Leveraging Multiple Representations to Support Knowledge Integration in Plate Tectonics

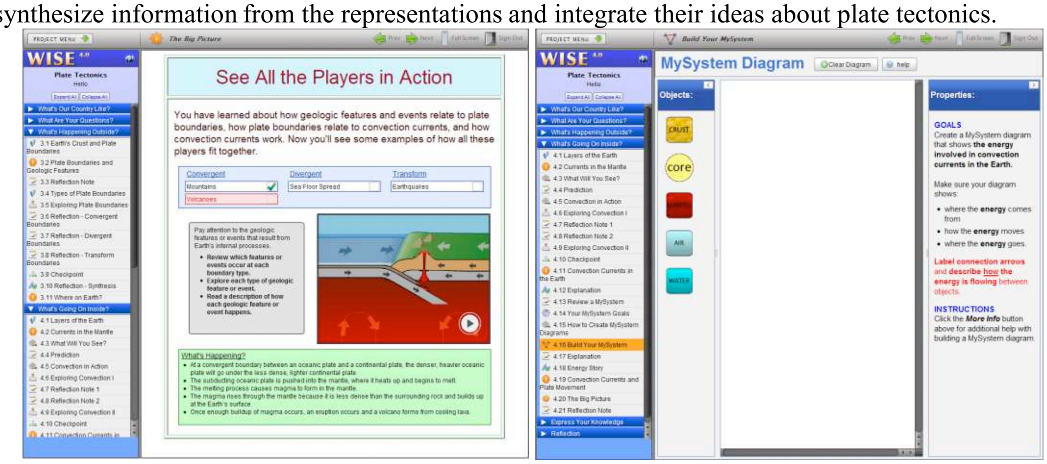
Abstract: This poster explores how students make connections between multiple representations to integrate their ideas about plate tectonics. An existing plate tectonics project was redesigned to incorporate interactive dynamic visualizations and activities in order to support students in making connections between representations and constructing a more coherent understanding of plate tectonics. Preliminary analysis of an observational study suggests that plate tectonics is a rich domain for investigating how multiple representations can support knowledge integration.

Introduction

This study examines how generating and interacting with multiple representations of plate tectonics helps students develop an integrated understanding of plate tectonics. Students study a six-day technology-enhanced curriculum project developed using the Web-Based Inquiry Science Environment (WISE, Linn, Davis, & Bell, 2004). Plate tectonics is a causal theoretical framework for past, current, and future geographical phenomena (Bencloski & Heyl, 1985). It is currently taught as an earth science unit in sixth grade in the state of California. It has traditionally been a difficult concept for middle school students, requiring students to learn about abstract processes and phenomena that lie outside of their direct experience and to integrate spatial, causal and dynamic information (Gobert, 2000). Prior studies have demonstrated that students often have difficulty integrating information from different representations and need support in making connections among them (Ainsworth, 2006). Yet the complexity of phenomena and necessity of integrating information across multiple levels make it advantageous for students to use powerful representations to learn plate tectonics.

The WISE Plate Tectonics Project

Building on a tested plate tectonics module, we revised the project based on prior results and a commitment to connect to the core scientific idea of energy (Varma et al, 2008). Guided by the integration framework (Linn, Eylon, & Davis, 2004), the revisions involved incorporating new dynamic visualizations and activities requiring students to make connections between representations as well as generate their own representations. The project elicited students' ideas about plate tectonics in the context of exploring geological patterns in the United States via maps, then guided them to link visible geological patterns on maps to sub-surface processes involving energy in plate tectonics. These included dynamic visualizations of convection in the mantle at the macroscopic level (involving heat flow) as well as at the molecular level. The project also asked students to generate explanations about the visualizations, as well as their own representations of the processes involved in plate tectonics, in ways that required them to synthesize information from the representations and integrate their ideas about plate tectonics.



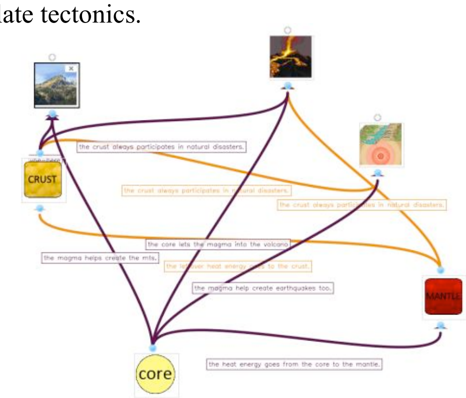
(a) (b)

Figure 1. The Plate Tectonics project. (a) A dynamic visualization of subduction. (b) The MySystem generation activity.

Methods

Nine teachers teaching 6th grade earth science classes (N≈600) implemented the newly redesigned plate tectonics project. Pre- and Post-tests were completed by individual students; project activities and embedded assessments were completed in pairs. Embedded assessments included short-response explanation prompts, reflection notes, visual models of energy transfer and transformation called MySystem diagrams (see Figure 1b), and longer narrative explanation prompts called Energy Stories (see Figure 2). Classroom observations and teacher interviews helped clarify the impact of the project.

Assessments were scored using rubrics based on the knowledge integration framework (Linn, Lee, Tinker, Husic, & Chiu, 2006). The rubric rewards coherence of ideas as represented by the number and complexity of connections students make between their ideas. We analyzed how the project helps students link ideas and representations about the plate tectonics.



The energy comes from the core and goes through the mantle, the upper mantle, the crust and back down to the core. It goes through the core by convection currents. This is how convection currents work. Well, the core is so hot and has so much heat energy it makes the molecules less dense than the air around it so it goes up. Once it goes up it doesn't have that heat source so it cools down and the molecules get less dense than the air around it so it goes back down. When it goes back down it is near the core, or its main heat source. So it goes again and the process keeps repeating. Whenever the energy goes through the upper mantle it then goes near the crust and it turns into kinetic energy. So beneath the crust the energy is going up and down and it eventually, (depending on which direction it's going), it will spread the crust through kinetic energy. So through convection currents it creates all sorts of new geological features, in the mantle, crust, and in the whole world.

(a) (b)

Figure 2. Sample student responses. (a) A MySystem diagram. (b) An Energy Story.

Results

Implementation of the Plate Tectonics project was successful. Students gained understanding of the topic as measured by pretest/posttest improvements. In interviews, teachers attributed students' progress in understanding convection to their prior experience with conduction and to the revisions of the Plate Tectonics project. Comparison of performance on Energy Stories and MySystem diagrams demonstrated that these representations elicit complementary aspects of understanding. MySystem elicits connections without requiring students to generate correct terminology. Energy Stories elicit specific, nuanced ideas and can reveal confusions about geologic terminology such as mantel. Embedded assessments showed that students make valid connections between the various representations. For instance, students explain that the molecules in the mantle become less dense due to thermal energy transfer from the core, based on a molecular simulation showing the relationship between heat and density in water. They link their understanding of the results of convection to geologic features and events on the surface such as mountains and volcanic eruptions. Thus, different representations may have different affordances for assessing student understanding. These initial findings suggest that plate tectonics is a rich domain for exploring student learning with multiple representations that are both self-generated and imposed upon the learner.

References

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