THE TECHNOLOGY BEHIND A VIRTUAL EXPLORATORIUM:
A RESOURCE FOR DISCOVERY-BASED
LEARNING IN THE GEOSCIENCES

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1. INTRODUCTION

The Virtual Exploratorium (VE) is an electronic geoscience learning environment. Much of this environment will be constructed on the Internet, with interactive elements developed in the Java programming language. Distribution of educational materials over the Internet has become a very common way for instructors to gather a little extra knowledge and gain valuable ideas as they prepare for their classes. By making this environment web-capable, it is added to the ever-increasing pool of knowledge available to today's teachers.

The VE was born from the ever-obvious shift from a static, passive, teacher-centered learning format to the more active, learner-centered environment. The design is focused primarily on students in undergraduate survey level courses.

For many, such a class may be the only science course they will take in their college career. Yet basic principles of scientific thought (i.e. - discovery, analysis, deduction, etc.) are vital to everyday life -- regardless of whether or not they ultimately become a scientist. It then is incumbent on this specific course to teach the student how to think like a scientist -- discovering and analyzing relationships.

2. GOALS

The goal of this project is to therefore encourage discovery-based geoscience learning by engaging the students to think, act, and make decisions just like a scientist. This actually means developing an environment that has access to a wealth of information and references (as a scientist would), while also not allowing a non-

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scientist to get completely lost in the whole effort. To give the students a sense of scientific enquiry, they will be provided access to real datasets and a visualization environment. However, to aid the exploration and further their understanding, interactive educational materials are linked to the datasets through visualizations, interactive models, and tools.

3. JAVA/INTERACTIVITY

The Exploratorium will use the Java programming language to develop interactive data-exploring tools and tutorials. Java has been recognized for years as a leading method for developing interactive elements on the Internet. Its object-oriented and therefore extensible nature lends itself to future development of the VE as important components of the code can be reused. In instances where a more simple interactive model is needed, software such as Shockwave and Flash (from Macromedia Inc.) can serve as more than adequate substitutes.

4. VISUALIZATION

The visualization environment will be constructed using the VisAD Java component libraries, developed by the Space Science and Engineering Center at the University of Wisconsin, UNIDATA, and the National Center for Supercomputing Applications at the University of Illinois.

5.1 VisAD Benefits

VisAD has many benefits for its use as our visualization environment. First of all, VisAD is written entirely in Java and would therefore be best suited for integration with Java-based aids and tutorials. It will also be constructed in such a way that you would now be able to utilize a visualization environment on your own web browser. Second, VisAD supports interactive 3D, so viewing 3D data sets and a pointer in 3-space
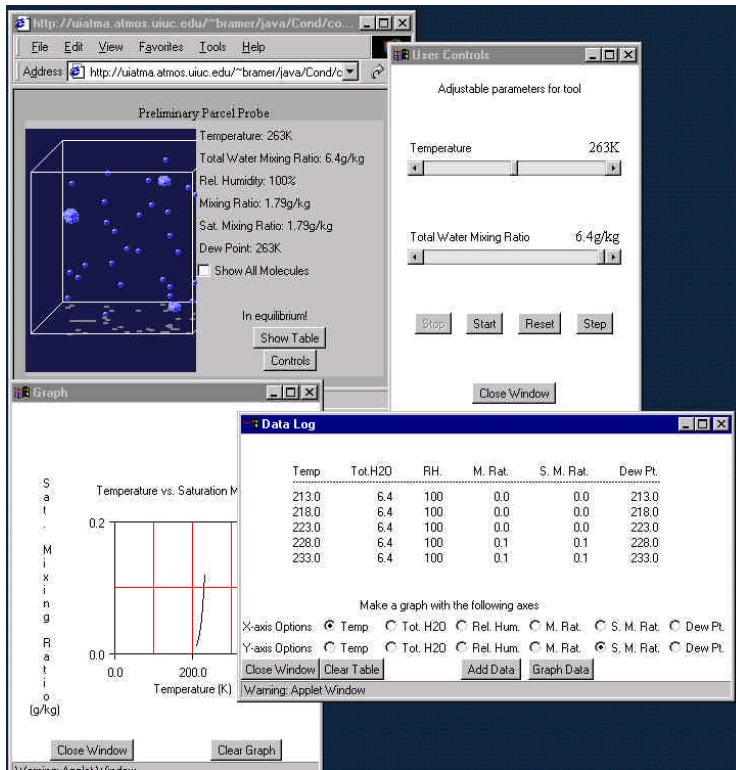
Fig. 1. Example screen shot of Condensation Tool Tutorial

are already possible. Third, VisAD has many classes in it to support a myriad of data file types -- so modeled visualization data can come from many sources and many people. Finally, there is development underway within the VisAD development group to finish a collaborative application -- in other words, a means for an instructor to manipulate the visualization while the same changes occur to each of the student's desktops.

5.2 VisAD Performance

Early on, the performance of Java for intensive 3D applications was a question mark, mainly having to do with large files and their download speed. However, improvements over the past year in the Java development and fine-tuning of VisAD have alleviated some of these concerns. Meanwhile, there has been steady improvement in microprocessor speeds and Internet bandwidth.

6. TOOL EXAMPLE

The goal of each tool implemented is to help the student learn a specific geoscience principle that a normal scientist would use when examining the data.

6.1 Data Set and Exploration

For example, a student may be studying El Niño and have a three-dimensional dataset displaying water content. They know from earlier studies that areas just below locations of higher water vapor content receive a greater amount of rainfall. They are then challenged to ask whether or not this observation (high levels of atmospheric water vapor) is indeed related to a higher rainfall in the El Nino datasets.

6.2 Using the Tool Tutorial

To learn more about how water vapor can turn into liquid water, and eventually rain, they can use the condensation tool tutorial. This tutorial allows a student to prescribe the initial temperature and moisture examine the relationship between temperature, moisture and relative humidity. For example, if the temperature is changed for a given moisture content, the relative humidity increases or decreases depending on the temperature change. Ultimately, if there is sufficient cooling, one observes condensation. The student notes that the water vapor happens to condense into tiny droplets when either the total humidity is increased, or the temperature of the volume is decreased.

6.3 Using the Tool in 3D-space

They can then apply this tool in three-dimensional dataset by using a 3D-space probe that can retrieve information from the data and transmit it to the condensation tool -- only now instead of the student changing the temperature and humidity of the volume, they move the 3D space probe around and view what the volume in that location is doing. They then see, in regions of highest water content, more of the water in a liquid form.

6.4 Result of Exploration

This simple experience has allowed them to notice a relationship (in this case, between water content in the atmosphere and rainfall amounts) and analyze it. They discover more information about water and its properties as well as condensation.

7. DLESE

The Digital Library for Earth System Education (DLESE) is a new effort in the

Geoscience community to develop an Internet library of educational resources. Such a library would help give teachers rapid-access to educational materials, data, and the information necessary to use them. In order for DLESE be successful, it would require the community to develop and share their content. The VE would serve as a powerful resource within DLESE.

8. ACKNOWLEDGEMENTS

9. SEE ALSO

Marlino, el al., 2001: A Digital Library for Earth System Education (DLESE). *Proceedings of the 10th Symposium on Education.* Albuquerque, NM, American Meteorological Society

Pandya, et al., 2001: Using the Virtual Exploratorium to Support Inquiry-Based Learning in Introductory Geoscience Courses: An ENSO Example. *Proceedings of the 10th Symposium on Education.* Albuquerque, NM, American Meteorological Society