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REPRESENTATIONAL GUIDANCE FOR COLLABORATIVE INQUIRY

INTRODUCTION

For a number of years, my colleagues and I (see acknowledgments) have been building, testing, and refining a diagrammatic environment (“Belvedere”) intended to support secondary school children’s learning of critical inquiry skills in the context of science (Suthers, Connelly, Lesgold, Paolucci, Toth, Toth, & Weiner, 2001; Toth, Suthers, & Lesgold, 2002). The diagrams were first designed to engage students in complex scientific argumentation with the help of an intelligent tutoring system. (For the purposes of this chapter, scientific argumentation is a dialectic in which participants mutually evaluate alternative hypotheses according to their consistency with empirical evidence and related criteria such as plausibility of the proposed causal explanations and reliability of the evidence. Participants may but need not necessarily take conflicting positions.) The diagrams were later simplified to focus on evidential relations between data and hypotheses. This change was driven in part by a refocus on collaborative learning (Koschmann, 1994; Slavin, 1980; Webb & Palincsar, 1996), which led to a major change in how we viewed the role of the interface representations. Rather than being a medium of communication or a formal record of the argumentation process, we came to view the representations as resources (stimuli and guides) for conversation and reasoning (Collins & Ferguson, 1993; Roschelle, 1994). Laboratory and field trials with Belvedere provided many examples of situations in which Belvedere’s diagrammatic representations appeared to be influencing learner’s argumentation. Meanwhile, various other projects with similar goals (i.e., critical inquiry in a collaborative learning context) were using substantially different representational systems (to be reviewed in this chapter). Finding that the literature lacked systematic research on this variable, I undertook a program of exploring the hypothesis that the expressive constraints imposed by a representation and the information (or lack of information) that it makes salient may have facilitative effects on students’ argumentation during collaborative learning.

This chapter provides a summary of the thinking behind this work and the empirical studies that my colleagues and I undertook. The chapter begins with an overview of the core claims of a theory of representational guidance and discussion of these claims from cognitive and social standpoints. I then exemplify applications

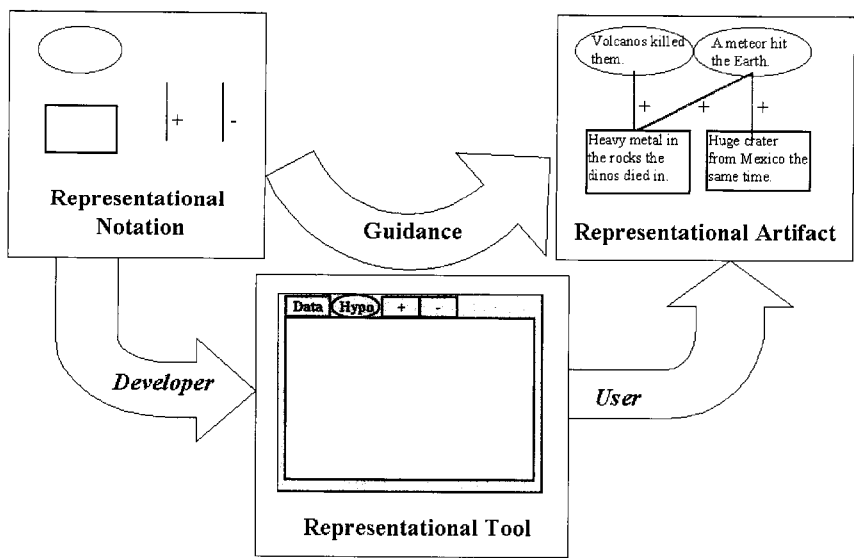


Figure 1. Flow of Representational Guidance across Notations, Tools and Artifacts

of the theory by making predictions about the effects of various representational systems found in the literature on software for inquiry learning. The third major section of the chapter summarizes research undertaken to test these predictions, including laboratory research that focused on process measures, and classroom research that focused on students’ work products. Results in both cases indicated that predicted representational effects are present, although there are interactions with other variables indicating that further study will be productive.

THEORY

In this section I outline my initial theory of how variation in features of representational tools used by learners working in small groups can influence learners’ knowledge-building argumentation and learning outcomes. In later sections I will summarize predictions I made concerning the effects of selected features of representational tools, and tests of these predictions. The discussion begins with some definitions.

Representational Guidance

Representational tools are software interfaces in which users construct, examine, and manipulate external representations of their knowledge. My work is concerned with symbolic as opposed to analogical representations. A notation/artifact distinction (Stenning & Yule, 1997), depicted in Figure 1, is critical to the theory. A

representational tool is a software implementation of a *representational notation* that provides a set of primitive elements out of which *representational artifacts* can be constructed. For example, in Figure 1, the representational notation (following Belvedere) is the collection of primitives for making hypothesis and data statements and “+” and “-” links, along with rules for their use. The software developer chooses the representational notation and instantiates it as a representational tool, while the user of the tool constructs particular representational artifacts in the tool. For example, in Figure 1 the representational artifact is the particular diagram of evidence for competing explanations of mass extinctions.

Each given representational notation manifests a particular representational guidance, expressing certain aspects of one’s knowledge better than others. The concept of representational guidance has its origins in artificial intelligence, where it is called “representational bias” (Utgoth, 1986). I use the phrase *guidance* to avoid the negative connotation of bias. My formulation was influenced by writings on “epistemic forms and epistemic games” (Collins & Ferguson, 1993) and the role of simulations in “mediating collaborative inquiry” (Roschelle, 1994). The concept of *affordances* was also influential. Indeed, it was tempting to use the phrase “representational affordances,” but see Norman (1999) for a discussion of the misuse of “affordances.” Representational guidance is closer to Norman’s “perceived affordances” than it is to Gibson’s original concept of affordances, although conventional uses of symbol systems (i.e., “epistemic games”) are also a factor.

The phrase *knowledge unit* will be used to refer generically to components of knowledge one might wish to represent, such as hypotheses, statements of fact, concepts, relationships, rules, etc. The use of this phrase does not signify a commitment to the view that knowledge intrinsically consists of “units,” but rather that users of a representational system may choose to denote some aspect of their thinking with a representational proxy.

Representational guidance manifests in two major ways:

Constraints: limits on expressiveness, and on the sequence in which knowledge units can be expressed (Stenning & Oberlander, 1995).

Salience: how the representation facilitates processing of certain knowledge units, possibly at the expense of others (Larkin & Simon, 1987).

As depicted in Figure 1, representational guidance originates in the notation and is further specified by the design of the tool. It affects the user through both the tool and artifacts constructed in the tool.

Central Claims

The central claims of the theory may now be stated as follows: Representational tools mediate collaborative learning interactions by providing learners with the means to represent emerging knowledge in a persistent medium, inspectable by all participants, where the knowledge then becomes part of the shared context. The representational notation in use constrains what knowledge can be expressed in the

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