THE PROCESSES AND CHALLENGES OF CONCEPTUAL CHANGE

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Abstract. Students engaged in learning a large body of related knowledge often possess some incorrect naive knowledge about the domain. These “misconceptions” must be removed and/or the correct conception must be built in order for students to achieve a deep understanding. This repair process is generally referred to as “conceptual change.” However, although conceptual change has been discussed for several decades within different research contexts, the literature nevertheless presents a somewhat blurry picture of what exactly misconceptions are, what constitutes conceptual change, and why conceptual change is difficult. In this chapter, we suggest that one should think of misconceptions as ontological miscategorizations of concepts. From this perspective, conceptual change can be viewed as a simple shift of a concept across lateral (as opposed to hierarchical) categories. We argue that this process is difficult if students lack awareness of when a shift is necessary and/or lack an alternative category to shift into. These ideas are explored using a detailed example (i.e. diffusion) from a broad class of science concepts (i.e. emergent processes) that are often robustly misunderstood by students.

1. INTRODUCTION

When students engage in the task of learning some large body of related knowledge, such as a specific topic within a science domain (e.g. electricity or the human circulatory system), they are faced with two main obstacles. First, a great deal of information is simply missing from their initial understanding, and this new information must be acquired. However, it is not the case that students enter a learning situation with a blank slate. Instead, students often have some naive knowledge or prior conceptions about the domain.

Naïve knowledge has two properties: it is often incorrect (when compared to formal knowledge) and it often (but not always) impedes the learning of formal knowledge with deep understanding. However, some type of naive knowledge can be readily revised or removed through instruction (for simplicity, instruction in this chapter refers to the presentation of knowledge through written text). We will refer to this type of naive knowledge simply as “preconceptions”. On the other hand, some other type of naive knowledge seems highly resistant to change. These misunderstandings persist strongly even when they are confronted by ingenious forms of instruction. We refer to these robust ones as “misconceptions.” In the following list of prior conceptions, the final four items are thought to be examples of misconceptions:

1) Insects are not a type of animal (Osborne & Wittrock, 1983)
2) The heart is responsible for reoxygenating the blood (Chi, de Leeuw, Chiu, & LaVancher, 1994)
3) The earth is spherical, and people stand on top or inside of it (Vosniadou & Brewer, 1992)
4) Whales are a type of fish
5) A thrown object acquires or contains some internal force
6) An object and the shadow it casts are made of the same kind of substance
7) Electrical current is stored inside the battery
8) Coldness from the ice flows into the water, making the water colder

All naive knowledge needs to be repaired in order to promote deep understanding. The challenge is to understand why misconceptions in particular are resistant to change. Thus, although all processes of revising or removing prior conceptions can be generically construed as “conceptual change”, the terms “conceptual change” are often reserved for referring to the processes of repairing misconceptions (Hewson, 1981; Posner, Strike, Hewson, & Gertzog, 1982). For emphasis, sometimes the specific processes of repairing misconceptions have been referred to as “radical” conceptual change (Keil, 1979), “genuine” conceptual change (Gunstone, Champagne & Klopfer, 1981), conceptual change “of the extreme sort” (Carey, 1991, p. 259), or nonconservative conceptual change (Thagard, 1996); whereas the processes of repairing non-robust preconceptions have been described as belief revision (Carey, 1991), mundane (Thagard, 1990), and ordinary (de Leeuw & Chi, in preparation). We will refer to the processes of repairing misconceptions as “conceptual change” and the processes of repairing preconceptions as “conceptual reorganization”.

Although conceptual change has been discussed for several decades in the context of developmental research, science education research, and in the philosophy of science, the literature nevertheless presents a somewhat blurry picture of what exactly misconceptions are, what constitutes conceptual change, and why it is difficult. The goal of this chapter is to address these three related questions of process and difficulty in conceptual change. Because we define conceptual change as the processes of removing misconceptions, this definition is circular unless we can first establish what constitutes a misconception. To preview, we base our definition of misconceptions on the assumption that misconceptions are, in fact, miscategorizations of concepts. Thus, our first claim is that misconceptions are concepts categorized into an (“ontologically”) inappropriate category.

From such a definition of misconceptions, our second claim follows, that conceptual change is merely the process of reassigning or “shifting” a misclassified concept from one “ontological” category to another “ontological” category. “Ontological” categories have a lateral relationship to each other. In contrast, reconceptualizations that occur within the same ontology or hierarchy are better referred to as “conceptual reorganization” (Chi, 1992). Our third claim then is that this conceptual shift process itself is not inherently difficult, but is instead challenging mainly when students lack awareness of their misconceptions (i.e., they lack the knowledge that they need to shift) and/or lack the alternative (“ontologically” distinct) categories (missing categories) to which they should reassign their misconceptions. We are not denying that conceptual change can also