MetaTutor: Analyzing Self-Regulated Learning in a Tutoring System for Biology

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Abstract. We report preliminary data of an initial laboratory study examining the effectiveness of self-regulated learning (SRL) training versus no training on learners' ability to deploy SRL processes and learn about the circulatory system with MetaTutor. MetaTutor is an intelligent tutoring system (ITS) designed to train and foster learners' SRL processes while learning about several complex human body systems. We used a mixed methodology approach and include the results of a subset of the participants (N = 30) whose product and process data we have analyzed. Overall, the results indicate that the SRL training group significantly outperformed the control group.

Keywords. Self-regulated learning, metacognition, hypermedia, scaffolding, biology, ITS

Introduction

Learning about conceptually-rich domains with open-ended computer-based learning environments (CBLEs) such as hypermedia involves a complex set of interactions between cognitive, metacognitive, motivational, and affective processes [1-7]. During SRL, students need to deploy several metacognitive processes to determine whether they understand what they are learning, and perhaps modify their plans, goals, learning strategies, and effort in relation to dynamically changing contextual conditions.

In this paper, we provide an overview of MetaTutor, an adaptive hypermedia learning environment designed to train and foster students' learning about several biological systems. We present preliminary results of a study aimed at examining the effectiveness of SRL training in students' deployment of key SRL processes during learning. We used a mixed-methodology approach to examine the quantitative differences in learners' SRL processes. Lastly, we provide theoretically-driven and empirically-based guidelines for supporting learners' SRL with MetaTutor.

1. MetaTutor

MetaTutor is an adaptive hypermedia learning environment that is designed to detect, model, trace, and foster students' self-regulated learning about human body systems [8]. Theoretically, it is based on cognitive models of self-regulated learning [1, 7, 9, 10-12].

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The underlying assumption of MetaTutor is that students should regulate key cognitive, metacognitive, motivational, social, and affective processes in order to learn about complex and challenging science topics. The design of MetaTutor is based on extensive research by Azevedo and colleagues' showing that providing adaptive human scaffolding enhances students' learning about science topics with hypermedia (e.g., see 3,8 for reviews of the research).

2. Research methods

Participants. The entire sample consisted of 59 high school and non-science majors from a public high school and college in the mid-South. The analysis reported in this study represents a sub-set of this sample (N =30) since we only have process data (i.e., concurrent think-aloud protocols) on 15 students in each group.

Research Design. We used a mixed methodology approach to examine the quantitative differences between learners' deployment of SRL processes during learning. The MetaTutor experiment included a 2 (condition: SRL training, control) X 2 (time: pretest, posttest) mixed factorial design to explore the gains in participants' pretest and posttest scores on several human body systems. Participants were video and audio recorded during learning tasks to determine when they deployed certain SRL processes such as taking notes and drawing. This paper focuses on the data collected in day one and four of the experiment.

*Procedure***.** On Day 1**,** participants were randomly assigned to one of two MetaTutor conditions (i.e., Control or Training). All participants completed the following: (a) a 13-item SRL quiz designed to gauge participants' existing declarative knowledge of SRL, and (b) a pretest on the circulatory system. On Days 2 & 3, participants in the Training condition spent two learning sessions (1.5 hours) learning declarative and procedural knowledge about SRL. Participants in the Control condition spent 1.5 hours learning about the digestive system and receive no SRL training. On Day 4, all participants completed a 1-hour learning session during which they provided concurrent think-aloud protocols. Equivalent forms of posttests were administered to the participants. Following the learning session, participants were given the same SRL quiz that was administered at pretest.

3. Preliminary Results

Product data—Learning outcomes. The results reported in this section represent preliminary data analyses since we are still collecting data. In relation to research question one, the data show that students in the Training condition scored significantly higher on the SRL quiz after training on the SRL processes and were also able to maintain their knowledge of the SRL processes ([t (32) = - 5.02, p < .05]). Preliminary results also indicate that there was no statistically significant difference between conditions for the matching task of the circulatory system, however, there were significant differences between groups on the labeling task ([t (32) = 2.02, p < .05]) and multiple choice circulatory system tests [t (32) = 1.85, p < .05]. Training condition participants outperformed those in the control condition.

Process data – Concurrent think aloud processes. We calculated several independent t-tests on the means of the SRL processes used by learners in each of the two conditions. Results indicate that learners in the MetaTutor SRL Training condition deployed significantly more instances of five SRL processes. More specifically, those

assigned to the Training condition engaged in more prior knowledge activation, recycled goals in the working memory (WM), monitored their emerging understanding by using (positive) judgments of learning, monitored their progress towards goals during the learning session, and used knowledge elaboration as a learning strategy.

4. Summary

Preliminary results indicate that SRL training is an effective method to develop students' SRL about challenging science topics with hypermedia. A key aspect of this study is to converge the think-aloud process data, with the product data to build a comprehensive model of the underlying SRL processes and an understanding of how and when the "trained" SRL processes were deployed during learning. This is a critical aspect in developing ITSs designed to foster SRL such as MetaTutor.

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