4.2 AN INQUIRY-BASED LEARNING STRATEGY FROM THE VISUAL GEOPHYSICAL EXPLORATION ENVIRONMENT (VGEE)

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1. INTRODUCTION

A key aspect of mature scientific understanding is the ability to connect fundamental theories about nature to direct experience of a natural system or, from the instructional point of view, the ability to connect the ideal learned in the classroom to the real event observed outside. Research suggests that novice learners in traditional lecture-driven classrooms with tightly scripted laboratories have particular difficulty in connecting classroom theoretical knowledge to their own experience.

Our own research suggests that inert knowledge is also a problem in the context of the atmospheric sciences. In September of 1999 and 2000, we interviewed students who were enrolled in or had completed an introductory meteorology course at the University of Georgia. In the 1999 study, student interviews included questions on basic processes like convection that are fundamental to the atmospheric sciences. We found that even the minority of students that could successfully define these processes had difficulty relating them to other processes or concepts. Students in the 2000 study had difficulty identifying fundamental processes within three-dimensional visualizations of atmospheric phenomenon. The difficulty students had in both of these activities, relating concepts and finding evidence for known processes in realistic phenomena, emphasize the gap between "classroom knowledge" and the ability to explain and understand real world meteorological events.

The Visual Geophysical Exploration Environment (VGEE) uses technology to offer stepping stones for students. Idealized concept models, small Java simulations of relatively simple physical systems, are available to students to help them learn and conceptualize fundamental physical processes. A five dimensional (three spatial dimensions, time and multiple variables) visualization environment allows students to explore the structure and evolution of geophysical phenomena that are represented by either observed data or data from simulations using complex numerical models of fluids. The chief innovation of the VGEE is the ability to use the idealized concept models as probes within the 5d visualization of geophysical processes. This provides a bridge between the idealized concept model and the real world represented by the 5d visualization. It also gives the students direct practice in seeing the relationship between their idealized knowledge and the behavior of a particular phenomena. Students are supported in this transfer by an inquiry-based curriculum

2. VISUALIZATION ENVIRONMENT

The core of the VGEE is a five-dimensional visualization environment in which students construct their own representation of geophysical phenomena from data sets generated by observation or by complex numerical models. Visualization offers a number of advantages for student understanding: it exploits a natural human talent, removes mathematical skill as a barrier to understanding, develops useful skills that can be applied even outside the sciences and provides an interesting "hook" to stimulate inquiry (Edelson, 1995). Learner-constructed visualization offers additional advantages beyond passive visualization: learners construct more robust and integrated understandings and avoid oversimplified cartoons. As an example, students are often introduced to frontal systems using a series of two-dimensional, highly idealized views of midlatitude systems. The complex task of integrating these views into a time-varying three-dimensional phenomenon is left to the learner. Further, the simplicity of the visualizations often frustrates their attempts to identify fronts in real weather observations. The visualization environment provides for simple integrated movements between different perspectives, allowing students to naturally construct a three-dimensional understanding and gives learners direct experience with the complexity of real data.

Our visualization environment is built in Java, using both UNIDATA MetApps (http://www.unidata.ucar.edu/metapps) and VisAD (http://www.ssec.wisc.edu/~billh/visad.html) objects. The Java- VisAD-MetApps development environment was chosen because of its platform independence, easy integration with other components of the VGEE, ready implementation of client-server architecture, and the easy extensibility provided by its open architecture and vigorous development community. Figure 1 shows the visualization environment.

3. CONCEPT MODELS AS PROBES

The VGEE includes a number of idealized computer simulations to give learners the ability to explore and discover fundamental meteorological concepts without the distractions of the complex, real-world interactions. One concept model explores adiabatic processes and buoyancy. Learners can vary the initial temperature and dew point of a parcel. As the parcel rises, learners see the molecules of the parcel slow in response to the expansion of the parcel. Once the parcel reaches the learner-specified height, it continues to rise or begins to fall according to its relative buoyancy. Learners use this concept model to isolate and systematically examine buoyancy driven vertical motion. This concept model also gives learners a perspective on buoyantly that relates to the kinetic theory of gases.

In the VGEE learners use the concept models as

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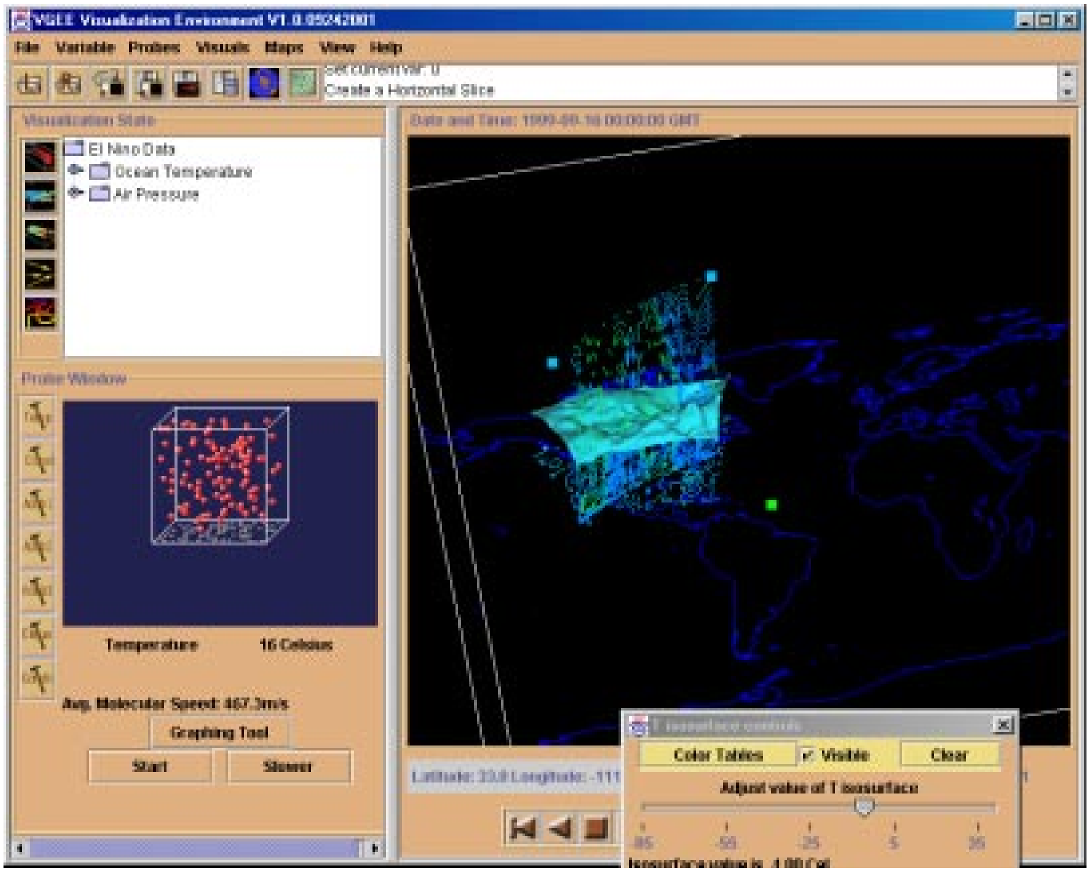

Temperature 16 Celsius

Avg. Molecular Speed: 467.3m/s

Latitude: 23.8 Longitude: -111

Isosurface value is 4.00 Cel

Figure 1: The Viszualization Environment of the VGEE. A Temperature probe is visible in the lower left.

probes to explore the role of fundamental processes in the context of realistic and complex natural phenomena. They do this by moving a pointer around inside the visualization environment and the concept model/probe responds according to the local conditions experienced by the probe. In this case, the visualization serves as a surrogate for real world phenomenon and students use the understanding gained in the concept model to explain relationships in the phenomenon they explore. In essence, the probe provides a model of transfer and addresses the gap between the classroom and nature. Figure 1 shows an example of the temperature concept model in the lower-left hand corner of the visualization environment.

4. AN INQUIRY STRATEGY

In our investigations, we found a significant number of students, particularly first year students, weren't systematic in their inquiry. The VGEE includes a loosely structured curriculum that models an inquiry process. In the first step, *recognize*, learners construct a number of 5d visualizations and look for patterns in and among variables. In the second step, *relate*, learners identify and isolate key patterns and relations between variables. For example, a student might wonder why clouds always seem be in the same regions as upward motion. *Explain*, the third stage, explores these relations using concept models. *Integrate,* the last step of the inquiry strategy, uses concept models as probes and explicitly requires that students transfer their knowledge from the theoretical to the practical.

5. CONCLUSION

Numerous national documents (e.g. *Geosciences Beyond 2000*; *Shaping the Future*) have identified weaknesses in science education and recommended strategies for reform. These strategies share a number of common features; they are hands-on, inquiry—based and they exploit new and emerging technology to develop tools that extend beyond what can be done in the classroom. We feel that the VGEE fits in with these recommendations by offering a technology-mediated, inquiry-based approach that helps students connect theoretical and abstract understanding to real world meteorological phenomena.

7. REFERENCES AND ACKNOWLEDGMENTS

Edelson, D. C., Brown, M., Gordin, D. N., & Griffin, D. A. (1999, February). Making visualization accessible to students. GSA Today, 9(2), 8-10.

Geosciences Beyond 2000 (NSF 00-28).

Hay, K. E (1999). The Digital Weather Station: A Study of Learning with 5D Visualization. A paper presented at the annual meeting of the American Educational Research Association, Montreal, Canada.

Shaping the Future: Volume II: Perspectives on Undergraduate Education in Science, Mathematics, Engineering, and Technology (NSF 98-128).

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