Higher Contributions Correlate with Higher Learning Gains

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Abstract: Students interacted with an Intelligent Tutoring System called *Operation ARIES*!,which involves two agents interacting with the human in natural language trialogs. We investigated the conditions in which the length of the students' contributions is correlated with learning. Word count and the proportional learning gains scores were correlated, especially in the later phases of the curriculum. The link between student contribution length and learning supports previous findings in human one-on-one tutoring.

1 Introduction

Previous research investigating one-on-one human tutoring sessions have reported a positive correlation between the amount of information a student contributes and learning gains [1,5]. Intelligent Tutoring Systems (ITS) with natural language interaction are often designed to use the same pedagogical techniques as human tutors [2]. Therefore, the present research will use an ITS to investigate the hypothesis that the more information the students contribute, the more they will learn. The students will interact with *Operation ARIES!* (*Acquiring Research Investigative and Evaluative Skills*), which teaches twenty-one topics related to scientific inquiry skills and requires the students to have three-way conversations (trialogs) with two animated pedagogical agents.

2 Description

2.1 Procedure

The experiment used a within-subjects design in which each college student completed the same task of learning about science inquiry skills through interacting with *ARIES*. The participants were 11 undergraduates enrolled in three diverse colleges, who were paid $100 for participating in the study which occurred over several weeks lasting 6-12 hours total. They were given a pretest on the *ARIES* material, followed by a video that explains the plot of the game aspects of *ARIES*, followed by training over multiple sessions and finally a posttest. During interaction with *ARIES*, the subjects are scaffolded by two artificial agents in order to teach the topics presented within *ARIES*. For each chapter the students read an electronic text of approximately 8 pages, answer 6 multiple

choice questions, and hold trialogs with agents on content related to the questions. Upon completion of interaction with *ARIES*, the students completed a posttest consisting of seventeen open-ended questions designed to cover the topics presented and were scored using a rubric which allowed for a maximum score of 34 points.

2.3 Analysis

 The pretests and posttests were graded by a rubric which was designed to score the open-ended questions based off of the expectations presented within the trialogs. In order to account for the varying levels of prior knowledge, proportional learning gains scores (PLG) were calculated using the formula (posttest-pretest/(1-pretest) [4] allowing for the students to be clustered into different levels of learning. Among the 11 students, there were a total of 1755 human turn contributions. These turn contributions were entered into Coh-Metrix [3] in order to extract the word count index as well as other characteristics of language that will be reported at the conference. An analysis of variance was performed on word count as a function of chapters, with the PLG clusters held as a random factor. There was a significant increase in words as a function of chapter number [$F(19,1693)=3.032$, $p<.01$], a significant effect of PLG cluster [$F(2,1693)=5.291$, $p<.01$], as well as significant Chapter X PLG interaction [$F(37,1693)=1.659$, $p<.01$]. The pattern of interaction showed that students with higher PLG scores had more words per turn, particularly for later chapters whereas students with lower PLG scores had fewer words and no change over chapters. We conclude that the size of the student's contribution positively correlates with learning, but only in later phases of the curriculum.

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