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Dear Susan;

This letter is a quarterly progress report for the On-Line Assessment of Expertise project (Grant number N00014-91-J-1529). It covers the period April, 1992 to June, 1992.

The two major accomplishments during the report period were a) we conducted three studies to further test the user interfaces and b) developed an initial integrated version of OLAE.

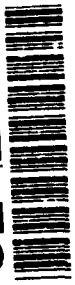
The first study conducted was designed to test two user interfaces for gathering data about a student's qualitative problem solving knowledge. Ten subjects were drawn from the Pitt introductory physics class for science and engineering majors and were each shown the two interfaces. Each subject was first introduced to the qualitative problem solving interface and taught how to use it. They were presented with 20 qualitative problems to solve. Some of the problems required multiple choice answers and some required drawing free body diagrams. All of the problems were relevant to the target chapter of their textbook (Chapter 5 - Newton's laws applied to translational motion) but were selected from different texts. After they finished answering all problems, they were asked to orally justify each answer. This first task lasted between 30 minutes and an hour, depending on the subject.

After a short break, they were then introduced to the difficulty estimation and basic approach interface and taught how to use it. They were presented with 11 quantitative problems and for each were asked to estimate difficulty and to identify a basic approach. Specifically, they were asked to specify what factors of the problem made it difficult or easy, to indicate the problem's overall difficulty on a five-point scale, and to indicate what steps they would take to generate a solution. Again, all of the problems were relevant to the target chapter, but were chosen from other texts. As expected, the first five subjects helped us identify several significant problems with the two interfaces. Subsequent analysis will be based on the five remaining subjects.

The second study that we conducted was designed to test the user interfaces for example studying and problem solving. We have already exposed students to both interfaces, but

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the subjects in our earlier study were already familiar with the material in Chapter 5. For the new study, we wanted to test how students react to the interfaces when the material in the examples and problems is novel. Five subjects were drawn from the Pitt introductory physics class. Each subject participated in a 3 hour session. First, each subject was given a 12 question pretest that tests knowledge of previous chapters, the necessary mathematics, and relevant conceptual knowledge. Each was then introduced to the system and taught how to use the poor man's eyetracker and the editors for problem solving. They were next given a photocopy of Chapter 5 with the worked out examples replaced by white space. They were instructed to read the chapter and whenever they encountered a white space, they were to read through the next worked out example using OLAE's poor man's eyetracker. They were also asked to give a verbal protocol as they studied the examples and were prompted when they fell silent.

When the subjects finished the chapter and examples, they were given a break and then asked to solve a set of quantitative physics problems. They worked until the end of the 3 hour session, solving as many problems as they could. Again, they were asked to give a verbal protocol. Initial analysis of the protocols and problem solving ability has shown that subjects who produce self-explaining behavior solved more of the problems correctly. In our subject pool, self-explainer also performed better on the pretest. Furthermore, self-explainers spent more time reading example lines on average and had a larger variance than did non-self-explainers. That is, the non-self-explainers spent about the same amount of time on all lines while the self-explainers spent much longer on some lines than on others.

The third study was designed to test the user interface for the problem classification task. Four subjects were drawn from the Pitt introductory physics class. Each subject was first introduced to the system and taught how to classify problems into categories and taught how to name the categories. They were then presented with 36 problems to sort. All of the problems were relevant to the target chapter but were selected from different texts. After they finished sorting all problems, they were asked to orally describe each category. All four subjects uncovered some significant problems with the user interface. We will draw additional subjects to test the repaired interface.

In this report period, we have also completed an initial version of OLAE, that integrates the four major components: the interfaces, a cognitive domain model (CASCADE), the bayesian inference engine, and an assessor's interface. For this initial version, we isolated the subset of the cognitive domain theory that models how people solve kinematics problems. Then for each problem in a problem set, OLAE generates a belief net. Each resulting belief net contains nodes for every action that a student might perform on the interface and nodes for every rule in the cognitive domain theory that a student might know. The belief net also has paths that represent how the rules might be used to produce actions.

When a student is then presented with a problem on the problem solving interface, the student's actions are collected. The nodes in the belief net that correspond to actions by the student are given a probability of 1. The belief net inference algorithm is then applied to infer which rules the student knows or does not know. Finally, the student model can be

viewed with a rudimentary assessor's interface.

The initial integrated version of OLAE has highlighted some difficulties with our current approach. As we expected, the generation of complete belief nets for each problem is far too expensive and will become worse when we adopt a more extensive cognitive domain model. In future versions of OLAE, we will use an incremental method for building belief nets that only builds the portion of the belief net that is necessary to analyze a subject's actions. A second difficulty with this version is that because students are able to perform a very, very large number of actions, the belief nets can have a very large number of nodes. This is true even when the belief nets are built incrementally. For example, students may write equations in many equivalent ways and may derive results in many different orders. We will partially address this problem by translating the raw actions from the interface into a simpler format for the belief net.

Sincerely,



Kurt A. VanLehn
Associate Professor of Computer
Science, Senior Scientist, LRDC

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