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ABSTRACT

The state government of West Virginia has been motivating a reform of high school science and technology education by actively funding projects that lead to innovative computer-based teaching techniques. Faculties at Marshall University (Huntington, West Virginia) have been active participants in this reform, and have been developing computer-based interactive multimedia models for high school students. These models are designed to promote and enhance high school science education, particularly in remote Appalachian high schools that lack ready access to either extensive laboratory equipment or computer resources, and to help high school teachers utilize computer technology in the classroom. The primary benefit of the models for students is that they learn the scientific processes of making their own hypotheses, and proving or disproving them using inferences, analysis, and critical thinking skills. (AEF)

Research Paper: Connecting Technology to Teaching and Learning

Interactive Computer Models for Science Education

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Abstract

At Marshall University, science faculties are developing computer-based interactive multimedia models for high-school students. These models are designed to promote and enhance science education among high-school students and help high-school teachers utilize computer technology in the classroom. This paper describes a development project funded by the government of the state of West Virginia for the last three years. The developed models are designed to promote science education in remote Appalachian high schools that lack ready access to either extensive laboratory equipment or computer resources. The paper describes the computer models and highlights the authors' experience working with high-school teachers.

Introduction

Concepts of teaching and learning, such as interactive learning, fostering critical thinking, and pragmatic teaching, have taken a major role in education, especially in the fields of science (Miller & Cheetham, 1990; Trimbur, 1989). Many educational organizations, such as the National Association for the Advancement of Science and the National Research Council, are calling for interactive learning and the involvement of both high school and college students in investigative/interactive learning of science (Soloway et al., 1997). To increase the knowledge of science and promote interest and enrollment of high-school students in basic sciences, these organizations recognize and stress the need for new techniques for teaching traditional science concepts in an innovative and stimulating manner.

In West Virginia, the state government is motivating a reform of science and technology education in high schools. The state government is actively funding projects that lead to innovative teaching techniques using current computer technology. The goal is to bring a change in how students learn course content and become active learners with critical- and creative-thinking abilities.

Faculties at Marshall University have been active participants in the reform process. The authors developed a set of computer-based interactive multimedia models to promote science education. The models are used by a selected group of high schools in the state, and are taught by science teachers in a variety of courses including Coordination and Thematic Science, Environmental Earth Science, Chemistry, Honors Chemistry, Applied Biology, Advanced Biology, AP Biology, Anatomy, and Independent Study. Using these models, students work with real-world scenarios and learn the science behind those scenarios. The models interactively teach students the concepts of basic sciences using a multidisciplinary approach. The rest of the paper addresses salient features of the developed models and how they help increase students' learning of science concepts.

The Computer Models

For the last three years, the authors received funding to develop, for high-school students, intuitive and interactive computer-based simulation models for learning the process of scientific analysis behind real-world scenarios. The authors are working with high-school teachers to help them utilize the developed models and computer technology in the classroom. The primary objectives of the models are to:

1. promote interactive science education among high-school students,
2. provide a mechanism of experiencing the process behind real-life scientific analysis methods that would otherwise not be possible because of limited resources,
3. provide a high level of interactivity so that the students feel involved in the process, and
4. increase students' interest and enrollment in basic sciences.

In addition to teaching science concepts, the models are designed to increase student awareness of issues that have a direct and critical effect on the quality of life and the economy of the state. For example, the Acid Mine Drainage model simulates the effect of the acid discharge from abandoned mines to streams and rivers. As of February 2000, we have completed the development of the DNA model, Wetland model, and Acid Mine Drainage model.

Description of the Models

The models are integrated in to a virtual community called *Highland Park*. Students learn to integrate a number of scientific and mathematical operations as they interact with their computers in a virtual world. *Highland Park*, like much of Appalachia, has undergone considerable environmental damage from past mining and timbering operations and is now being developed into a tourist center and nature preserve. Students enter the park through an interactive image that first explains their work assignments and then provides access to these assignments. Students are directed to assess the effects of past environmental degradation and to develop plans to remedy this environmental degradation by interacting with the computer models.

Some of the models require numeric data collection and manipulation. Such models are integrated with Microsoft® Excel and Word for handling numeric and textual data. In most cases, data files have default names so that the users do not have to worry about which files to access and save. The models are installed on the server, and accounts are assigned to students. Student progress is saved in a database and is accessed by a user name and password. The database allows the students to save their work during a session and continue at a later time. The instructor explains the experiment and the necessary background materials using handouts, online documents, Web pages, and so forth. Students are divided in to groups, members of which are rotated.

DNA Model

The DNA model simulates the process of DNA analysis using the Restriction Fragment Length Polymorphism (RFLP) method. The model uses a crime scene of a badly burned car that was found at the base of a cliff in *Highland Park*. The model starts by presenting a full description of the crime scene and detailed information about the car and the four victims found at the scene. In addition, the model provides necessary information about relatives of the victims.

Students are informed that a murder has been committed and that the crime can be solved only by using DNA analysis on tissue and blood samples gathered at the crime scene and from relatives. The model interactively guides students through the entire DNA analysis process, from preparing blood samples to reading the final results and presenting a final report. Throughout the process, students are asked to make decisions and predictions. Based on their decisions, they may get incorrect results.

Initially students enter the laboratory, where they use interactive lab tools to cut and size DNA. DNA data are entered in to a database. Students take the initial step in solving the crime by querying the database for DNA matches with crime scene evidence. Ultimately, a lab kit, provided by the Integrated Science and Technology Program at Marshall University, provides the final clues necessary to solve the crime.

Wetland Model

The Wetland model simulates the effect of tourism on the wetlands. Using tools built in to the model, students assess the effect of visitors on the various elements of the wetland, including birds, rattlesnakes, salamanders, and a trout fishery. They also assess the effect of waste from condominiums at a nearby ski resort.

Students assess the possible usefulness of a wetland as a tourist attraction by inventorying the bird fauna. Using a binocular tool, students capture images of birds and then record their calls. Images of nests and basic ecological data are also collected. After determining that the wetland contains suitable bird species to attract tourists, students must build a quantitative model that predicts how many tourists can be allowed in to the wetland without negatively affecting the wetland habitat. Students also use the mark-recapture tool to inventory the number of rattlesnakes in an abandoned mine site used as a tourist attraction, salamanders used for food in a turkey habitat, and trout in a trout fishery.

Students are informed that nitrogen-based waste from condominiums at a ski resort may negatively affect a portion of the wetland. They are instructed to build a qualitative model that relates increases in nitrogen concentration to changes in pH, dissolved oxygen, the photosynthetic rate, carbon dioxide, and alkalinity.

Acid Mine Drainage Model

The Acid Mine Drainage model simulates the treatment of acid mine water from an old abandoned mine operation. The model gives students a history of mining in the Blackwater River Valley of West Virginia. Students are presented with an image of the largest treatment facility; maps of the area; and a database that gives pH, dissolved oxygen, alkalinity, carbon dioxide, calcium carbonate, and air and water temperatures for monthly samples gathered during a one-year period. Students go through a series of simulations of lab exercises that demonstrate how pH changes relative to alkalinity. Students interpret their lab data and data from the database relative to standard titration curves. They then use their titration curves and water quality data from the database to interpret overall water quality in the Blackwater River Basin. Finally, students locate the treatment facility on the river by noting where pH and alkalinity increase dramatically. The goal of this model is to direct students to estimate the cost of treating a 4 cubic feet per second (cfs) acid mine discharge for one year. This task requires students to learn basic chemistry skills such as balancing equations and calculating and measuring water quality parameters, including pH, alkalinity, acidity, and hardness.

Acid Rain Model

In the Acid Rain model students try to establish a relationship between acidity in rainfall and whether acid rain is negatively affecting a spruce forest. Students pick five-year-old spruce trees from the forest by drawing a transect line on a scanned photograph of a spruce tree forest. Next they measure the height of the trees from the scanned photographs using a custom tool developed and integrated in to the model. This process is repeated for five sets of data. The acidity of rainfall is simulated by using various concentrations of aerated soft drinks, and measured using pH meters in the wet laboratory. The data are automatically moved in to an Excel environment where students draw graphs and conduct statistical tests to see whether the relationship between growth and acidity is significant. The results are then imported in to MS Word to generate reports.

Experience and Benefits

The primary benefit of the models is that students learn the scientific processes of making their own hypotheses, and proving or disproving them using proper inferences, analysis, and critical-thinking skills. Using current news events helps keep up interest in the scientific process. In addition, some of the tedious and time-consuming steps of the simulated process can be reduced or made more interesting using interactive multimedia. Other benefits are that students learn practical skills using standard tools.

Conclusions and Future Work

The models are currently used in high-school science classes. The current phase of the development includes expansion of each model and integrates the models in to one interactive system, called Wildlife Nature Preserve. The new integrated system includes a set of tools that allows the students to work with wildlife and environmental issues. The tools include a Wildlife Surveying Tool, Visitor Impact Estimating Tool, Environmental Systems Modeling Tool, and Environmental Analysis Tool.

As part of the project, we have conducted training workshops for high-school teachers. Science teachers from selected high schools were invited to participate and receive training and support materials. We also have set a number of scheduled meetings with the teachers and visits to those schools. In addition, we conducted two workshops during the West Virginia Science Teachers Association Annual Conference (Al-Haddad & Little, 1999a, 1999b). We plan to invite more high schools and put the models in more classrooms throughout the state. We presented the concept of these models in national conferences and workshops to science teachers (Little, 1997, 1998; Little & Al-Haddad, 1999), and received favorable comments and recommendations.

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