Internet vs. Matter: Differences in Students’ Concept Development from Elementary through High School

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ABSTRACT

Internet is an emerging complex scientific concept that children have not yet systematically learned in schools but continuously experience in their daily lives. In contrast, matter is a classic complex scientific concept that children systematically study from elementary through high school in addition to continuous everyday experiences. In this study, with two independent samples of grades 4-12 students, the authors deliberately compared these two concepts to understand the effects of formal and informal learning experiences. Understandings of Internet and matter were measured and then converted into a same interval scale through Rasch modeling. Results show that the development of Internet understanding has a much lower rate than that matter and the development of Internet understanding shows more heterogeneous than that of matter. These findings suggest that formal learning helps increase the students’ understanding growth rate while reduce variation in understanding among students.

Keywords: Conceptual Change, Conceptual Learning, Formal Schooling, Informal Schooling, Internet, Matter, Rasch Model

INTRODUCTION

Studying how school students understand complex scientific concepts such as Internet or matter has been an important and productive area of research in both science education and developmental science (e.g., Chi, 2005; Hmelo-Silver & Pfeffer, 2004; Hmelo, Holton, & Kolodner, 2000; Jacobson & Archodidou, 2000; Jacobson & Wilensky, 2006; Penner, 2000; Resnick, 1995; Resnick & Wilensky, 1998).

In science education, research on student alternative conceptions of various science concepts is a well-established domain, known as the Alternative Conceptions Movement (ACM) (Wandersee, Mintzes, & Novak, 1994). One of important findings of ACM is that “students’ alternative conceptions are tenacious and resistant to change, even when sustained, high-quality conventional instruction is offered to able, highly motivated, and well-prepared students” (Wandersee et al., 1994, p. 186). In order to further understand how school students develop scientific concepts, science educators have be-
gun to examine students’ concept development in the long-term. One particular approach to studying students’ concept development is to incorporate developmental theories to look at the degree to which students’ concept development is due to developmental constraint. For example, Liu and McKeough (2005) applied Case’s staircase developmental stage theory (Case, 1992, 1998) to examine students’ concept development on energy from elementary to high school. They found that there existed clear stage-like development of the energy concept that parallels the general stages of students’ psychological development, suggesting a strong effect of development and informal science learning. However, in another series of study on students’ concept development on matter from elementary through high school, Liu and colleagues (Liu & Lesniak, 2005, 2006) were unable to identify this similar stage-like development pattern. Instead, they found that the change pattern was more gradual and holistic, suggesting effects of formal science learning at school.

In developmental science, similar to science education research, studying children’s scientific concept development in natural and informal settings has a long history (e.g., Piaget, 1929, 1930, 1954). In the past 30 years, significant contributions to concept development have been made by seminar studies of children’s understanding of physical, biological, and mental concepts (e.g., Carey, 1985; Hatano & Inagaki, 1994; Gopnik, Meltzoff, & Kuhn, 1999; Keil, 1989; Kuhn, 1989; Spelke, Breinlinger, Macomber, & Jabson, 1992; Wellman & Gelman, 1998). In particular, the extensive developmental literature has documented that young children have already developed theory-like intuitive understanding of basic concepts in physics, psychology, biology, and other domains (e.g., Harris, Brown, Marriot, Whithall, & Harmer, 1991; Gopnik, Meltzoff, & Kuhn, 1999; Wellman & Gelman, 1998; Siegler & Thompson, 1998; Vosniadou & Brewer, 1992) and further revise their intuitive theories as they get older (e.g., Carey, 1985, 1999; Hatano & Inagaki, 1994; Simons & Keil, 1995; Smith, Solomon, & Carey, 2005). For example, Wellman and Gelman (1998) found that children have foundational theory-like understandings of physical, biological, and psychological concepts before the child has language to describe these understandings. Besides examining processes of children’s conceptual understanding, developmental researchers have investigated sources of conceptual understanding (e.g., Carey, 1999; Harris & Koenig, 2006; Piaget, 1983; Sax, 1999; Vygotsky, 1978). Carey (1999), for instance, examined students’ conceptual change in intuitive biology and compared three possible accounts for sources of conceptual development, that is, a new concept is socially constructed, developed via equilibrium, or learned based on domain-general cognitive development.

While both science education research and cognitive development research contribute to the current knowledge of how and why children acquire and develop concepts, the two fields of research have been more or less independent. On the one hand, science education research understandably focuses on the role of learning and instruction at school, but pays less attention to the specific effects of students’ cognitive development and informal learning. On the other hand, cognitive development research understandably focuses on how and why children develop their domain-general and domain-specific concepts in informal learning settings, but unfortunately pays less attention to how formal school learning could systematically change the course of conceptual change. A complete picture of students’ conceptual development would benefit from the integration of both approaches above.

There are at least two unique methodological challenges contributing to the above lack of integration. First, it is difficult to distinguish the effects of formal schooling and informal learning. Given formal schooling is a basic human right, it is generally unethical and infeasible to randomly assign some children to an experimental group with formal schooling and others to a control group without formal schooling. This makes actually impossible to design a typical experimental research design of
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