



Hot factors for a cold topic: Examining the role of task-value, attention allocation, and engagement on conceptual change

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ABSTRACT

The primary purpose of this study was to evaluate a proposed model between learner motivation, attention allocation, cognitive engagement, and conceptual change. We hypothesized that task-value orientation (i.e., utility and attainment values) would positively influence learners' attention allocation and level of cognitive engagement which, in turn, would influence opportunities for conceptual change. A total of 291 undergraduates participated in this study. Results indicated task values were strongly associated with engagement and engagement with conceptual change. Results of structural equation modeling showed attention allocation having a direct effect on cognitive engagement, which in turn was predictive of conceptual change. Implications of our findings are further discussed along with directions for future research.

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1. Introduction

The current climate of pressure to increase student achievement in science prompted this investigation between conceptual change, learner motivation, attention allocation, and cognitive engagement. It is well established in the research literature that students draw upon their prior knowledge in science learning contexts (Duit & Treagust, 2003; Mikkila-Erdmann, 2002). Oftentimes this knowledge, based on everyday life experiences, does not align with the scientific viewpoint. Young children often hold the misconception of a flat Earth based on their everyday experiences (Vosniadou & Brewer, 1992). These misconceptions commonly interfere when learning about science concepts (Limon-Luque, 2003; Sinatra & Mason, 2008).

For example, Vosniadou and Brewer (1992) found that young children commonly have the misconception of the shape of Earth as flat. These children can undergo a process of conceptual change when they learn that the Earth is instead spherical in which they synthesize the two models (i.e., flat, round) to form a pancake-shaped model of the Earth. Over time and with additional instruction, the children typically form a spherical Earth model that aligns with the scientific viewpoint.

The process of conceptual change is typically effortful, occurs slowly over a length of time, and requires deep cognitive engagement

with the to-be-learned information (Chi, 2008). Consequently, educational psychologists have proposed theoretical models that have deep cognitive engagement as a key factor of conceptual change. Engagement is viewed on a continuum, from low to high. Low cognitive engagement decreases the likelihood of change, while high engagement increases the likelihood of conceptual change (Dole & Sinatra, 1998).

One aspect missing from the current theoretical models of conceptual change, motivation, and engagement, is attention allocation. Subsequently, we focused on attention allocation as a factor of conceptual change. We hypothesized that attention allocation would predict cognitive engagement, which in turn would predict conceptual change. Cognitive psychologists have investigated attention allocation in relation to learning from text. For example, Reynolds (1992) argued that readers are likely to allocate greater attention to text elements they deem as most salient based on task instructions.

Additionally, Gaddy, van den Broek, and Sung (2001) argued that attention allocation is central to reading comprehension, explaining, "The dynamic distribution of attention over the course of reading determines which concepts enter into the comprehension process and how they connect to each other" (p. 92). As readers attend to key ideas in the text they are more likely to critically and carefully consider them against their previously formed misconceptions, which in turn increases the likelihood of conceptual change (Kendeou & van den Broek, 2005; Sinatra & Broughton, 2011).

We used a refutation text for the present study with the goal of helping readers focus their attention on key ideas about causes of the common cold, which in turn we hoped would deepen cognitive

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engagement and thus increase the likelihood of conceptual change. Refutation texts have been found to be highly effective in promoting conceptual change (Guzzetti, Snyder, Glass, & Gamas, 1993; Tippet, 2011).

2. Background literature

2.1. Conceptual change

It is well established in the research literature that students' form conceptual understandings based on everyday life experiences and often, these conceptions conflict with the accepted scientific explanation (Duit, Treagust, & Widodo, 2008). The process through which the learner's prior beliefs are restructured to align with the scientific explanation is defined as *conceptual change* (Dole & Sinatra, 1998; Murphy & Alexander, 2008; Vosniadou & Brewer, 1987). Some examples of misconceptions about science topics commonly held by students include: photosynthesis (Mikkila-Erdmann, 2002), seasonal change (Broughton, Sinatra, & Reynolds, 2010), viral infections (Johnson & Bungum, 2013; Johnson & Sinatra, 2013), and Newtonian physics (Kendeou & van den Broek, 2005; Linnenbrink & Pintrich, 2002). Students who hold misconceptions such as these often find it very difficult to alter their prior knowledge to align with the scientific explanation (deLeeuw & Chi, 2003; Murphy, 2007; Vosniadou, 2003).

Posner, Strike, Hewson, and Gertzog (1982) proposed a theoretical explanation of the change process as well as a possible explanation as to why students' misconceptions are highly resistant to change. They described four necessary conditions that the learner must experience in order for conceptual change to occur. These conditions are: *dissatisfaction* with previously formed conceptions, and deeming the scientific explanation to be *intelligible*, *plausible*, and *fruitful*. Conceptual change is unlikely to occur should the learner lack one or more of these conditions.

Contemporary models of conceptual change propose that "hot" factors (Sinatra, 2005) such as motivation, affect, and self-efficacy play a role in the change process in addition to the four conditions described by Posner et al. (1982). The CRKM (Dole & Sinatra, 1998) describes the interaction between the message and the learner as central to conceptual change. Message characteristics include whether the learner finds the message as comprehensible, coherent, plausible, and rhetorically compelling (Dole & Sinatra, 1998). Each of these four message characteristics must be present for the possibility of conceptual change occurring (Sinatra, 2005).

Learner characteristics include the individual's background knowledge and motivational factors (Dole & Sinatra, 1998; Sinatra, 2005). Background knowledge is viewed as consisting of three key aspects – strength, coherence, and commitment – each of which influence whether or not conceptual change occurs. Strength refers to how richly connected and deeply embedded the learner's relevant prior knowledge is. The stronger the learner's prior knowledge, the less likely change will occur. The conceptual coherence of ideas is the second key aspect of the learner's background knowledge that influences change. The likelihood of conceptual change increases when the learner has less coherent ideas. The third key aspect is the learner's commitment to their previously held knowledge. Ideas that a learner is strongly committed to are less likely to change than those to which the learner is not as strongly committed.

Each of the three key aspects of the learner's background knowledge described in the CRKM (Dole & Sinatra, 1998) have a motivational focus. Motivational factors that may influence the likelihood of conceptual change include *dissatisfaction* with existing knowledge, *personal relevance*, *need for cognition*, and *social context*. Dissatisfaction is identified by Posner et al. (1982) as well as Dole and Sinatra (1998) as being a key motivational factor of the conceptual change process. Personal relevance refers to motivation

associated with "interest, emotional investment, self-efficacy, and having a stake in the outcome" (Sinatra, 2005, p. 110). It is possible that learners will find scientific information about topics like the causes of the common cold as highly personally relevant, resulting in increased motivation for learning the new information (Johnson & Sinatra, 2013). Need for cognition is described as a motivational characteristic of the learner in relation to the learner engaging with the message. Learners with a high need for cognition are likely to critically and thoughtfully weigh the new information with their prior knowledge.

Dole and Sinatra (1998) argue that the interaction between the learner and message characteristics determines the level of cognitive engagement with the new information. Cognitive engagement is described as the quality of the learner's thinking associated with cognitive strategies including rehearsal and elaboration (Linnenbrink, 2007). The CRKM suggests that engagement is on a continuum ranging from low cognitive to high metacognitive engagement.

Empirical studies that have investigated the influence of motivation on both engagement and conceptual change have employed motivational constructs from varying theoretical frameworks, including achievement goal theory and expectancy-value theory (see Johnson & Sinatra, 2013; Johnson & Sinatra, 2014; Linnenbrink & Pintrich, 2002). Collectively, these studies illustrate that different motivational constructs result in different conceptual change experiences as they differentially focus a learner's attention and engagement on varying aspects of the learning task (see also Cordova, Sinatra, Jones, Taasobshirazi, & Lombardi, 2014).

2.2. Expectancy-value theory

The contemporary perspective of Expectancy-Value Theory (EVT) is conceptualized today as a social cognitive theory of motivation, maintaining the premises that individuals are motivated to engage in tasks or behave in a motivated manner because they value the task [task values] and/or expect to do well on the task [expectancies] (Eccles & Wigfield, 2002). Within this contemporary framework of EVT, four task-values and two expectancies are defined. Of the four task-values, utility values are characterized as finding a task to be useful and/or relevant to one's present or future experiences; attainment values are defined as finding a task important because it affirms salient aspects of one's self schema; intrinsic [interest] values are characterized as finding a task to be interesting and/or enjoyable; and cost values are traditionally characterized as being the negative consequences of a task (Wigfield & Eccles, 2000). The two expectancies are termed outcome expectancies and efficacious expectancies, where outcome expectancies are defined as one's expectation that a certain outcome will occur and efficacious expectancies are defined as one's belief in their abilities to obtain a desired outcome (Bandura, 1997).

For example, using an expectancy-value theory framework, Johnson and Sinatra (2013) reported that inducing college students with either an attainment value (a motive to engage in a task because it is perceived as important to confirming salient aspects of one's self-schema) or a utility value (a motive to engage in a task because it is perceived as useful) enhanced students' engagement and conceptual change; with those induced with a utility value experiencing the greatest amount of conceptual change. Johnson and Sinatra (2013) concluded that inducing learners with a utility value focuses their attention on useful information presented in a learning task, resulting in greater engagement and conceptual change; whereas inducing learners with no value fails to activate learners' prior knowledge, and inducing learners with an attainment value may focus learners' attention on superficial information (only those pieces of information that confirm salient aspects of one's self-schema) presented in a learning task as opposed to deeper

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