The Adaptive Nature of Learning from Stat Lady

Kevin Gluck (KGLUCK@CMU.EDU)
Marsha Lovett (LOVETT@CMU.EDU)
John Anderson (JA@CMU.EDU)
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213 USA

Background

Over the last dozen years or so, the ACT theory of cognition (Anderson, 1983) and its successors have proven to be extremely useful for modeling student learning on a number of intelligent tutoring systems across a variety of domains (Anderson, Corbett, Koedinger, & Pelletier, 1995).. In every past example of this, however, it has been the case that the tutors were designed with the ACT theory in mind. Therefore, the utility of the ACT theory for capturing learning in non-ACT-based tutors has not been evaluated. The motivation for this project was to explore what it would buy us, in terms of understanding student knowledge and skill acquisition, to go to the effort to construct an ACT-R (Anderson, 1993) model of learning in a tutor not originally designed for a student model at the production level. In the course of this investigation, we have stumbled across an interesting auxiliary research issue that complements nicely the original student modeling agenda. It has to do with what *else* students learn when using a computer-based tutoring system, besides the curriculum objectives. To foreshadow, they acquire a representation of the structure of the environment in which they are learning, and use this knowledge adaptively to produce more efficient performance.

The Tutor

The tutor chosen for this project was the *Stat Lady Descriptive Statistics Tutor* (Shute & Gluck, 1994). It consists of five sections, each designed to teach a slightly different content area (e.g., simple frequency distributions, bar charts). Within a section there is an initial instruction portion, where new declarative knowledge and procedural skills are taught, followed by a test portion. Each test portion consists of five scenarios, and subjects select a scenario of their choice (e.g., restaurants, football). Every scenario in a section is isomorphic with the others, in that questions testing particular curriculum objectives always appear in the same order.

Participants

The first step was to get a sense for the nature and time-course of learning on the tutor. In order to have detailed data of student processes while using the system and acquiring the domain knowledge therein, we ran four verbal protocol subjects through the tutor. These subjects were required to do all the scenarios in every section, in order to produce as much performance data as possible. Two of these subjects were graduate students in the department, considered to be "experts" in this relatively simple introductory material. The other two subjects, both staff persons at CMU, had no statistics or computer science classes in college, and reported complete unfamiliarity with the domain.

Decomposition of Learning

In the early stages of transcription and coding, we noticed a qualitative shift in the approach to the tutor as a subject moved through the scenarios in a section. This led to the hypothesis that subjects were acquiring a representation of the structure of a scenario that allows them to adapt to it, such that they learn to ignore certain portions of the interface. Examples of such a component that would come to be ignored with practice are the *instructions* that accompany each activity in the scenarios. Within each scenario are instructions for what to do next and how to go about doing it, and these instructions are identical from one scenario to the next. The ACT-R theory predicts that students develop a declarative memory representation for the information in the instructions, and that this representation is strengthened with exposures across scenarios. From then on, subjects can retrieve this representation to determine what step is required next. A retrieval like this is certainly faster than re-reading the text, and so would be an adaptive behavior (provided that the goal is to move through the tutor as quickly as possible). The sub-symbolic mechanisms that drive learning and adaptation in ACT-R support precisely this sort of shift in behavior. We will use this session to present evidence from our protocol analysis that this sort of adaptation is taking place, and to discuss the implications of this for models of cognition and student learning.

References

Anderson, J. R. (1983). The architecture of cognition. Cambridge, MA: Harvard University Press.

Anderson, J. R. (1993). Rules of the Mind. Hillsdale, NJ: Erlbaum.

Anderson, J. R., Corbett, A. T., Koedinger, K. R., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. The Journal of the Learning Sciences, 4(2), 167-207.

Shute, V. J., & Gluck, K. A. (1994). Stat Lady Descriptive Statistics Tutor: [Unpublished computer program]. Brooks AFB, TX: Arsmstrong Laboratory.