Searching For Predictors of Learning Outcomes in Non Abstract Eye Movement Logs

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Abstract. We present a study that addressed if providing students with scaffolding about how to "integrate" science text and animations impacts content learning. Scaffolding was delivered by a pedagogical agent and driven by student's eye gaze movements (compared to controls). We hypothesized that students in the pedagogical agent condition would engage in richer learning as evidence by a more "integrated" pattern from text to animation and back, etc. In addition to eye gazes we collected pre- and post test knowledge about the domain, and open responses to explanation-type questions. We are currently analyzing these data.

Keywords. Eye tracking, pedagogical agent, plate tectonics, science learning.

1 Introduction

Previous research has shown that pedagogical agents can be effective in directing students' to acquire knowledge from diagrams representing electrical circuits, as evidenced by higher post-test conceptual scores (Ozogul, et al., 2011). Although not used in the aforementioned study, eye-tracking data have been successfully used to understand and create accurate models of user actions (Conati et al., 2005). In the present study, we explore if a pedagogical agent (compared to a control group), driven by eye-tracking data, can be used to effectively promote students' acquisition and integration of information from animations and text, and whether better integration leads to better performance on open response questions and post-test gains (compared to pre-test). We are currently analyzing these data specifically to: 1) test whether the pedagogical agent directed students to "interweave" their knowledge acquisition from text and animations, 2) examine which propositions in the text and viewing areas in the animations were attended to in each condition, and, 3) and examine the post-test conceptual items and explanations in each condition. This is being done with the goal finding useful data that could be incorporated in an online scaffolding system driven by eye tracking traces.

2 Method

2.1 Participants

This study consisted of 30 volunteer middle school students from central Massachusetts who had no prior classroom exposure to plate tectonics. Students' names were entered in a drawing for a gift card as compensation for participation in the study.

2.2 Materials

Plate tectonics activity. In this study, we used four animations and corresponding textual descriptions that were developed in earlier work (Gobert & Pallant, 2004) including: a cross section of the earth, continental-continental convergence, oceanic-continental convergence, and oceanic-oceanic convergence. An example is shown in Figure 1. Reading regions and viewing regions were defined a priori for each of the four screens, also shown in Figure 1.

Eye tracking system. The computer set-up was augmented with a Mirametrix S1 eye-tracking system to record. We were specifically interested in the order in which students acquired information from sections of the text (defined in Figure 1 as reading regions RR1-6) and their corresponding viewing regions within each animation (VR1-VR6). Backend code was written in C to identify which paragraph or area of the animation the student was looking at and to determine if all the prerequisite regions had been examined. For example, if a student tried to read the second paragraph (RR2) without viewing region 1 (VR1), then, in the scaffolded condition, a message was displayed by Rex, our pedagogical agent. A patent application is in place for this process (Gobert & Toto, 2012).

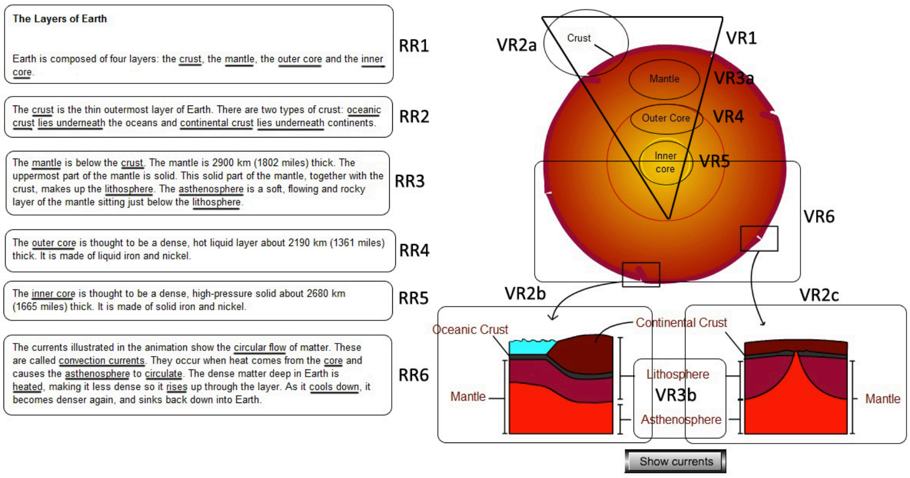

Fig. 1. Example of plate tectonics screen and the eye tracking regions.

Pre- and Post-tests. To measure content gains, we constructed 10 multiple-choice and 4 open response questions used as both pre- and post- tests. The tests were composed of questions addressing both spatial/static and causal/dynamic concepts. Static questions tested the participants' understanding of the spatial/static layout of the earth, while dynamic questions tested causal and dynamic concepts about plate tectonics-related phenomena. The open response tasks (4) asked students to write detailed explanations about each screen; for example, the first was: "*Write a detailed explanation describing the different layers of the earth and the processes that happen inside the earth. Include all the information about these layers that you can so that a friend who did not do this activity could lean about it?*"

2.3 Procedure

Participants completed a pre-test used to assess each participant's prior knowledge of the domain; this was done in small groups in a computer lab. Using a random number generator, each participant was randomly assigned to either the Rex or control condition (no Rex) and escorted to the eye tracker workstation located in another lab. Once seated at the computer, the eye tracker was adjusted to account for the height and distance of the participant from the monitor. Participants were asked to limit the movement of their head as much as possible during the calibration and data collection session to improve accuracy of the eye tracker. The eye tracker was then calibrated to the individual participant using the software supplied by the manufacturer, Mirametrix. To verify calibration, each participant was then recorded for approximately 10 seconds reading the webpage www.thisafterthat.com, which was chosen for its large text and spacing. If the calibration was sufficiently inaccurate or the eye tracker was not following the participant's eyes, the calibration process was repeated up to 3 times. The final calibration numbers were recorded for each participant and a note was included if the participant wore glasses. Students then viewed and read each of the screens, namely, Layers of the Earth, Continental-Continental Convergence, Oceanic-Continental Convergence, Oceanic-Oceanic Convergence. For those in the control condition, Rex, who was on the lower right portion of the screen, did not generate text. For those in the scaffolded condition, if the prerequisite reading and viewing regions were not viewed/read, such as reading the second paragraph without reading the first, then a scaffolding message was displayed by Rex. After each student was finished with the eye-teaching portion of the task, they were moved to another work station in the same lab and asked to answer the post-test questions and answer the four open response questions.

3 Data Scoring & Analyses

3.1 Labeling of eye-tracking data.

As previously stated, the interface is split into regions (see Figure 1). Particular key words (high in semantic value) in the reading regions and parts of images (high in semantic value) were labeled. A human coder watched video playbacks of each student's eye gaze traces and labeled segments of those playbacks with screen regions. As such, the process of manually coding the videos of eye tracking traces generated an output file with three columns: 1) timestamp of the action, 2) interface region, 3) specific area within reading region/viewing region, and 4) current simulation/screen being coded. The timestamps are based on the coder's reaction to observing the students' actions rather than the actions themselves. When factoring the video playback speed, coders' reactions aligned with the actual student actions.

3.2 Scoring of Conceptual Data.

Scoring of multiple choice pre- and post-test data was done automatically within the learning environment Science Assistments (Gobert et al., 2012), now referred to as Inq-ITS (www.inq-ITS). Scoring of open response data was done by hand; coders scored each open response tasks according to a two rubrics: one reflecting the inclusion of correct spatial/static information from the text, and one reflecting the inclusion of causal/dynamic information from the text (fuller description of a similar coding scheme can be seen in Gobert & Clement, 1999; Gobert, 2000).

3.3 Data analysis.

We are in the process of analyzing the effects of scaffolding by Rex on the various measures: eye tracking gazes, open responses, and pre-post test gains. Specifically we are: 1) testing whether the pedagogical agent directed students to "interweave" their knowledge acquisition from text and animations, 2) examining which propositions in the text and viewing areas in the animations were attended to in each condition, and, 3) and examining the post-test conceptual items and explanations in each condition. With these data, we will be able to evaluate the efficacy of Rex in guiding students' knowledge acquisition patterns as they read and viewed the animations, and whether such scaffolding lead to: more "interwoven" knowledge acquisition processes, higher post-test gains, and better explanations, as indicated by a larger amount of semantic information reflecting both spatial/static and causal/dynamic information.

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