Eight Issues in Knowledge Acquisition: A Microgenetic Study of Learning in Chemistry

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This paper reports the results of an experimental microgenetic study of children learning complex knowledge from text and experiments. The purpose of the study was to address eight empirical issues identified by Chinn and Brewer (in press) as fundamental issues that should be addressed by any theory of knowledge acquisition: (a) What is the nature of the knowledge change? (b) What intermediate stages occur during knowledge change? (c) What initiates knowledge change? (d) How do different subdomains of knowledge interact during knowledge change? (e) What is the fate of the old knowledge and the new knowledge after knowledge change occurs? (f) What is the relationship between belief and knowledge? (g) What changes in meta-awareness occur during knowledge change? (h) What factors influence the answers to each of the previous issues? These issues were addressed in a study of middle-school students learning about molecules and chemical reactions.

Method

Many of the eight issues listed above can be addressed only with detailed information about fine-grained, moment-to-moment changes in knowledge over an extended duration. Therefore, a microgenetic design was employed, in which individual students were studied intensively for about 11 to 15 hours as they learned about molecules and chemical reactions.

In the study, 61 sixth- and seventh-graders participated in 11 sessions, most lasting about 60 to 80 minutes, in which they worked one on one with an undergraduate instructor as they learned about molecules, states of matter, chemical reactions, and heat transfer from experiments and texts. The instructors guided the students as the students conducted experiments and thought out loud about texts. The instructors also asked a dense array of questions designed to provide as complete a picture as possible of children's moment-to-moment and day-to-day changes in knowledge. There was also an experimental manipulation. The students studied either textbook passages or highly explicit explanations of matter and chemical reactions.

Results

Briefly, results on the eight empirical issues are as follows: (a) Most students' preinstructional knowledge was fragmented, so that successful learners moved from fragmented to more structured knowledge. Successful students also underwent conceptual change; successful learners moved from the view that matter is homogeneous and continuous to a compositional view of matter. (b) Preliminary results suggest that simply reading texts, rather than encountering anomalous data or experiencing impasses, was the major initiator of knowledge change. (c) Intensive analyses of five students' data documented at least two distinct patterns of movement through intermediate states. (d) Prior background knowledge and prior domain knowledge interacted in complex ways as students constructed new knowledge. (e) A variety of fates of old and new knowledge were documented in the five students' data. Examples include forgetting initial knowledge and replacing it with new knowledge, reinterpreting old knowledge in terms of new knowledge, and reinterpreting new knowledge in terms of old knowledge. (f) Belief and knowledge appeared to move in lock step for most or all of the 61 students; students believed whatever knowledge they were currently constructing and did not construct separate representations of a new theory that they could compare *in toto* with their old theory. (g) No changes in meta-awareness were found. (h) The experimental manipulation revealed a strong advantage for explicit explanations. Students who received explicit explanations were much more successful at constructing a molecular understanding of matter, states, chemical reactions, and heat transfer than were students who received textbook explanations. Multiple explicit explanations (e.g., highly explicit explanations of three or four chemical reactions) appear to be necessary for some students to master key concepts. Practical and theoretical implications of these findings are discussed.

Reference

Chinn, C. A., & Brewer, W. F. (in press). Theories of knowledge acquisition. In B. Fraser & K. Tobin (Eds.), *International Handbook of Science Education*. Dordrecht, Holland: Kluwer.