Supporting Science Understanding through a Customized Learning Service for Concept Knowledge (CLICK)

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Problem

Educational digital libraries hold great potential to further the science education reform movement because of plethora of information made available by them. But they fall short of realizing their full potential because they adopt one size fits all approach. On the other hand the cognitive research has shown that maximum learning benefits can be achieved when the information is personalized using learners' prior knowledge, individual differences and learning styles (Bransford, Brown, & Cocking, 2000). In order to achieve maximum learning effectiveness, educational digital libraries should provide individualized learning interactions suited to each learner.

Approach

Our approach "Customized Learning Service for Concept Knowledge" (CLICK) addresses the issue of meaningful customized interactions, by taking a semantic approach to customizing student interactions with the educational digital libraries. Our approach builds on significant experience gained from research on adaptive learning environments (Shuell, 1992), conceptual browsing interfaces (Sumner et al., 2005) and conversational learning theory (Laurillard, 1993; Pask, 1975). We see the interaction between student and digital library as a dialogue in which each participant takes turn in a very specific manner. Conversational learning theory provides a framework for individualizing and adding educational value to these exchanges. The computational realization of conversational exchanges is made possible by constructing a student model, and a domain model. The student model is compared to the domain model to identify knowledge gaps and misconceptions, which are then used to guide a meaningful interaction between student and the digital library.

Concept maps are used to capture student understanding as well as the domain knowledge because research suggests that concept maps can offer effective encodings of complex science domain knowledge and are reliable representations of learner understanding and flexible models to track and assess cognitive development. In addition our prior work has shown that student using concept map based digital library interfaces to engage more with science content compared to the student using keyword base search interfaces. Besides, using concept maps provide a semi-formal way of representing knowledge therefore avoiding the issues associated with more formal knowledge representation schemes, such as ontologies and first order logic.

Scenario

Our approach to customizing can be illustrated by following scenario.

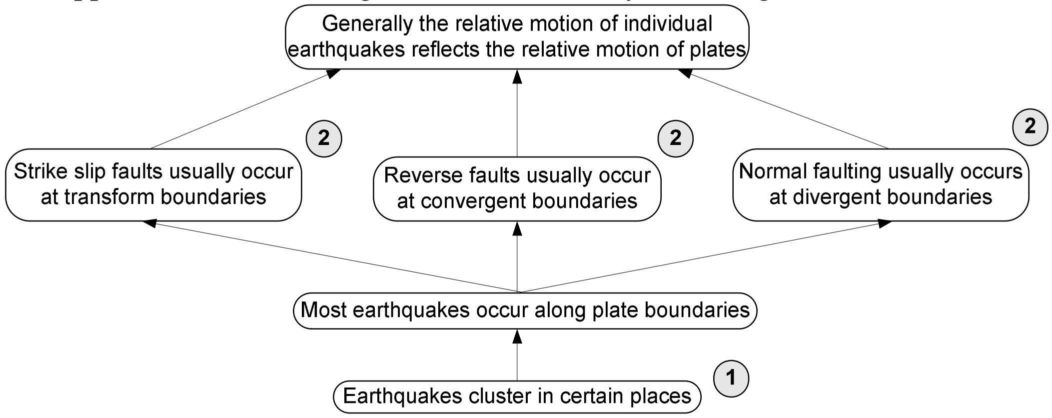

Figure 1: Partial plate tectonics reference concept map

Consider the scenario where Heather, a 12th grade science student, has been assigned the task of writing an online essay on the causes of earthquakes using Click. Click has previously processed digital library resources from DLESE to construct a reference concept map of Changes in the Earth's Surface, which includes the concepts about plate tectonics shown in the figure 1.

Heather writes that earthquakes can occur all over the world and requests feedback from Click. Click analyzes and detects critical differences between Heather's essay and node 1 of its internal reference concept map. To address this misconception, Click presents the contents of this node to Heather as a hint. Click's response makes Heather reflect on the inaccuracy of her current conception. Heather remembers that there are more earthquakes in California than in Colorado. Heather explores this difference using a DLESE resource about plate boundaries suggested by Click. This educational resource helps Heather understand that earthquakes are concentrated along plate boundaries.

Methodology

We have adopted a human-centered approach to inform the automation algorithms for constructing and comparing concept maps. Human domain experts have constructed concept maps from digital library resources and student essays. We are analyzing the human concept map construction process to inform our natural language processing algorithms for constructing concept maps. For the comparison part our human experts are going to compare student concept maps and domain concept map to identify misconceptions and knowledge gaps. From the human comparison process we will extract important heuristics for automating the comparison process. Finally, we will build customized digital library and learning environments interfaces.

What we will present

We would welcome the opportunity to discuss this work with others at the NKOS Workshop. We would be interested in sharing our human-centered design methodology, findings from the concept map construction and comparison process, and our initial algorithmic work of automating the concept map comparison process.

References

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