Chapter 7

Computer-Supported Collaborative Scientific Conceptual Change: Effects of Collaborative Processes on Student Learning

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ABSTRACT

One problem in science education is that students neither construct in-depth conceptual understanding nor are they able to apply scientific thinking processes. A myriad of studies on conceptual change have investigated the nature and process of conceptual change, and pedagogical strategies to foster conceptual change and improve higher-level thinking. We propose a new framework - the collaborative scientific conceptual change model – to stresses the importance of high quality collaborative discourse and scientific epistemic practices in the process of conceptual change. To investigate how group interactions influence individual students’ learning gains, multilevel analysis was used to analyze the hierarchically nested data and qualitative analyses were presented to compare high and low-achievement groups’ discourse and their application of epistemic practices. The results found that predicting and coordinating theory and evidence were key practices that predicted students’ individual posttest performance and the group interactions were related to the group understanding.

INTRODUCTION

One problem in science education is that students neither construct in-depth conceptual understanding nor are they able to analyze and apply scientific thinking processes (National Research Council, 1996). A myriad of studies on conceptual change have investigated the nature and process of conceptual change, pedagogical strategies to foster conceptual change and improve higher-level thinking. One common instructional strategy is to confront
students with discrepant events, causing cognitive conflicts, which is widely accepted to be essential for conceptual change (Posner, Strike, Hewson, & Gertzog, 1982). However, other researchers propose that conceptual change is a gradual process and argue that adults, children and even trained scientists fail to change their theories when faced with conflicting evidence (Chinn & Brewer, 2001; Mason, 2003). Accordingly, other factors must be considered, such as peer interactions and engagement in the epistemic practices of science. We propose a new theoretical framework – the collaborative scientific conceptual change (CSCC) model – to explain conceptual change processes.

COLLABORATIVE SCIENTIFIC CONCEPTUAL CHANGE MODEL

This model proposes that conceptual change occurs when learners co-construct new knowledge and make a shift from naive ways of thinking towards the ways of thinking that scientists use to explain phenomena. The CSCC framework echoes with Sinatra’s urges to use multiple theoretical spotlights to understand conceptual change. Sinatra (2002) suggested the pursuit of both internal (cognitive and motivational) and external (social and contextual) aspects of conceptual change. Thus, this framework integrates three major perspectives (i.e., cognitive, social, epistemic) to explore the conceptual change process with a particular stress on social and epistemic aspects. We explore how collaborative discourse and epistemic practices mediate conceptual change in the context of using computer simulations to learn about aquarium ecosystems.

Conceptual change is not easy to achieve because students tend to use their intuition to explain science concepts, which can lead to superficial understanding that may be resistant to instruction (Chi, 2005). Posner, Hewson, and Gertzog (1982) believe that conceptual change is a rational process “by which people’s central, organizing concepts change from one set of concepts to another set, incompatible with the first” (p. 211). On the practical level, they presented four conditions that foster conceptual change. First, learners should be dissatisfied with their existing conceptions and such dissatisfaction leads to cognitive conflict. Secondly, the new conception must be understandable to learners so that they can make accommodation in their thinking. Additionally, the new conception should appear initially plausible so that learners may use that to solve problems or construct explanations of phenomena in current context. Finally, the new conception must be fruitful so that learners can transfer the understanding to other different contexts.

In addition to the cognitive aspect, other researchers noticed that the social artifacts play a role in conceptual change. Social constructivists insist that knowledge develops through social negotiation and through the judgment of the application of the ideas of others. The distributed nature of cognition suggests that conceptual change requires communication among people (Pea, 1993). As misconception research shows, students have strong tendencies for meanings to diverge. The features of collaborative learning may help students converge differentiated meanings as they construct meanings for scientific concepts. Peer discourse may create an awareness of the need for knowledge revision and encourage the deep processing needed for conceptual change (Roschelle, 1992). In addition, the intersubjective meaning-making in peer discourse helps create joint interpretations through phases of negotiation focused on shared information (Suthers, 2006). There are several benefits of collaborative discourse in student conceptual change. First, peer interactions may stimulate students to restructure their existing knowledge, which may lead to conceptual change (Smith, diSessa, & Roschelle, 1993). In addition, Roschelle (1992) suggested that by asking learners to work together on joint problems, they are faced with challenges of establishing
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