



# The curious case of climate change: Testing a theoretical model of epistemic beliefs, epistemic emotions, and complex learning



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## ABSTRACT

We propose a theoretical model linking students' epistemic beliefs, epistemic emotions, learning strategies, and learning outcomes. The model was tested across two studies with 439 post-secondary students from Canada, the United States, and Germany for Study 1, and 56 students from Canada for Study 2. For Study 1, students self-reported their epistemic beliefs about climate change, read four conflicting documents about the causes and consequences of climate change, self-reported their epistemic emotions and learning strategies used to learn the content, and were given an inference verification test to measure learning. Study 2 used the same procedure but added a think aloud protocol to capture self-regulatory processes and emotions as they occurred. Path analyses revealed that epistemic beliefs served as important antecedents to the epistemic emotions students experienced during learning. Students who believed that the justification of knowledge about climate change requires critical evaluation of multiple sources experienced higher levels of enjoyment and curiosity, and lower levels of boredom when confronted with conflicting information. A belief in the complexity of this knowledge was related to lower levels of confusion, anxiety, and boredom. A belief in the uncertainty of this knowledge predicted lower levels of anxiety and frustration, and a belief in the active construction of knowledge predicted lower levels of confusion. Epistemic emotions predicted the types of learning strategies students used to learn the content and mediated relations between epistemic beliefs and learning strategies. Learning strategies predicted learning outcomes and mediated relations between epistemic emotions and learning outcomes. Implications for research on epistemic beliefs, epistemic emotions, and students' self-regulated learning are discussed.

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## 1. Introduction

In today's society, students are faced with an overwhelming amount of information. A search about a complex topic can quickly become a daunting task. For example, a Google<sup>®</sup> search on climate change results in approximately 1,390,000,000 hits. As Ferguson, Bråten, and Strømsø (2012) argue, students often struggle to make judgments about vast amounts of information in terms of its relevance and reliability, particularly when there are multiple sources that present conflicting information. Moreover, when faced

with multiple sources of information, students must make decisions regarding the epistemic nature of that information. That is, students must evaluate the veracity of the information, judge whether it counts as knowledge, and decide if there is sufficient evidence to make justified knowledge claims. The processes used to make such judgments are referred to as epistemic cognition (Greene, Azevedo, & Torney-Purta, 2008; Kitchener, 2002), which can be described as cognitive manifestations of individuals' epistemic beliefs (Sinatra & Chinn, 2012), or individuals' beliefs about knowledge and knowing (Hofer & Pintrich, 1997).

Although several frameworks have been developed since Perry's (1970) seminal work, two primary lines of research have emerged. These include the developmental perspectives (e.g., Belenky, Clinchy, Goldberger, & Tarule, 1986; Kitchener & King, 1981;

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Kuhn, 1991) and those that explore epistemic beliefs from a multidimensional perspective (e.g., Hofer & Pintrich, 1997; Schommer, 1990), with some recent frameworks that integrate the two (e.g., Greene et al., 2008; Muis, Bendixen, & Haerle, 2006). Because of its prominence and conceptual clarity, we adopted Hofer and Pintrich's (1997) multidimensional framework for the present study. Specifically, Hofer and Pintrich (1997) proposed four belief dimensions about knowledge and knowing that vary along a continuum from less constructivist to more constructivist. These include: 1) the certainty of knowledge, ranging from knowledge is certain and unchanging to knowledge is uncertain and evolving; (2) the simplicity of knowledge, ranging from knowledge is organized as isolated bits and pieces to knowledge is organized as highly interrelated concepts; (3) the source of knowledge, ranging from knowledge is handed down by authority (e.g., passively acquired) to knowledge is acquired through reason or logic (e.g., actively constructed); and, (4) the justification of knowledge, which refers to how individuals consider how a proposition or belief becomes justified knowledge via personal experience and one's own subjective opinion or through systematic inquiry and integration of multiple sources of information. The first two dimensions reflect individuals' beliefs about knowledge, whereas the last two dimensions reflect individuals' beliefs about the process of knowing. For the purposes of our study, we use labels that reflect the constructivist end of these beliefs, which include a belief in (1) uncertainty, (2) complexity, (3) source: active construction, and (4) justification: inquiry, respectively.

Within the broader epistemic beliefs literature, several studies have examined the role that epistemic beliefs play in learning, motivation, and learning outcomes. For example, students' conceptions of knowledge and knowing are linked to various facets of learning, such as their use of cognitive and metacognitive strategies (Hofer, 2004; Mason, Boldrin, & Ariasi, 2010; Pieschl, Stahl, & Bromme, 2008; Strømsø & Bråten, 2010), self-regulation during problem solving (Muis, 2008), conceptual change (Mason, Gava, & Boldrin, 2008), motivation (Muis & Franco, 2009; Nussbaum, Sinatra, & Poliquin, 2008), and academic performance (Schommer, Crouse, & Rhodes, 1992). Epistemic beliefs have also been shown to relate to comprehension within and across multiple documents in various domains (Bråten & Strømsø, 2009; Ferguson et al., 2012; Strømsø, Bråten, & Samuelstuen, 2008).

Given the growing empirical evidence that epistemological thinking "matters" (Kuhn, 1999), the notion of epistemic beliefs has been incorporated into more encompassing theories, such as theoretical models of self-regulated learning (e.g., Greene, Muis, & Pieschl, 2010; Muis, 2007). However, as Bendixen and Rule (2004) argued, an important question that has not been addressed in the literature is the role that affect plays in facilitating or constraining epistemological thinking and reasoning. Hofer and Pintrich (1997) and Mansfield and Clinchy (2002) have also called for research to explore the link between emotion and epistemic beliefs, but little has been done to date. As Pintrich (2000) noted, the next generation of research on epistemic beliefs must consider the "hot" nature of these beliefs about knowledge and knowing. As such, what is still lacking in the vast majority of empirical investigations and theoretical conceptualizations of epistemic beliefs (cf., Bendixen, 2002; Bendixen & Rule, 2004; Ferguson et al., 2012) is consideration of emotions that are specifically directed at epistemic ends, which are called *epistemic emotions* (Morton, 2010; Pekrun & Linnenbrink-Garcia, 2012; Pekrun & Stephens, 2012;). These epistemic emotions include, but are not limited to, surprise, curiosity, enjoyment, confusion, anxiety, frustration, and boredom.

Following Pekrun and Linnenbrink (2012), we define epistemic emotions as emotions that are caused by cognitive qualities of task information and the processing of that information. For example,

during mathematics problem solving, an individual may believe there is only one correct solution. If, however, that individual is shown multiple correct solutions, he or she may experience frustration given that the information presented is counter to his or her beliefs. Frustration is considered an epistemic emotion if the focus of the emotion is on the cognitive incongruity implied by information that is in conflict with one's beliefs or prior knowledge. In contrast, the emotion is considered an achievement emotion if, for example, the individual is not able to correctly solve the problem and the focus is on the failure to solve the problem. In this regard, the object focus of emotions is an essential element to their definitions. Accordingly, epistemic emotions arise when the focus is on the epistemic aspects of learning (e.g., knowledge generation) and cognitive activities (Pekrun, 2006).

Although the philosophical (Morton, 2010) and academic emotions (Pekrun & Stephens, 2012) literatures have theorized about the antecedents and consequences of epistemic emotions, research is lacking with regard to exploring both antecedents and consequences simultaneously. As argued by Bieg, Goetz, and Hubbard (2013), one important aspect of research on academic emotions is the investigation of the possible antecedents, which is paramount to inform the development of interventions and instructional techniques to foster positive learning outcomes. Given the nature of epistemic emotions, it seems logical to explore individuals' epistemic beliefs as one important antecedent to these emotions, along with their consequences. As such, our research responds to these needs across diverse literatures and integrates them to propose a theoretical model linking epistemic beliefs, epistemic emotions, and students' learning.

Specifically, by drawing from several theoretical models and frameworks from the epistemic beliefs (Bendixen & Rule, 2004; Hofer & Pintrich, 1997), self-regulated learning (Muis, 2007), and academic emotions (Pekrun, 2006; Pekrun, Goetz, Titz, & Perry, 2002) literatures, we integrate these perspectives to explore the role that epistemic emotions play in mediating relations between epistemic beliefs, self-regulated learning, and learning outcomes. We first describe the models that guided our research, and then outline the theoretical framework we developed for the present research.

## 2. Theoretical models of epistemic beliefs and emotions

### 2.1. Muis's (2007) model of epistemic beliefs and self-regulated learning

Drawing on goal-oriented (Pintrich, 2000) and metacognitively driven (Winne & Hadwin, 1998) models of self-regulated learning, Muis (2007) proposed a model of self-regulated learning to establish why epistemic beliefs relate to self-regulated learning. Similar to most models of self-regulated learning (Puustinen & Pulkkinen, 2001), Muis (2007) proposed four phases of learning. The four phases include: 1) task definition, 2) planning and goal setting, 3) enactment, and, 4) evaluation. In the first phase of learning, an individual constructs a perception of the task, which is influenced by external conditions, such as context, and internal conditions, such as prior knowledge, motivation, and an individual's epistemic beliefs. During the second phase, components from the first phase influence the types of goals an individual sets for learning and the plans made for carrying out the task. A goal is modeled as a multifaceted profile of information (Butler & Winne, 1995) and each standard in the profile is used as a basis to compare the products created when engaged in the activity. The product is compared to the goal's criteria via metacognitive monitoring. Planning includes selecting the types of learning strategies to carry out the task, identifying the type of information on which to focus

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