THE DESIGN AND IMPLEMENTATION OF MULTIMEDIA WEB-BASED INSTRUCTIONAL MODULES IN K-12 EDUCATION

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1. INTRODUCTION

Since its initiation, the Internet has exhibited an enormous potential to transform science education as we know it. Physical walls of the classroom no longer exist within the Internet, as we now have the ability to access data and information from around the globe. From e-mail to the World Wide Web, the Internet opens the door to an unprecedented arena for obtaining and exchanging information. However, it is becoming very apparent that we traverse this "super highway" with a coarse road map as we are increasingly confronted with the intriguing problem of finding ways to effectively use this powerful resource for the purpose of science education.

In light of this, members of the Department of Atmospheric Sciences (DAS) at the University of Illinois (UIUC) have taken up the challenge to provide extensive and broadly useful educational resources over the Internet. A select group of UIUC faculty and students is engaged in the development of multimedia instructional modules that are Internet accessible through The Daily Planet™ (TDP) (http://www.atmos.uiuc.edu/) web server provided by DAS. These modules take advantage of the latest innovations in the field of multimedia information technology to introduce and educate students on fundamental topics in atmospheric science. Such multi-media instruction provides an alternative approach to learning, where the student, through interaction with the computer, becomes actively involved in the learning process. The purpose of this paper is to describe our activities in the development of multimedia modules, their usage in the classroom, and the creation of an interactive learning environment.

2. MULTIMEDIA INSTRUCTIONAL MODULES

Several faculty from UIUC, along with project partners at Northwestern University and the Exploratorium museum in San Francisco, are participating in an NSF-funded project known as "Collaborative Visualization" or CoVis (http://www.covis.nwu.edu). The objective of CoVis is to enhance Earth and Environmental Science education at participating high schools through project-based inquiry that is aided by a new generation of telecommunications and computing technologies. CoVis provides students with the opportunity to work and learn in an environment consistent with that of the

scientific community. CoVis has focused on three areas; 1) project enhanced science learning (PESL), 2) collaboration, and 3) scientific visualization, as a means for creating learning communities and transforming science education as we know it. In this process, we have worked with high school teachers in the development of activities to transform their classrooms from traditional teacher-centered classes to project-enhanced classes in which students learn about science through personal and group inquiries (Ramamurthy & Wilhelmson, 1994).

An important UIUC contribution to the CoVis project is the development of web-based multimedia instructional modules for use by the CoVis community, which not only includes teachers and students, but also research scientists, museum-based informal science educators, and science education researchers. The instructional modules are designed to play an integral role in this new approach to science learning. Through the use of colorful diagrams, video and audio, scanned images and text, these modules introduce and discuss essential concepts in atmospheric sciences as they arise in project science inquiry. The first generation of modules, which explored forces responsible for winds and techniques for reading weather maps, were designed using the Hypercard interface from Apple and were therefore, not network accessible. However, given the increasing usage and popularity of the Internet, effort was redirected towards the development of instructional modules using World Wide Web technology and all modules are currently available on The Daily Planet™.

Early web-based modules focused on topics such as Pressure, Forces and Winds, and Interpretation of Weather Maps and Satellite Images. Through the use of colorful diagrams, video clips, text, and audio narration, a student becomes acquainted with topics like high and low pressure centers, how to identify such features on weather maps, and what role they play in the generation of wind. Two Chicago-area high schools (Evanston and New Trier) incorporated appropriate resources from these modules into their curriculum and these modules have been revised based upon feedback given by teachers and students (Ramamurthy & Wilhelmson, 1994).

More recently completed modules deal with topics such as Atmospheric Optics, Cloud Classification, and Severe Storms. Brilliant slides depicting these phenomena have been scanned in and are accompanied by descriptive audio, text, and schematic diagrams. The Guide to Atmospheric Optics, for example, introduces students to an array of optical effects from rainbows to sundogs and sunsets to mirages. Schematic diagrams and text explain processes responsible for the development of such phenomena, like reflection and refraction. The Storm Spotters Guide contains an impressive collection of slides (provided by NOAA) and descriptive text designed to educate students about severe weather.

Other modules nearing completion focus on; 1) Fronts, where students learn about the various types of fronts and their influence on the weather, 2) Midlatitude Cyclones, where students investigate the evolution of cyclones from cyclogenesis to dissipation, examine surface and upper-level features, while relating this to an "actual" case study on the infamous "Storm of the Century", 3) Weather along Coastlines, concentrates on land/sea breezes and their role in the development of lake effect snow, and 4) Weather Forecasting. The forecasting module carefully steps through the processes meteorologists use when preparing a forecast, introduces general forecasting methods, interprets key weather maps and images and provides valuable tips to improve the student's forecasting ability. Since all our completed modules are Internet accessible through TDP, their usage is not

limited to the CoVis project, and, in fact, they are being accessed daily by users across the network. User feedback and comments have helped shape the design of current and future modules.

3. NEW DEVELOPMENTS

With the CoVis community having expanded from two Chicago-area high schools to more than forty high schools and elementary schools from Texas to New Jersey, the next step is to integrate the modules with other on-line resources on the CoVis Geosciences Web Server that is currently under development. One example already under construction is the integration of module pages into the new web-based CoVis Weather Visualizer, which is discussed in more detail in a companion paper (Ramamurthy *et al.* 1995). The visualizer allows users to generate customized weather images from real-time weather data. Also included are built-in helper sections to provide useful information about the weather features available in the visualizer (for example, fronts, radar, etc.). They are accessible by simply clicking on the word in question. For example, if the user clicked on "Frontal Analysis", module pages comprised of descriptive text and images would be accessed that not only introduce the various types of fronts, but also clarify how to identify fronts on weather maps, and their importance in interpreting the weather. Figure 1 depicts one of the many instructional module diagrams that have been incorporated into the helper section provided by the CoVis Weather Visualizer. The purpose of the helper sections is to equip the user with the knowledge and skills required for valuable and correct interpretation of images generated by the weather visualizer.

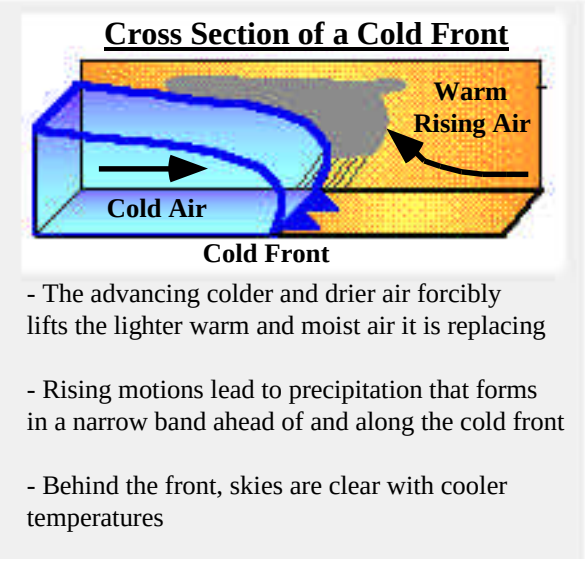

Figure 1. A three-dimensional cross-section across a cold front taken from the **Fronts** instructional module. This resource has also been incorporated into the helper sections of the CoVis Weather Visualizer.

UIUC will also be conducting weekly interactive weather briefings for the CoVis community via Apple Quicktime Video Conferencing software (QTC). Using the shared window capability of QTC, downloaded images will be viewed by both student and meteorologist as the briefing is conducted. Prior to the briefing, however, students will have access to instructional modules that provide essential background material describing weather maps and images that will be presented during the briefing. This allows the student to spend more of his/her time concentrating on the weather itself rather than on how to read the maps.

Future advances in web-technology point to a transformation of web-browsers to more "active" learning tools. Through the combination of new technologies and the hypermedia modules, our goal is to create an

interactive learning environment by increasing the amount of interactivity between student and computer. For example, *Hot Java* technology (currently under development) involves the distribution of programs, or "Applets", that would support highly interactive images that run locally on the user's machine. Interactive weather maps, for example, would provide students with the capability to click on unfamiliar features, like a cold front and access module pages (as in figure 1) that provide useful information about cold fronts. Such technology would also enable students to generate and modify weather maps and visualizations locally on their machine, without having to repeatedly send requests across the network.

In addition, selected modules will also contain student activities and quizzes that will not only foster an interactive learning environment, but will also reinforce and assess a student's understanding of the concepts introduced. Instructional web-based weather scenarios comprised of module pages instruct students on the factors contributing to the development of selected weather phenomena, for example, winter storms. These scenarios are an integral part of a CoVis Interschool Activity (CIA), which is one of many projects coordinated and supported by CoVis personnel. In a step-by-step manner, students use actual weather data to learn about the importance of low-level moisture, jet streaks, and other features that play a role in the development of snowstorms. Helpful module pages support the weather data and prepare students for embedded quiz questions. By using clickable image-maps, a student, for example, may be asked to identify the jet stream on a weather map by pointing and clicking where he/she thinks the jet stream is located. The type of response given would be based upon whether or not the answer was correct. These modules strive to create a more interactive environment where the student becomes an active participant in the learning process.

As a requirement for successfully completing the CIA, students are asked to construct their own weather scenarios and present them to members of the class and/or the CoVis community. Another portion of the CoVis Geosciences Web Server, discussed in a companion paper (Ramamurthy *et al.* 1995), will contain a collection of project-based activities, including CIA's, that provide teachers with practical applications for data, student mentoring, and other Internet resources.

4. CONCLUDING REMARKS

Given the challenge of providing valuable educational resources on the Internet, the CoVis group at UIUC is developing multimedia instructional modules that introduce and educate students on selected topics in atmospheric science. The hypermedia modules take advantage of the latest innovations in the field of multimedia information technology and contain text, colorful diagrams, scanned and animated images, and audio and video clips. These web-based materials are Internet accessible through The Daily Planet™. A practical test-bed for these modules is accomplished through UIUC's participation in the NSF-funded project CoVis. Participating CoVis high schools integrate appropriate resources from these modules into their curriculum and these modules have been revised based upon their feedback. This process is part of a collaborative effort to create an interactive learning environment, where students become more actively involved in the learning process through increased interaction with the computer. Our vision at UIUC is to deliver extensive and broadly useful multimedia resources over the Internet in support of diverse project inquiries. The multimedia

modules are not only improving education at the K-12 level by making it more interactive through the use of advanced computer technologies, but are also providing a collection of curriculum resources for the whole Internet community (Ramamurthy & Wilhelmson, 1994).

ACKNOWLEDGMENTS

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