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Modeling and Case-Based Reasoning in Support of Reflective Inquiry in Earth Science

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Abstract: We describe the activities that make up a new series of design oriented earth science unit for middle school. These units are currently under development and testing.

Keywords: middle school, modeling/models, reflection, science education

The Learning-by-Design group at Georgia Tech has been developing science units for middle school that engage students in design problem solving (Kolodner, et al, 1998). While achieving design challenges, students identify what they need to learn and why, engage in investigation activities, and have myriad experiences applying what they are learning in iterative design attempts. They have ample opportunity for practicing science process (e.g., experiment design, measuring, observation), communication, planning, design, and collaboration skills. Cases, classroom rituals, and journaling prompts (design diaries) scaffold inquiry, investigation, and application, as well as reflection needed to explain failures, to extract lessons from their experiences, to develop their skills, and to acculturate themselves into the practices of science and design.

We are now developing and testing three units for earth science (erosion, earth formations, and plate tectonics). The Erosion Management unit focuses on two major issues in addition to erosion – how to make and use models and the possibility of negative “downstream” consequences of our actions. The unit challenges students to manage erosion around an outdoor basketball court at the bottom of a hill. Students develop an operational definition of models that specifies how to use a model to understand a design problem. Parts of that definition are similarity (does it look like what you see in the world?) and scale (are the pieces of it the correct relative size?). Similarity is supported by an initial activity observing erosion and erosion management in the students’ neighborhood. Physical Models are used first to reproduce what was seen and later to explore potential management methods.

The Tunneling unit continues the theme of operational definitions by using physical characteristics to identify rocks and minerals rather than their enormously variable superficial appearance. It also introduces the third criterion for models -- reliability. All models are approximations. We gain trust in them only if different models reach similar conclusions. This idea is scaffolded through the design and use of models as well as by discussion of the models used in a Nova videotape, *The Fall of the Leaning Tower*. The unit introduces abstract models by noting that maps fit the three criteria. Students create and use geologic, topographic, satellite, relief, cross section and bathymetric maps, individually and in combinations. In addition, simple physical models are constructed for, e.g., exploring how water migrates through the ground into aquifers and how physical characteristics of rock affect tunnels. Their goal is to produce a geologic report detailing the potential problems to be encountered in the construction of tunnels for a train across Georgia. They will need to pick out the places that are likely to be difficult and also where the geology is sufficiently ambiguous that core samples should be taken for further information.

Principles of Design

What we’ve struggled with most in designing our earth science units is how to provide students with useful feedback that would help them identify their misunderstandings and gradually develop deeper and more accurate conceptions. Since constructing and running working examples is not feasible, we had to find other ways afford useful , authentic feedback. We hope their use as a system will provide the kind of feedback students need.

Pinups and gallery walks Previously used for sharing ideas with others, and adding more diversity to the experience of science concepts. Feedback was less critical. For our earth science units, however, we encourage students to be critical advisors for others by distributing their expertise. Students do different investigative activities and read different cases. They become expert in certain areas and are able to provide informative critiques of each others' work.

Modeling activities Students can't construct and test tunnels, but they can model the way different kinds of soil or rock formations affect structural integrity when a tunnel is drilled, the way water travels through formations, the effects of rain on soil formations, and so on. This kind of modeling activity is integral to the work of engineers and architects. Student use of modeling as a tool of science helps them learn to build and exploit representations of real things. Benchmarks (AAAS, 1993) tell us that modeling is an important science skill for students to learn.

Exploration of multiple perspectives and representations is afforded by the wealth of maps available. Each highlights different earth characteristics. We introduce students to maps as models – each type of map focuses on different properties and therefore employs a different representation. Each affords answering different questions. Students might reason based on one set of maps and critique based on another set.

Reading about and reasoning about real-world cases (Kolodner, 1997; Dahger, 1997). Our earth science design challenges require much knowledge about geologic processes and their influence on construction. We write cases to focus on three issues (Kolodner, 1993): the problem the geology posed; the way those challenges were handled; and what happened as a result. Students extract rules of thumb that connect our knowledge about the earth to our ability to manipulate it.

Commentary and critique by experts During a design challenge, a visiting expert can critique students' ideas and ground the challenge in personal experience. Later, an expert critique can clarify lessons learned, helping to fill in gaps.

We can't expect students to know how to do modeling or to use cases right away, or even to be expert in useful critiques of their peers' design ideas. We therefore take a developmental approach to helping students learn these skills (Vygotsky, 1978). They use the above activities to develop expertise in those skills while they are learning earth science.

References

American Association for the Advancement of Science. (1993). Benchmarks for science literacy: Project 2061. New York: Oxford Press.

Barrows, H. S. (1985). *How to design a problem-based curriculum for the preclinical years.* NY: Springer.

Dagher, Z. R. (1997). The case for analogies in teaching science for understanding. In J. J. J. Mintzes, H. H. Wandersee, and J. D. Novak (Eds.). (1997). Teaching Science for Understanding: A human constructivist view. (195-211). NY: Academic Press.

Kolodner, J. L. (1993). *Case-Based Reasoning*. Morgan-Kaufmann Publishers. San Mateo, CA.

Kolodner, J. L. (1997). Educational implications of analogy: A view from case-Based Reasoning. *American Psychologist,* 52, 35-44.

Kolodner, J.L., Crismond, D., Gray J., Holbrook, J., & Puntambekar, S.(1998). Learning by Design from Theory to Practice. *Proceedings Third International Conference of the Learning Sciences '98,* pp.16 - 22.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, Mass.: Harvard University Press.

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