefs sophistication often report high levels of complex task comprehension when their actual performance is quite low, in comparison to students who have highly sophisticated epistemological beliefs yet are likely to report low levels of comprehension.

From a developmental perspective, the current line of research could move into the area of investigating sources of confusion emotion concept knowledge and modes of transmission (e.g., teachers, parents, media). This might include exploring from where students (and people in general) acquire their confusion emotion concept knowledge, how the source of information might shape its contextually perceived meaning and function, and the impact of different concept knowledge sources on resulting behavioral responses. In a similar vein, new studies could explore psychological constructions of confusion in other, non-school settings and the impact of these constructions on outcomes such as scientific literacy, reflective judgement and decision-making, and willingness to interact with different others. And still other studies might investigate the role of feelings of confusion in the relationship between authoritarianism and prejudice. For example, studies have linked authoritarianism to a rigid hierarchical view of the world; but it might be possible that such rigid views are associated with different psychological constructions of confusion. Where some individuals might construct confusion as threat signal and thus have a desire to avoid or minimize feelings of confusion by adopting a simplistic, inflexible view of the world, others might construct confusion as a challenge signal and seek to explore and better understand the complexities of the world. In turn, such differences might manifest themselves in the form of variation in levels of authoritarianism.

And finally, a most critical area for future work will be to translate and apply the findings related to confusion in the form of interventions for school/other learning environments. This could include working with educators (e.g., teachers and teacher-education students) to develop new language around the concept of confusion that does not necessarily deny it's uncomfortable physiological signature, but that instead stresses the normalcy and productive benefit that come from experiencing confusion during difficult learning tasks. As alluded to in the implications section above, educational psychologists are in a unique position in terms of our ability to generate research that has direct applicability for student learning and development, and the present dissertation study can serve as a basis for further investigating the developmental sources of students' confusion concept knowledge and the impact that different concept knowledge categories have on student learning.

CONCLUSION

Based upon the findings from this and other studies, there is most certainly a need to re-think how confusion is understood in the context of complex reasoning and learning; yet at the same time, in light of Barrett's (2017) Theory of Constructed Emotion, it should not necessarily be assumed that students perceive their confusion in the same way, nor that there will always be a positive relationship between confusion and inferential reasoning performance for everyone. As it relates to the specific research questions and hypotheses advanced in this dissertation study, the results of the statistical analyses overwhelmingly support the idea that confusion seems to play a meaningful role in students' complex inferential reasoning performance. But what seems most impactful about this study in terms of its contribution to our knowledge about how emotions, and more specifically feelings of confusion, operate in the context of complex reasoning and learning, is that there is now a bit more evidence that should prompt us to not only embrace the theory that emotions are psychological constructions, but should also challenge us to help re-shape what students know about confusion and believe about the nature of knowledge and learning. Indeed, problem-solving and the skill of reasoning scientifically are no longer strictly cognitive endeavors, and this dissertation has argued that in attempting to help students improve their higher-order, complex reasoning capacities, it is important that the role of psychologically constructed epistemic emotions, like confusion, be regarded as useful additions.

REFERENCES

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Sage.

Apple, W. M. (2005). The State and the Politics of Knowledge.

Aronson, E. (1995). The Social Animal New York. *H. Freeman*.

Arum, R., & Roksa, J. (2011). *Academically adrift: Limited learning on college campuses*. University of Chicago Press.

Barrett, L. F. (2004). Feelings or words? Understanding the content in self-report ratings of experienced emotion. *Journal of personality and social psychology*, *87*(2), 266.

Barrett, L. F. (2005). Feeling Is Perceiving: Core Affect and Conceptualization in the Experience of Emotion.

Barrett, L. F. (2006a). Are emotions natural kinds?. *Perspectives on psychological science*, *1*(1), 28-58.

Barrett, L. F. (2006b). Solving the emotion paradox: Categorization and the experience of emotion. *Personality and social psychology review*, *10*(1), 20-46.

Barrett, L. F. (2011). Was Darwin wrong about emotional expressions?. *Current Directions in Psychological Science*, *20*(6), 400-406.

Barrett, L. F. (2013). Psychological construction: The Darwinian approach to the science of emotion. *Emotion Review*, *5*(4), 379-389.

Barrett, L. F. (2014). The conceptual act theory: A précis. *Emotion Review*,*6*(4), 292-297.

Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. *Social cognitive and affective neuroscience*, *12*(1), 1-23.

Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual review of psychology*, *58*, 373.

Barrett, L. F., Wilson-Mendenhall, C. D., & Barsalou, L. W. (2014). The conceptual act theory: A road map. *The psychological construction of emotion. New York, NY: Guilford*.

Barsalou, L. W. (2010). Grounded cognition: Past, present, and future. *Topics in cognitive science*, *2*(4), 716-724.

Beasley, T. M., & Schumacker, R. E. (1995). Multiple regression approach to analyzing contingency tables: Post hoc and planned comparison procedures. *The Journal of Experimental Education*, *64*(1), 79-93.

Biggs, J. B. (1987). *Student Approaches to Learning and Studying. Research Monograph*. Australian Council for Educational Research Ltd., Radford House, Frederick St., Hawthorn 3122, Australia.

Biggs, J. B. (1988). Assessing student approaches to learning. *Australian Psychologist*, *23*(2), 197-206.

Bjork, E. L., & Bjork, R. A. (2011). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. *Psychology and the real world: Essays illustrating fundamental contributions to society*, 56-64.

Bråten, I. (2010). Personal epistemology in education: Concepts, issues, and implications.

Bråten, I., & Strømsø, H. I. (2006). Effects of personal epistemology on the understanding of multiple texts. *Reading Psychology*, *27*(5), 457-484.

Bråten, I., & Strømsø, H. I. (2009). Effects of task instruction and personal epistemology on the understanding of multiple texts about climate change. *Discourse Processes*, *47*(1), 1-31.

Bråten, I., & Strømsø, H. I. (2011). Measuring strategic processing when students read multiple texts. *Metacognition and Learning*, *6*(2), 111-130.

Bråten, I., Britt, M. A., Strømsø, H. I., & Rouet, J. F. (2011). The role of epistemic beliefs in the comprehension of multiple expository texts: Toward an integrated model. *Educational Psychologist*, *46*(1), 48-70.

Chin, C., & Brown, D. E. (2002). Student-generated questions: A meaningful aspect of learning in science. *International Journal of Science Education*,*24*(5), 521-549.

Clore, G. L., & Ortony, A. (2008). Appraisal theories: How cognition shapes affect into emotion.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge.

Darwin, C. (1872, 1965). *The expression of the emotions in man and animals* (Vol. 526). University of Chicago press.

Dewey, J. (1997). *How we think*. Courier Corporation.

D'Mello, S. K., & Graesser, A. C. (2011). A synthesis of research on emotions during complex learning. *American Educational Research Association, New Orleans, LA*.

D'Mello, S. K. & Graesser, A. C. (2014). Confusion. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), International handbook of emotions in education (pp. 289-310): Routledge: New York, NY.

D'Mello, S., Lehman, B., Pekrun, R., & Graesser, A. (2012). Confusion can be beneficial for learning. *Learning and Instruction*, *29*, 153-170.

D'Mello, S., Taylor, R. S., & Graesser, A (2012). Monitoring Affective Trajectories during Complex Learning.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological review*, *95*(2), 256.

Ekman, P. (1992). An argument for basic emotions. *Cognition & emotion*, *6*(3-4), 169-200.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

Fiske, S. T., & Taylor, S. E. (2013). *Social cognition: From brains to culture*. Sage.

Flores, K. L., Matkin, G. S., Burbach, M. E., Quinn, C. E., & Harding, H. (2012). Deficient critical thinking skills among college graduates: Implications for leadership. *Educational Philosophy and Theory*, *44*(2), 212-230.

Gendron, M., Roberson, D., van der Vyver, J. M., & Barrett, L. F. (2014). Perceptions of emotion from facial expressions are not culturally universal: Evidence from a remote culture. *Emotion*, *14*(2), 251.

Gordon, C., & Debus, R. (2001). Enhancing Learning Approaches in an Undergraduate Teacher Education Program.

Gordon, C., & Debus, R. (2002). Developing deep learning approaches and personal teaching efficacy within a preservice teacher education context. *British Journal of Educational Psychology*, *72*(4), 483-511.

Graesser, A. C., & D'Mello, S. (2012a). Moment-To-Moment Emotions During Reading. *The Reading Teacher*, *66*(3), 238-242.

Graesser, A. C., & D'Mello, S. (2012b). 5 Emotions During the Learning of Difficult Material. *Psychology of Learning and Motivation-Advances in Research and Theory*, *57*, 183.

Graziano, P. A., Reavis, R. D., Keane, S. P., & Calkins, S. D. (2007). The role of emotion regulation in children's early academic success. *Journal of school psychology*, *45*(1), 3-19.

Grover, S., & Pea, R. (2013). Computational Thinking in K–12 A Review of the State of the Field. *Educational Researcher*, *42*(1), 38-43.

Haak, David C., Janneke HilleRisLambers, Emile Pitre, and Scott Freeman. "Increased structure and active learning reduce the achievement gap in introductory biology." *Science* 332, no. 6034 (2011): 1213-1216.

Haller, E. J. (1992). Small Schools and Higher Order Thinking Skills.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Educational Psychology Review*, *13*(4), 353-383.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of educational research*, *67*(1), 88-140.

Ingleton, C. (1999, July). Emotion in learning: a neglected dynamic. In *HERDSA annual international conference, Melbourne*.

Izard, C. E. (2007). Basic emotions, natural kinds, emotion schemas, and a new paradigm. *Perspectives on psychological science*, *2*(3), 260-280.

Jones, M., Meijen, C., McCarthy, P. J., & Sheffield, D. (2009). A theory of challenge and threat states in athletes. *International Review of Sport and Exercise Psychology*, *2*(2), 161-180.

Kelly, G. J., McDonald, S., & Wickman, P. O. (2012). Science learning and epistemology. In *Second international handbook of science education* (pp. 281-291). Springer Netherlands.

King, B. A., & Magun-Jackson, S. (2009). Epistemological beliefs of engineering students. *The Journal of Technology Studies*, *35*(2), 56-64.

Kitchener, K. S., & King, P. M. (1981). Reflective judgment: Concepts of justification and their relationship to age and education. *Journal of applied developmental psychology*, *2*(2), 89-116.

Kort, B., Reilly, R., & Picard, R. (2004). An affective model of interplay between emotions and learning. In *Proceedings of IEEE International Conference on Advanced Learning Technologies* (pp. 43-46).

Kuh, G. D., Kinzie, J., Schuh, J. H., & Whitt, E. J. (2011). *Student success in college: Creating conditions that matter*. John Wiley & Sons.

Laird, T., Shoup, R., & Kuh, G. D. (2005). Measuring deep approaches to learning using the National Survey of Student Engagement. In *annual meeting of the Association for Institutional Research*.

Lazarus, R. S. (1984). On the primacy of cognition.

Lipson, A. (1990). Learning: A momentary stay against confusion. *Teaching and Learning: The Journal of Natural Inquiry*, *4*(3), 2-11.

Lipson, A. (1992). The confused student in introductory science. *College Teaching*, *40*(3), 91-95.

Martin, J. (2007). The 17 great challenges of the twenty-first century. *The Futurist*, *41*(1), 20.

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into practice*,*41*(4), 226-232.

McDaniel, M. A., & Butler, A. C. (2011). A contextual framework for understanding when difficulties are desirable. *Successful remembering and successful forgetting: A Festschrift in honor of Robert A. Bjork*, 175-198.

Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2012). The effect of challenge and threat states on performance: An examination of potential mechanisms. *Psychophysiology*, *49*(10), 1417-1425.

Muis, K. R., Pekrun, R., Sinatra, G. M., Azevedo, R., Trevors, G., Meier, E., & Heddy, B. C. (2015). The curious case of climate change: Testing a theoretical model of epistemic beliefs, epistemic emotions, and complex learning. *Learning and Instruction, 39*, 168-183.

Newmann, F. M. (1991). Promoting higher order thinking in social studies: Overview of a study of 16 high school departments. *Theory & Research in Social Education*, *19*(4), 324-340.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of educational research*, *62*(3), 307-332.

Panksepp, J. (1998). Affective neuroscience: The foundations of human and animal emotions. Oxford university press. Chicago

Panksepp, J. (2007). Neurologizing the psychology of affects: How appraisal-based constructivism and basic emotion theory can coexist. Perspectives on Psychological Science, 2(3), 281-296. Chicago

Paul, R. W. (1984). Critical Thinking: Fundamental to Education for a Free Society. *Educational leadership*, *42*(1), 4-14.

Pauli, W. J. (1960). Confusion and Problem Solving. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *35*(2), 79-82.

Pekrun, R. "Emotions as Drivers of Learning and Cognitive Development." *New Perspectives on Affect and Learning Technologies* 3 (2011): 23.

Pekrun, R. (2016). Academic emotions. *Handbook of Motivation at School*, 120.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational psychologist*, *37*(2), 91-105.

Pekrun, R., & Stephens, E. J. (2010). Achievement emotions in higher education. In *Higher education: Handbook of theory and research* (pp. 257-306). Springer Netherlands.

Perry, W. G. (1970). Forms of intellectual development in the college years. *New York: Holt*.

Piaget, J. (1952). *The origins of intelligence in children* (Vol. 8, No. 5, pp. 18-1952). New York: International Universities Press.

Quigley, K. S., Lindquist, K. A., & Barrett, L. F. (2014). Inducing and measuring emotion and affect: Tips, tricks, and secrets.

Ravindran, B., Greene, B. A., & DeBacker, T. K. (2005). Predicting preservice teachers' cognitive engagement with goals and epistemological beliefs. *The Journal of Educational Research*, *98*(4), 222-233.

Russell, J. A., & Barrett, L. F. (1999). Core affect, prototypical emotional episodes, and other things called emotion: dissecting the elephant. *Journal of personality and social psychology*, *76*(5), 805.

Schoenfeld, A. H. (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognitions as driving forces in intellectual performance. *Cognitive science*, *7*(4), 329-363.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of educational psychology*, *82*(3), 498.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so.*Journal of educational psychology*, *84*(4), 435.

Schutz, P. A., & Pekrun, R. (2007). Introduction to emotion in education. *Emotion in education*, 3-10.

Shipley, W. C. (1940). Shipley-Hartford Retreat Scale, manual of directions and scoring key. *Hartford, Conn.: Hartford Retreat*.

Skinner, N., & Brewer, N. (2004). Adaptive approaches to competition: Challenge appraisals and positive emotion. *Journal of Sport and Exercise Psychology*,*26*(2), 283-305.

Smith, T. W., & Colby, S. A. (2007). Teaching for deep learning. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *80*(5), 205-210.

Strain, A. C., & D'Mello, S. K. (2011, January). Emotion regulation during learning. In *Artificial Intelligence in Education* (pp. 566-568). Springer Berlin Heidelberg.

Strømsø, H. I., Bråten, I., & Britt, M. A. (2010). Reading multiple texts about climate change: The relationship between memory for sources and text comprehension. *Learning and Instruction*, *20*(3), 192-204.

Wood, P., & Kardash, C. (2002). Critical elements in the design and analysis of studies of epistemology. *Personal epistemology: The psychology of beliefs about knowledge and knowing*, 231-260.

Wood, P., & Kardash, C. (2004). Design and Analysis of Studies of Epistemology. *Personal Epistemology: The Psychology of Beliefs about Knowledge and Knowing*, 231.

Yik, M., Russell, J. A., & Steiger, J. H. (2011). A 12-point circumplex structure of core affect. *Emotion*, *11*(4), 705.

Young, M. R. (2005). Personal epistemological beliefs and their relationship to learning. *Journal for Advancement of Marketing Education*, *6*.

Zimmerman, C. (2000). The development of scientific reasoning skills. *Developmental Review*, *20*(1), 99-149.

Zohar, A., & Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: Are they mutually exclusive?. *The journal of the learning sciences*,*12*(2), 145-181.

APPENDIX

About You
(Demographic Questionnaire)

Please provide responses to the items below. Your answers are anonymous.

DG1. *Year in College* ***[CHECK THE APPROPRIATE BOX]***

1	2	3	4	5
▢**1st**	▢**2nd**	▢**3rd**	▢**4th**	▢**5th or beyond**

DG2. *Major* ***[CHECK THE MOST APPROPRIATE BOX]***

▢**1 Education** ▢**2 Business** ▢**3 Computer Science** ▢**4 Other**

____

DG3. *Gender* ***[CHECK THE MOST APPROPRIATE BOX]***

Female	Male	Neither/Other
▢**1**	▢**2**	▢**3**

DG4. *Race/Ethnicity* ***[CHECK THE MOST APPROPRIATE BOX]***

Black/African-American	▢**1**
Hispanic/Latino-American	▢**2**
White/Caucasian/European-American	▢**3**
European-Immigrant	▢**4**
Asian-American	▢**5**
Native American	▢**6**
Pacific Islander	▢**7**
Alaska Native	▢**8**
African Immigrant	▢**9**
Asian Immigrant	▢**10**
Hispanic/Latino Immigrant	▢**11**
Other (non-White/Caucasian/European)	▢**12** ____________________

Shipley Hartford Verbal Ability Scale

Shipley–Hartford Scale

For each item in Column A, circle the word from Column B, C, or D that means the same thing. You may guess if you aren't sure.

A	B	C	D
(1) TALK	draw	eat	speak
(2) PERMIT	allow	sew	cut
(3) PARDON	forgive	pound	divide
(4) COUCH	pin	eraser	sofa
(5) REMEMBER	swim	recall	number
(6) TUMBLE	drink	dress	fall
(7) HIDEOUS	silvery	tilted	young
(8) CORDIAL	swift	muddy	leafy
(9) EVIDENT	green	obvious	skeptical
(10) IMPOSTER	conductor	officer	book
(11) MERIT	deserve	distrust	fight
(12) FASCINATE	welcome	fix	stir
(13) INDICATE	defy	excite	signify
(14) IGNORANT	red	sharp	uninformed
(15) FORTIFY	submerge	strengthen	vent
(16) RENOWN	length	head	fame
(17) NARRATE	yield	buy	associate
(18) MASSIVE	bright	large	speedy
(19) HILARITY	laughter	speed	grace
(20) SMIRCHED	stolen	pointed	remade
(21) SQUANDER	tease	belittle	cut
(22) CAPTION	drum	ballast	heading
(23) FACILITATE	help	turn	strip
(24) JOCOSE	humorous	paltry	fervid
(25) APPRISE	reduce	strew	inform
(26) RUE	eat	lament	dominate
(27) DENIZEN	senator	inhabitant	fish
(28) DIVEST	dispossess	intrude	rally
(29) AMULET	charm	orphan	dingo
(30) INEXORABLE	untidy	involatile	rigid
(31) SERRATED	dried	notched	armed
(32) LISSOM	moldy	loose	supple
(33) MOLLIFY	mitigate	direct	pertain
(34) PLAGIARIZE	appropriate	intend	revoke
(35) ORIFICE	brush	hole	building
(36) QUERULOUS	maniacal	curious	devout
(37) PARIAH	outcast	priest	lentil
(38) ABET	waken	ensue	incite
(39) TEMERITY	rashness	timidity	desire
(40) PRISTINE	vain	sound	first

Wood-Kardash Epistemological Beliefs Survey

Please indicate how strongly you agree or disagree with each of the statements listed below. Please circle the number that best corresponds to the strength of your belief.

1. You can believe most things you read.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

2. The only thing that is certain is uncertainty itself.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

3. If something can be learned, it will be learned immediately.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

4. I like information to be presented in a straightforward fashion; I don't like having to read between the lines.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

5. It is difficult to learn from a textbook unless you start at the beginning and master one section at a time.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

6. Forming your own ideas is more important than learning what the textbooks say.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

7. Almost all the information you can understand from a textbook you will get during the first reading.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

8. A really good way to understand a textbook is to reorganize the information according to your own personal scheme.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

9. **If scientists try hard enough, they can find the answer to almost every question.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

10. **You should evaluate the accuracy of information in textbooks if you are familiar with the topic.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

11. **You will just get confused if you try to integrate new ideas in a textbook with knowledge you already have about a topic.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

12. **When I study, I look for specific facts.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

13. **If professors would stick more to the facts and do less theorizing, one could get more out of college.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

14. **Being a good student generally involves memorizing a lot of facts.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

15. **Wisdom is not knowing the answers, but knowing how to find the answers.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

16. **Working on a difficult problem for an extended period of time only pays off for really smart students.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

17. **Some people are born good learners; others are just stuck with a limited ability.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

18. **Usually, if you are ever going to understand something, it will make sense to you the first time.**

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

19. Successful students understand things quickly.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

20. Today's facts may be tomorrow's fiction.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

21. I really appreciate instructors who organize their lectures carefully and then stick to their plan.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

22. The most important part of scientific work is original thinking.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

23. Even advice from experts should be questioned.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

24. If I can't understand something quickly, it usually means I will never understand it.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

25. I try my best to combine information across chapters or even across classes.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

26. I don't like movies that don't have a clear-cut ending.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

27. Scientists can ultimately get to the truth.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

28. It's a waste of time to work on problems that have no possibility of coming out with a clear-cut answer.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

29. Understanding main ideas is easy for good students.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

30. It is annoying to listen to lecturers who cannot seem to make their mind up as to what they really believe.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

31. A good teacher's job is to keep students from wandering from the right track.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

32. A sentence has little meaning unless you know the situation in which it was spoken.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

33. The best thing about science courses is that most problems have only one right answer.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

34. Most words have one clear meaning.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

35. The really smart students don't have to work hard to do well in school.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

36. When I learn, I prefer to make things, as simple as possible.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

37. I find it refreshing to think about issues that experts can't agree on.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

38. The information we learn in school is certain and unchanging.

strongly disagree	disagree	unsure	agree	strongly agree
1	2	3	4	5

Learning Verification Task

ACCURATE

1. To limit the natural greenhouse effect, the UN's climate panel recommends that the industrial countries reduce the consumption of fossil fuels significantly during the next 50 years — ***Yes*** ☐ ***No*** ☐

Now, circle the letter next to <u>one set</u> of words below that best describes how you were feeling <u>while</u> working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about your feeling

1	2	0	4	5
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

2. Human beings' increased consumption of fossil fuels can increase the deposits of gold, diamonds, copper, and zinc in the northerly regions — ***Yes*** ☐ ***No*** ☐

Now, circle the letter next to <u>one set</u> of words below that best describes how you were feeling <u>while</u> working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about your feeling

1	2	0	4	5
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

		ACCURATE	
3.	New technology can make it possible to store nature's own discharges of climate gases	**Yes** ☐	**No** ☐

Now, circle the letter next to <u>one set</u> of words below that best describes how you were feeling <u>while</u> working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about the feeling

1	2	0	4	5
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

4.	Even the seemingly insignificant increase in the earth's average temperature during the last 150 years may have very large consequences for life on earth	**Yes** ☐	**No** ☐

Now, circle the letter next to <u>one set</u> of words below that best describes how you were feeling <u>while</u> working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about the feeling

1	2	0	4	5
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

ACCURATE

5. The global warming that takes place now can be due to both a manmade strengthening of the greenhouse effect and astronomical conditions **Yes** ☐ **No** ☐

Now, circle the letter next to one set of words below that best describes how you were feeling while working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about the feeling

1	**2**	**0**	**4**	**5**
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

6. The stronger greenhouse effect has made the oil companies develop new technology for removal and injection of carbon dioxide **Yes** ☐ **No** ☐

Now, circle the letter next to one set of words below that best describes how you were feeling while working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about the feeling

1	**2**	**0**	**4**	**5**
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

		ACCURATE	
7.	Global warming could have a negative impact on the economies of many countries, while it other places in the world could create new economic opportunities	**Yes** ☐	**No** ☐

Now, circle the letter next to <u>one set</u> of words below that best describes how you were feeling <u>while</u> working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about the feeling

1	2	0	4	5
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

8.	Climate changes that have natural causes may open the Northwest Passage as a transportation route	**Yes** ☐	**No** ☐

Now, circle the letter next to <u>one set</u> of words below that best describes how you were feeling <u>while</u> working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about the feeling

1	2	0	4	5
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

		ACCURATE	
		Yes	**No**
9.	Human activities in tropical forest areas can contribute to colder weather in the Nordic Region	☐	☐

Now, circle the letter next to <u>one set</u> of words below that best describes how you were feeling <u>while</u> working on this question

A	apprehensive, on edge, tense, up-tight	**D**	muddled, thrown-off, tense, alert	**G**	at ease, unbothered, chill, calm
B	hostile, aggressive, tense, up-tight	**E**	interested, quick-witted, alert, attentive		
C	uninterested, indifferent, tired, dull	**F**	irked, annoyed, tense, up-tight		

Next, circle the number below that matches how certain you are about the feeling

1	2	0	4	5
Extremely Uncertain	**Uncertain**	**Can't Decide**	**Certain**	**Extremely Certain**

Emotion Adjective Tetrads (Word Set)
(The conventional emotion labels are NOT shown to participants)

Now, circle the letter next to one set of words below that best describes how you were feeling while working on the question

A. (apprehensive, on edge, tense, up-tight) – AFRAID
B. (hostile, aggressive, tense, up-tight) – ANGRY
C. (uninterested, indifferent, tired, dull) – BORED
D. (muddled, thrown-off, tense, up-tight) – CONFUSED
E. (interested, quick-witted, alert, attentive) - ENJOYMENT
F. (irked, annoyed, tense, up-tight) – FRUSTRATED
G. (at ease, unbothered, chill, calm) – NEUTRAL

Students' Experiences in School Questionnaire (SES-Q)

The purpose of this task is to understand what students sense about experiences that may happen in school. Please do the following: (1) Read the scenario below about 'Susan'; (2) Rate how much you agree with each of two possible statements that describe what Susan *might sense* and do about the experience; then (3a) Pick ONE statement that describes what you believe Susan *most likely senses* about the experience and (3b) report your level of confidence in the answer. Remember, there are no right or wrong answers; Give your honest opinion

(1) The Scenario: Susan believes she is well prepared for an important history exam. The exam requires her to complete a detailed map of ancient civilizations. Last week, Susan's teacher gave the class a study map (shown in Figure 1 at the bottom of the page) to help them prepare; BUT, when Susan is presented with the exam map (shown in Figure 2 at the bottom of the page), she feels very confused!

(2) Now, Rate how much you agree with Statements A and B (below), that describe what Susan *might* sense and do about her confusion. For both statements, Mark an 'X' under the rating that matches how much you agree.

Statement A
Susan senses a feeling of not knowing, and realizes that it will hurt her status as an intelligent student if she can't recall the specific memorized image of the map. She thinks she should probably drop the class.

Strongly Disagree	Disagree	Somewhat agree & disagree	Agree	Strongly Agree

Statement B
Susan senses a feeling of not knowing, and realizes that her preparation for the test was not very good. She thinks she needs another strategy besides trying to recall specific memorized content.

Strongly Disagree	Disagree	Somewhat agree & disagree	Agree	Strongly Agree

(3a) Next, Pick ONE Statement (either A or B presented in question #2 above) that describes what you believe Susan *most likely senses* and does about her confusion. Mark an 'X' beside one statement.

STATEMENT A ---------------

STATEMENT B ---------------

(3b) Now, Rate how confident you are about your answer to (3a). Circle ONE number rating below.

	0	1	2	3	4	5
Not at all Confident						Extremely Confident

Figure 1: STUDY MAP

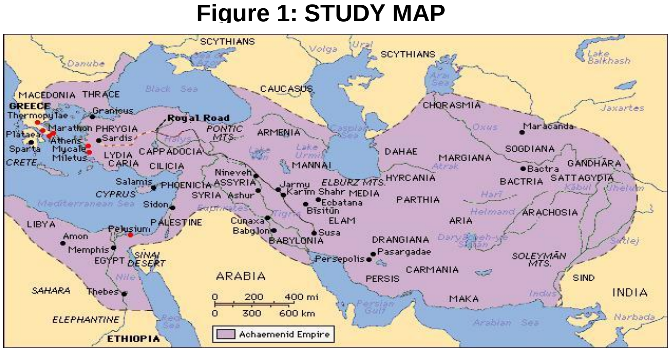
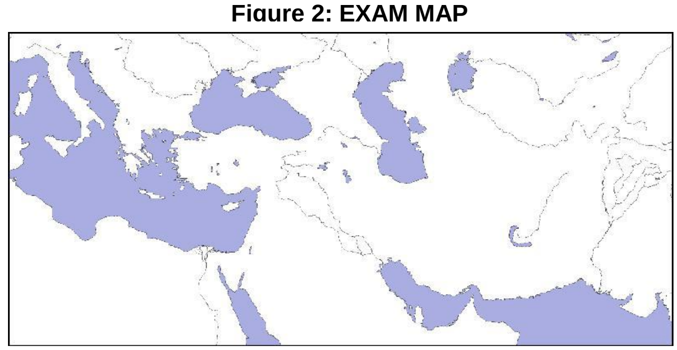


Figure 2: EXAM MAP



THE UNIVERSITY OF ALABAMA | Office of the Vice President for Research & Economic Development
Office for Research Compliance

January 23, 2017

Territa Poole

ESPRMC
College of Education
Box 87023 1
Re: IRB#: 17-0R-033 "What Do Students Sense about Problem Solving and Learning?"

Dear Ms. Poole:
The University of Alabama Institutional Review Board has granted approval for your proposed research. Your application has been given expedited approval according to 45 CFR part 46. You have also been granted the requested waiver of written documentation of informed consent. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies

Your application will expire on January 22, 2018. If your research will continue beyond this date, complete the relevant portions of the IRB Renewal Application. If you wish to modify the application, complete the Modification of an Approved Protocol Form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, complete the appropriate portions of the IRB Request for Study Closure Form.

Please use reproductions of the IRB approved stamped consent/assent forms to obtain consent from your

participants.
Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.
Sincerely,

[redacted]

Director & Research Compliance Officer

358 Rose Administration Building I Box 870127 | Tuscaloosa, AL 35487-0127
205-348-8461 Fax 205-348-7189 | Toll Free 1-877-820-3066