My Knowledge of Knowledge

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Intelligent tutoring systems contain a lot of knowledge; they have to know what to teach, as well as when and how to teach it, tailored for each learner. The general goal of my talk is to discuss two programs that I've been working on recently in terms of how they work in concert to acquire and manage all this knowledge required by any ITS.

The first program is called DNA (Decompose, Network, Assess). It provides the blueprint for instruction, obtaining curriculum elements directly from the responses and actions of multiple subject-matter experts who answer structured queries posed by the computer (Shute, Torreano, & Willis, in press). The second program is called SMART (Student Modeling Approach for Responsive Tutoring), a student modeling paradigm that assesses performance on each curriculum element by way of a series of regression equations based on the level of assistance the computer gives each person, per element (Shute, 1995). On the basis of the relationship between the computed, probabilistic value and the current mastery criterion, SMART decides what to instruct next (i.e., present a different version of same curriculum element, remediate that element, or present the next element for that particular learner). This decision is further informed on the basis of the knowledge structure provided by DNA. Thus, DNA relates to the "what" to teach, while SMART addresses the "when" and "how" to teach it.

DNA works by successively decomposing the expert's knowledge into primitives, then allowing the expert to network these elements via relational information to synthesize a knowledge structure. This hierarchical knowledge structure constitutes the curriculum for instruction. DNA was expressly designed to work together with SMART to make ITS development more principled and automated, as well as to render computerized instructional programs intelligent. A critical feature of both DNA and SMART is the notion that the elements making up the knowledge structure have different "flavors" that interrelate in particular ways, each with its own simple-to-complex continuum. These knowledge types include symbolic, procedural, and conceptual knowledge.

This knowledge-type distinction is important for several reasons. First, the questions used by DNA to elicit the knowledge types vary in accord with what is being captured. For instance, to elicit procedural knowledge, the computer queries the expert for progressively more detailed step-by-step information, while conceptual knowledge elicitation focuses more on probing for relational information among concepts. Second, the three knowledge types have unique ways in which they are instructed as well as assessed. This is an important characteristic of SMART, which handles the instruction and assessment of curriculum elements. I'll provide a lot of examples of the different types of knowledge, as well as examples of different instructional techniques and assessment probes. Finally, I'll describe our attempts to create a hybrid representational scheme that embodies the range of knowledge types. This allows one to represent both procedural and semantic/conceptual knowledge within a common network structure.

In summary, my contention is that individuals possess qualitatively different types of knowledge, and there are optimal ways to elicit, instruct, and assess them. Concluding with a (loose) analogy, when you go out fishing and want to lure many fish to your line, use the appropriate bait. That is, some types of fish are attracted to squirmy worms, while others go after shiny, moving objects. It is thus critical, for effective fishing, to match bait to the type of fish you're after.

B.P. Goettl et al. (Eds.): ITS '98, LNCS 1452, p. 4, 1998.