ALPS: BRINGING ACTIVE INQUIRY INTO ACTIVE PROBLEM SOLVING

Scott M. Stevens, Albert T. Corbett, Kenneth R. Koedinger, Angela Z. Wagner, Chih-yu Chao, Harry Ulrich, Sharon Lesgold
Human-Computer Interaction Institute, Carnegie Mellon University
5000 Forbes Ave., Pittsburgh, PA 15213, U. S .A.
sms@cs.cmu.edu
corbett+@cmu.edu
koedinger+@cmu.edu
awagner@cmu.edu
cchao@cmu.edu
hgu@cs.cmu.edu
slesgold@cmu.edu

ABSTRACT

The ALPS project (Active Learning in Problem Solving) is building and evaluating an educational technology that combines cognitive tutors with a novel interactive questioning environment called Synthetic Interviews. Our goal is to develop an "active learning" environment that rivals the effectiveness of human tutors. The first version combines an existing cognitive algebra tutor with a virtual algebra teacher that students can query for additional help. Beta versions of the system have been used by over one hundred middle school (six, seventh, and eighth grade) students. This demonstration will allow participants to work through a simple algebra problem with the cognitive tutor while they ask deeper questions of the Synthetic Interview.

KEYWORDS

Cognitive Tutor Virtual Agent Active Learning

1. INTRODUCTION

K-12 mathematics and science education is shifting from teacher-centered "learning-by-listening" to student-centered "learning-by-doing." However, the individual attention that students require to learn with maximum efficiency is necessarily still lacking in classrooms of 20-30 students. While the peer support afforded by small-group problem solving is effective, it is less effective than the individualized support provided by the best human tutors.

The ALPS project (Active Learning in Problem Solving) is building and evaluating an educational technology that addresses this classroom need. In developing this environment, the project is building on a growing body of research regarding effective learning and tutoring strategies. It integrates a state-of-the-art educational technology called Cognitive Tutors with a novel interactive question-answering environment called Synthetic Interviews to develop an active learning environment that rivals the effectiveness of human tutors.

Over the past 15 years, Cognitive Tutors has been highly effective in supporting learning-by-doing problem solving. Cognitive Tutors are constructed around detailed cognitive models of the ways that students solve problems. They provide the help that students need in problem solving, both feedback on problem-solving actions and in-context problem-solving advice on request. Cognitive Tutors speed problem-based learning by as much as a factor of three (Corbett & Anderson 2001) and yield an achievement effect size of about one-standard deviation, compared with conventional instruction (Anderson et al. 1995, Corbett 2001). Student motivation and achievement in cognitive tutor classrooms outstrip that observed in traditional

classrooms. Students working with Cognitive Tutors are active problem solvers and Cognitive Tutors reveal students' learning opportunities in great detail. But Cognitive Tutors do not directly support the help-seeking and metacognitive skills that characterize active learners.

In contrast, Synthetic Interviews are active question-answering environments. Given a question/query, a response is automatically retrieved and presented based on both the contents of the query and its context in a dialogue space that may span numerous questions and answers (Stevens & Marinelli 1998). Synthetic Interviews have been used in educational and entertainment settings to simulate master teachers, celebrities, to serve as travel and medical information sources on the web, and to simulate customers in sales training. However, Synthetic Interview technology lacks an underlying model of learning and teaching.

Overcoming these deficiencies, this project is to build an active learning environment combining the framework and benefits of "active problem-solving" through Cognitive Tutors with the scaffolding support of "active inquiry" through Synthetic Interviews. Such an environment will support the acquisition of conceptual knowledge and its application to problem solving, engaging students in interactive "learning-by-talking" episodes and enabling and promoting active student questioning and metacognitive skills.

The project leverages natural language processing and tutorial dialog research underway in the NSF-funded CIRCLE Center and employs natural language dialog tools developed there. Several technical challenges are being addressed to interpret student utterances in the context of tutorial dialogues. Isolated successful tutorial dialogue cases are being studied to develop an understanding of how the algorithms can be effectively integrated. To extend the tutor's dialogue capabilities, a rapid authoring environment for non-programmers is being developed.

Research in effective human tutoring is scrutinized and extended to design an effective interactive learning support. The resulting "active learning" environment is being deployed and evaluated in middle school mathematics classes. So far, more than 5000 questions and variations have been collected, and around 200 answers have been created for the Synthetic Interview. This learning environment, in turn, is serving as a research tool to systematically study tutorial interventions.

In addition to developing basic knowledge of and computational modeling of learning and teaching, this project is helping transform classroom practice and educational outcomes nationally. As in past CMU Cognitive Tutor research, what has been developed is not just a technology, but full classroom curricula suitable for use in real-world schools. If the expected result of achieving the effectiveness of the best human tutors is met, this active learning environment will transform classroom practice and increase mathematics and science achievement around the nation.

This demonstration will allow participants to work through a simple algebra problem with the cognitive tutor while they ask deeper questions of the Synthetic Interview.

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