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ABSTRACT

This paper presents a case study analyzing the instructional design process and interactive World Wide Web product developed by instructional technology graduate students at Virginia Tech to support the National Aeronautics and Space Administration (NASA) CONNECT distance education program. The NASA CONNECT program is described, and the various ways to interact with the program are enumerated. The paper focuses on the "virtual lab" Web component, highlighting design, student progression and interaction through the virtual lab, supporting sub-lessons, and keeping track of cosmological time. NASA CONNECT is an award-winning distance education program that incorporates multiple modes of delivery and student engagement and is managed out of the NASA Langley Research Center (Virginia). Serving thousands of students each year, NASA CONNECT is one of a myriad of educational programs sponsored by NASA. (Contains 26 references.) (MES)

Creating Virtual Labs to Teach Middle School Astronomy Principles: The NASA Connect Education Program Series

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Abstract: This paper will present a case study analyzing the design process and interactive web product developed by instructional technology graduate students at Virginai Tech to support the NASA CONNECT distance education program. The NASA CONNECT program will be described and the various ways to interact with this dynamic program will also be enumerated. NASA CONNECT is an award winning distance education program that incorporates multiple modes of delivery and student engagement and is managed out of the NASA Langley Research Center, located in Hampton, Virginia. Serving thousands of students each year, NASA CONNECT is but one of a myriad of educational programs sponsored by NASA. But some might question "Why NASA is involved with education at all?"

Why is NASA Interested in Education?

The National Aeronautics and Space Administration has as one of its cross cutting strategic enterprise goals the charge of sharing NASA's content knowledge with k-12 education and enlightening inquisitive minds through supporting the nations education goals and standards in science, mathematics, technology and geography. NASA's top administrator, Dan Goldin, in his April 1999 address to the United States Congress, House of Representatives Committee on Science stated:

> Education is the single most important issue our generation faces today that will influence our Nation's course for the future...NASA's success depends on the educational system to produce the highly skilled and knowledgeable workforce that is necessary to perform this cutting edge work. Likewise, the Nation's educational system looks to NASA for inspiration and to exemplify doing things that once were only imaginable -- feats that motivate and encourage our students to study science, mathematics, technology, and engineering. Future leaders of America, even if not astronauts, scientists, or engineers, must have a fundamental understanding of science, mathematics, and technology to reap the rewards of NASA's discoveries.

NASA CONNECT Program Overview

As stated previously, The NASA Langley Research Center produces the NASA CONNECT program, which is targeted toward middle schools students in grades 5-8. The overarching goal of NASA CONNECT is to establish the "connection" between the mathematics, science, and technology concepts taught in the classroom and NASA research as tied to appropriate national standards. NASA CONNECT capitalizes on multiple modes of dissemination (web, print, and video) and utilizes several methods of student engagement (interactive virtual labs, hands-on classroom inquiries, critical student discourse using complimentary video questionnaire guides). A series of live video broadcasts provide the foundation for the NASA CONNECT program and are broadcast nationally over NASA TV, Satellite and PSB TV stations. An in-depth teacher guide is also available to download after registering to participate in the free NASA CONNECT learning program. Samples of the titles for the 2000-2001 season include: (a) MEASUREMENT, RATIOS, AND GRAPHING: 3, 2, 1...Crash; (b) GEOMETRY AND ALGEBRA: Glow with the Flow; (c) DATA ANALYSIS AND MEASUREMENT: Ahead, Above the Clouds; and (d) FUNCTIONS AND STATISTICS: International Space Station (ISS)-Up to Us.

NASA CONNECT: Asynchronous Interaction

The video component of NASA CONNECT may also be viewed asynchronously by dubbing the copyright free content during a live broadcast or by ordering a high fidelity copy from NASA CORE (Central Operations of Resources for Educators) for a nominal fee.

CORE is a worldwide distribution center for NASA-produced multimedia materials and can be found on the web at: http://www.core.nasa.gov. Interested parties may request via phone, fax or print mail other multimedia productions in addition to previous NASA CONNECT videos. The NASA CONNECT video series may also be dubbed free of charge by bringing a blank VHS tape to the nearest NASA Educator Resource Center (ERC) in your state. To locate the nearest ERC available to you visit the ERC Network on the web at: http://spacelink.nasa.gov/ercn/.

The interactive web-based virtual labs, hands-on classroom inquiries and student video questionnaires from previous and future NASA CONNECT topics are available on the web at the NASA Langley Research Center and may be located at: http://connect.larc.nasa.gov/. To locate current and future topics click the "2000-2001 Season" link found at the URL above. Previous components of prior shows may be found by clicking on the "Educators" link on the home page and then the link titled "Library of Shows" that appears atop the new page that loads for educators.

Our "Virtual Lab" Web Component

Our design project developed an interactive prototype web-based instructional unit to support the video program titled: *Algebra: Mirror, Mirror on the Universe*, which originally aired in April of 2000. In this multi-modal program students were encouraged to discover how algebra and telescopes are used in space exploration and why optics (the study of light) is important in astronomy. Students are guided to discern for themselves through the virtual web lab component the value of placing orbital observatories in space. Students move from backyard astronomy to mountain observatories and the Hubble Space Telescope to discern what we can learn about the origin of our universe and galaxies. Ultimately, a discussion of the Next Generation Space Telescope is presented. Topics like the electromagnetic spectrum, red shift, right ascension, and declination are discussed in detail with vivid multimedia animation and strong user control, feedback and interactivity.

A Look Back: Designing the "Virtual Lab"

We first met with the NASA CONNECT team members to discuss possible directions for our instructional program. The folks at NASA did not have a concrete vision as to what they wanted for the instructional program. They provided us with a list of science and math standards for students in grades 6 through 8 that they were interested in addressing, as well as an extensive list of information about telescopes. From that list we chose as many key concepts as we thought would be appropriate for the length of the instructional program, the development time, and

the age group involved. With this information at hand, we set out to develop an interactive program that would help students learn about telescopes and celestial observation while at the same time covering certain required science and mathematics standards.

We started by creating a context in which students would help NASA scientists search back in time for the origins of the universe. Astronomers are constantly attempting to see farther back in time in an effort to discover the origins of the universe. The way they do this is through the use of telescopes to observe celestial objects that lie at great distances from the Earth. Due to certain scientific occurrences, the more distant the objects that we are able to view, the further back in time we are looking. The way we implemented this context was by developing an interactive simulation in which students can view the night sky from different locations on Earth and in space using increasingly more powerful viewing instruments. Each student takes on the role of an observer on the Earth who is using various viewing instruments to view the night sky. As the program progresses they learn more about telescopes, including their advantages, limitations, and the factors that influence their operation.

From the start we also wanted to incorporate many of the stunning images that have been provided by the Hubble telescope. This includes images from the farthest reaches of space that have never before been seen – images that have captivated people all over the world since they were made public. This fit in perfectly with our simulation because the final scene of the simulation would allow students to use the Hubble to view celestial objects.

Our design project may currently be found at: http://www.albyers.com/CONNECT/index.htm. The NASA Langley Learning Technology Program Manager is now overseeing the formative review and revision of our content and design. In hindsight, the design process may have been simplified if: (a) the graduate student instructional designers could have coaxed more salient program objectives from the NASA subject matter experts, and (b) more time could have been allowed to conduct early formative revision of the product, such as expert reviews, one-on-one student reviews, small group and pilot testing.

Student Progression and Interaction through our "Virtual Lab"

The virtual lab begins with a Web-based introductory section that introduces students to the idea of looking back in time. Inquiry questions are used to gain attention and provide an advance organizer to help direct students' attention. The types of questions include, "Where did the human race come from?", "How did the Earth come into being?", and "When did the universe begin?" these types of questions help lead students into taking on the role of a curious astronomer. It is also a way of gaining the students' attention through the use of decorative images produced by the Hubble telescope.

The completed instructional program/virtual lab contains three separate simulation scenes of increasing depth and interactivity, surrounded by a variety of supporting instructional materials. The simulation portions of the virtual lab were developed in Macromedia Director and then exported as a series of Shockwave movies, while the supporting material was developed as Web pages. Director was chosen for its ability to easily combine different graphical elements with sound effects, as well as for its animation capabilities. Director's Lingo programming language was utilized extensively to control the switching of graphics as well as the movements of the various telescopes across the viewing window.

The simulation part of the virtual lab comprises three different interactive "scenes". In the first scene students begin on Earth using only their naked eyes to view the night sky. In addition, they have a choice of three different viewing locations: mountain, desert, or city. Each location provides a different level of viewing depending on several factors. At the end of this scene students have learned the optimal Earth-based location for viewing the night sky, as well as the various obstacles that can make viewing more difficult.

Once the student has determined the optimal viewing location, this leads into the next scene of the simulation. In this second scene students are limited to one Earth-based location, but they are now given the option of using several different viewing instruments with which to observe the sky, including a telescope and a larger mountaintop observatory. It is at this point that they are introduced to the concepts of right ascension and declination. This is the coordinate system that is used by astronomers to locate objects in the sky using telescopes. Since students now have the use of two different telescopes we programmed the simulation so that students must first choose which telescope

they wish to use, and then decide which part of the sky they wish to view using their selected telescope. After determining where they wish to point their scope, they must enter the appropriate coordinates (in the form of right-ascension and declination) for that location in an entry window in order to move the telescope to that location. The telescope viewer then moves to that location in the sky. If there is an object to see at that location it appears within the scope. If a student clicks on the scope at that point he or she will then see an enlarged picture of the object. These pictures are actual NASA photographs that approximate what the object would look like using that particular telescope.

By focusing the scopes on different sections of the sky students are able to view various celestial objects, some of which are not viewable with the naked eye. Those that *are* viewable with the naked eye are seen in much greater detail when using one of the telescopes. By the end of this scene students will have learned that telescopes allow us to view celestial objects in much greater detail than we can using just our eyes, and that even more powerful telescopes allow us to view new objects that are farther away from the Earth, and thus farther back in time. At end of this scene, however, students realize that there are limitations even with mountaintop observatories, and that astronomers have still not been able to see all the way back to the origin of the universe.

This leads to the third scene of the lab, in which students blast off into space to view celestial objects without the impediment of the Earth's atmosphere. At this point they have advanced to using the Hubble telescope, and can view the same objects as before in the greatest detail available to us. In addition, the use of the Hubble opens up the sky to allow them to view even more distant objects, including objects that have never been seen before: start clusters, great spiral galaxies, and brilliant nebulae. In programming this scene we were able to make use of many of the breathtaking images captured by the Hubble telescope.

Supporting Sub-lessons within the "Virtual Lab"

In addition to discussing the operation of telescopes, we chose to include other concepts that were deemed important to the overall context of the program. They were chosen based on how well they could be incorporated into the concepts covered in the simulation scenes. We did not want to give the impression that the simulation was "stopping" while we fed the students needed verbal information. The goal was to make it seem as though students were interacting with a continuous instructional program.

These concepts are introduced during Web-based "sublessons" that fall between the three different simulation scenes. At the end of each simulation scene students enter one of these sublessons, where they are first presented with a review of the concepts covered in the previous scene. After that, new concepts are introduced that will enable students to progress to the next scene of the simulation. For example, before moving on to the scene that features the Hubble telescope, students first go through a sublesson that discusses what the Hubble telescope is and why it is important to astronomers. In doing so students understand that when astronomers reach the limits of what they can observe in the sky, they must turn to new technologies to enable them to see further and thus continue their cosmic quest to discover the origins of the universe. Colorful graphics, Shockwave animations, and JavaScript quizzes are employed in the sublessons to help keep students interested throughout these non-simulation segments of the program. In addition, these sublessons are where we chose to integrate the various math concepts that were deemed important by the NASA team.

Keeping Track of Cosmological Time in the "Virtual Lab"

During the development process it was important for us to keep in mind the ultimate goal of students' celestial observations, which is to search back in time for the origins of the universe, and galaxies in particular. To that end we integrated a way for students to keep track of how far they have progressed in this quest. Throughout the program they keep track of their progress through the use of a chronometer. The chronometer is a graphical representation of how far back toward the origin of the universe students have been able to view at that point in the simulation. The chronometer is updated throughout the program as a student progresses to using more advanced telescopes, and thus is able to see more distant objects. At the end of each part of the simulation students see that there is still farther to go, and that we need to use more advanced techniques in order to keep traveling back in time. This progressively leads to the subsequent sections.

No Answer in Sight: The Need for the Next Generation Space Telescope

At the end of the program students can see from the Chronometer that there is still farther to travel in order to see back to the origins of the galaxies, and that new advanced telescopes must continually be developed to help astronomers in their quest. Students realize that we are continually limited in our knowledge of certain scientific questions, and that our knowledge and understanding is limited by the power of our observations. The program then finishes up with a discussion of several advanced telescopes that are currently being developed and/or deployed. These next generation telescopes are necessary to help us answer the complex questions posed to us by the universe around us, and to provide greater explanatory insight into the cosmological origins of the universe.

Will any of today's students become tomorrow's astronomers? It is hoped that programs such as this, and the many others provided by NASA CONNECT, will help to stimulate student interest in science, mathematics and technology, and by doing so help shepherd in a new generation of space explorers, scientists, and engineers who will attempt to solve these challenging endeavors.

In Closing:

This paper analyzed the instructional design process employed to develop a "Virtual Lab" in support of the NASA Langley CONNECT distance education program. NASA CONNECT is a series of educational programs developed by the NASA Langley Research Center that employ multiple ways to engage middle school students in learning standards-based mathematics, science and technology using NASA content. The CONNECT programs employs multiple modes of delivery and student interaction via web-based virtual labs, classroom inquiries and video-facilitated student discourse.

Our interactive shockwave-based project in support of a NASA CONNECT "Virtual Lab" is described in detail and the design decisions that transpired are reflected upon. Internet URL's are also provided throughout our document for readers to access not only the NASA CONNECT program, but also our existing version of the project, as well as how to obtain prior NASA CONNECT programs via NASA's Central Operations of Resources for Educators.

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