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REMOTE SENSING EDUCATION CD-ROM: AN INTERACTIVE APPROACH TO TECHNOLOGY TRANSFER UTILIZING REAL RESEARCH RESULTS

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ABSTRACT:

This article focuses on describing a set of two CDs for teaching remote sensing applications to conservation and preservation at the college level in Brazil. This project is a joint effort between NASA, INPE/MCT and ISU. Multimedia products for technology transfer of topics such as remote sensing and its applications have become more widely available in recent years. The expansion of computer facilities in universities and schools and the advance in Internet technologies have offered new opportunities to delivering instructional materials using digital media. Brazil has a large demand for college programs that are not being supported by existing universities. Distance education programs could be a solution addressing that college program demand by reaching more people outside university campuses. The multimedia technology used to develop these CDs is generally amenable for their content to be delivered via the Internet. The first CD is divided in three sections: (1) introduction to preservation and conservation concepts, (2) introduction to remote sensing principles and satellite image processing, and (3) case studies based on LBA-Ecology research in the Amazon. The second CD provides digital data sets, software tutorial materials and image processing software for students to use in experimentation or their own research.

1. INTRODUCTION

The use of multimedia for technology transfer of topics such as remote sensing and its applications has grown in recent years. Examples include Antarctic Expeditions: Ozone, Exploring Wetlands with Satellite Remote Sensing, CEOS Resources in Earth Observation, DataSlate, Exploring Remote Sensing: a Hands-on Approach, Geomorphology from Space, Pacific Expeditions: El Niño, River Expeditions: The Amazon, Signals of Spring, and Visit to an Ocean Planet (NASA Earth Science Enterprise Education Products, http://earth.nasa.gov/education/catalog/products.html). It is reasonable to say that this new approach to remote sensing education parallels the growth of general multimedia instructional material development in recent years (i.e. CDROM, Internet, and videoconference). The expansion of computer facilities in universities and schools and the advances in Internet related technologies have offered new opportunities to delivering instructional materials using digital media. The use of multimedia in the classroom brings an entertainment side by using visual aids to make a lecture livelier and the ability to clarify difficult concepts (Ben-Ari, 1999). These benefits are related to the use of animations and simulations for material development as well as interactivity with the material through hands-on activities and quizzes (Wu et al., 2001, Crown, 2001, Ben-Ari, 1999,). The introduction of multimedia materials in the classroom is changing the classroom experience in many schools and universities (Jones et al., 2002, Jason et al., 2001, Sankaran et al., 2000). Many of the products currently available are designed to enhance problem-based and cooperative learning strategies (Oliver and Hannafin, 2000, Ben-Ari, 1999, Williams et al., 1998). It is important to note that multimedia is only a tool and it will not necessarily improve teacher performance. In other words, excellent multimedia instruction material can be ineffectual or even can do harm if the teacher lacks the skills to properly use it in the classroom (Ben-Ari, 1999). Several studies emphasize that a teacher's role, when implementing multimedia problem-based materials, should be more as facilitator rather than traditional lecturer (Jones et al., 2002, Grasha and Yangarber-Hicks, 2000, Herreid, 1998). A good teacher who is overloaded with instructional tasks, on the other hand, can take advantage of multimedia materials by making them more widely available to students without requiring additional time or staff, while assuring that students get a good educational experience (Crown, 2001). The way that multimedia instructional materials are structured and delivered in the classroom can enhance learning by broadening the scope of student learning styles that can benefit from them. A simple lecture presented through a slide show enhances content acquisition by students with a visual learning style. More complex multimedia material, combined with related individual or group activities, can cover a wider range of learning styles (Grasha and Yangarber-Hicks, 2000, Shoffner and Dalton, 1998).

Brazil has a large demand for college programs demonstrated by the increasing number of students starting college studies and the growing number of private universities in the last decades (i.e. 1004 private against 176 public institutions in 2000 according to INEP – Instituto Nacional de Estudos e Pesquisas Educacionais). The total number of college students in the country in 2000 was 2,694,245 according to INEP. This number, however, corresponds to only 7.7 % of the 20 to 24 year-old population group (Faria et al., 2000). The authors also estimate that only 18.3 % of the total demand of young and adult Brazilians, who are eager to starting college, is fulfilled by university programs in the nation. Several constrains inhibit the expansion of college programs offered by both public and private institutions. Government expenditure in higher education has shrunk in the last years as well as has faculty retention due to low wages. Some public university faculties are migrating to private universities for better salaries, although frequently giving up research opportunities. However, the

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number of well-prepared faculty is still below the county's demand for higher education, even in private universities. This scenario has opened an opportunity for establishing a wider spectrum of distance learning programs, such as the UniRede initiative (Faria et al., 2000) in the public sector. There is an increasing interest in quality computer-based learning at both undergraduate and graduate levels. Public universities, although in crisis, still manage to keep most of their well-prepared and creative faculty necessary to generate quality distance education (DE) programs that are in demand. UniRede envisions that DE programs could close a great portion of the gap between course offerings and demand in higher education in Brazil by reaching out to those people who cannot attend a university campus. This process is also viewed as a democratization of education since more people will have access to college level education and degrees. The methods necessary to implement DE programs also embed the additional component of "learning how to learn" breaking the traditional student attitude of only learning what is given by the instructor during a conventional lecture (Longo, 2000). In a DE framework students have to manage their own pace of learning and strive for an honest and dependable learning process in order to get the knowledge they expect.

A set of CDs for teaching remote sensing and its applications to conservation and preservation at the college level in Brazil is currently under development by a joint effort of INPE/MCT, NASA and ISU with the contribution of several other education institutions in Brazil. Many aspects of the structure and concepts of these CD-ROMs under development are based on an existing set of CDs developed by ISU under a NASA grant that focused on remote sensing application to wetland restoration. On these CDs there are three main sections: (1) an introduction to wetland concepts and restoration issues, (2) an introduction to remote sensing principles and satellite image processing, and (3) a comprehensive case study applying remote sensing to wetland restoration site selection. A second CD, which is part of the set, provides satellite data sets, image processing software and software tutorial allowing students to have hands-on experience in remote sensing by developing their own experiments or research. The Brazilian CD set will be based on remote sensing applications applied to more general environmental issues with the main focus on Amazon environments. The first CD (CD1) is also divided in three sections: (1) introduction to preservation and conservation concepts focusing on the Amazon, (2) an updated version of the original introduction to remote sensing principles and satellite image processing, and (3) major case studies based on results of real research being developed in the Amazon under the LBA-Ecology program (Large Scale Biosphere-Atmosphere Experiment in Amazonia). The second CD (CD2) provides digital spectral and vector data sets, software tutorial and image processing software for students to develop their own experiments or research.

The multimedia technology currently being used to develop the Brazilian remote sensing CDs is structured to permit its availability through the Internet. The main constraint for supporting this format in the near future is the limitation in bandwidth to deliver the material to students. The choice for using CD-ROM based delivery is a safe one at this time. However, once the gap between material streaming demand and Internet delivery narrows down then the content material produced by this project can be part of the set of materials being developed to expand DE to undergraduate Brazilian students.

2. MATERIAL DESCRIPTION

2.1 Principles of Preservation and Conservation

CD1 will be divided in three sections where the first section will be devoted to teaching principles and concepts of conservation and preservation focusing on Amazon environments and issues. Topics presented on this section are shown on Table 1. The first three topics (Introduction, Basic Concepts, and Natural Resources) provide an overview of environmental science concepts and principles while relating them with human activities and natural processes in the Amazon. The next two topics (Energy and Environmental Impacts) discuss influence that human activities have had in altering the natural environment and provide some alternative approaches to deal with these issues. The last three topics

PRESERVATION AND CONSERVATION TOPICS
I. Introduction
A. Environmental Science
B. The Global Outlook
C. The Amazon
D. Development in the Amazon
E. Sustainable Development
F. Environmental Laws
G. Environmental Education
II – Basic Concepts
A. Ecosystems
B. Ecosystem Structure
C. Ecosystem Distribution
D. How Do Ecosystems Work?
III – Natural Resources
A. Introduction
B. Water
C. Soils and Minerals
D. Atmosphere and Climate
E. Flora and Fauna
F. Ecosystems as Natural Resource
IV – Energy
A. Introduction
B. Fossil Fuels
C. Generation of Electricity
D. Sustainable Alternatives
V – Environmental Impacts
A. Introduction
B. Pollution by Chemical Agents
C. Air Pollution
D. Physical Impacts
E. Impact Prevention Versus Containment
VI – Amazon Ecosystems
A. Flooding Ecosystems
B. Highland Ecosystems
VII – Human Impacts on Amazon Ecosystems
A. Deforestation
B. Cattle Ranching
C. Commercial Fishing
D. Hydroelectric Power
VIII – Alternatives for Preservation and Conservation of Amazon Ecosystems
A. Logging
B. Cattle Ranching
C. Extractivism, CDM and Ecotourism
D. Agroforestry
E. Mineral Exploration

Table 1. Preservation and conservation topics discussed in the first section of CD1.

REMOTE SENSING TOPICS
I. Introduction to Remote Sensing
II. History of Remote Sensing
III. Principles of Remote Sensing
A. Basics of Remote Sensing
B. Electromagnetic Spectrum
C. Sensors and Satellites
D. Light Interactions with Earth Surface
IV. Satellite Images and Interpretation
A. Introduction
B. Visual Interpretation
C. Color Composite
V. Computer Interpretation
A. Introduction
B. Spectral Signatures
VI. Classification and Accuracy
A. Introduction
B. Supervised Classification
C. Unsupervised Classification
D. Accuracy Assessment
VII. Remote Sensing Applications
A. Forest Succession in the Amazon
B. Soil Classification
C. Plant and Animal Habitat Studies
D. Coastal Studies
E. Urban Thermal Pattern Studies
F. Deforestation in the Amazon Basin
G. Geological Application
H. Amazon Studies Using Radar Data
I. Water Quality Studies
J. Atmospheric Studies

Table 2. Principles of remote sensing discussed in the second section of CD1.

provide a closer examination of the issues related to traditional development activities versus alternative approaches to achieving sustainable development in the Amazon.

2.2 Principles of Remote Sensing

The second section of CD1 will cover the principles of remote sensing and the techniques involved in image processing and information extraction. Topics presented on this section are shown on Table 2. The remote sensing topics provide a general overview of this technology and cover its basic principles. It also provides the basic knowledge to understanding how images are generated, how they can be analyzed and what value can be obtained from the information generated. The final topic illustrates some of the types of applications that can be implemented using remote sensing technology.

2.3 LBA Case Studies

The third section will present examples of LBA research that uses remote sensing as a major source of information to generate the research results. Some of these examples include integration of remote sensing and GIS for spatial analysis. Although the GIS layers are used only as reference vector information to enhance the remote sensing analysis, an introduction to the principles of GIS and the specific GIS processes used is included at the beginning of this section. Selected examples cover several issues associated with the Amazon, such as the influence of farming practices on deforestation and secondary succession recovery rate, quantitative measurement of annual deforestation rates, the impact of roads on land use patterns, and the impact of logging on land cover change. These examples are formatted in a way that the student will get the impression that he or she is actually doing the analysis, but all the steps are guided in a controlled multimedia environment in a way that no mistake can be made in any step of the process. Since these examples are based on actual LBA research, the methods implemented by the scientists are emulated via multimedia. Using in this approach the students are also practicing the use of the scientific method while doing the case study activities. The goal of these examples is to integrate the concepts and principles of preservation, conservation, and remote sensing provided in the first two sections of CD1 with real world applications of these principles and concepts.

2.4 Hands-on CDROM

The second CD of the set (CD2) will include satellite multispectral data, vector data and a combined image processing and GIS software developed by INPE/MCT, called SPRING. The goal of this CD is to allow students conduct their own experiment or research utilizing elements of existing data sets that were used in real research. The data sets will cover different regions of Brazil to provide a wider variety of image processing and GIS applications. A complete tutorial will be included with this CD to teach students about the basic procedures of image and GIS analysis using SPRING. The tutorial will offer a full screen version of software procedures as well as partial screen version that the student can follow while using SPRING. CD2 also include a detailed description of each data set and a discussion on how these data were used in research giving students ideas about analyses that could be performed with these data. Suggestions for additional student analysis are also provided for each data set.

3. PREVIOUS TESTING RESULTS

Multimedia technology offers an effective way of delivering information to students in the classroom because it covers a broader range of learning styles among students. In order to test this assumption a group of 275 students from 9 schools throughout the United States were given a pre and posttest while using the CDROM **"**Exploring Wetlands with Satellite Remote Sensing." Two questions were posed to test that assumption: (1) Did students learn when using the CD?; and (2) Was there a difference in learning of those students with different learning styles? Statistics produced by *t*-test analysis for the first question indicated that the mean number of correct answers on the two tests is significantly different and that the students did learn from the CD. To answer the second question an ANOVA was conducted on Dunn and Dunn Learning Styles Inventory results where students' scores were organized in 14 groups of preference. Results indicate that there was no difference in the amount of learning between learning style groups. These results indicate that the use of multimedia technology allows delivering content in the form of sound for those who prefer listening, graphics for those who are visually motivated and text for those who prefer reading. In order to have maximum learning style capability in the product under development, the CD is designed to include high quality graphics, animations, audio, video, interactive activities, quizzes, student progress database, and curriculum customization tool.

4. MULTIMEDIA COMPONENTS

4.1 Content material

Content material in the Brazilian CD is extensive as discussed earlier, therefore, delivery of this material requires a method that provides the most effective student content retention rate. The strategy implemented on CD1 provides short pieces of information being delivered in text and audio formats and illustrated by static or animated graphics. Although the extensiveness of the material is significant, breaking it up in small pieces with individualized illustrations makes it more easily retained by students. At the same time, it allows students to move through the material at their own pace since each student can determine how fast he or she wants to move through it by going forward or going back and reviewing what was presented. Figure 1 shows one of the screens of content material. The main features on the figure are the graphic, text and navigation buttons. The audio component covers the same text presented in each page.

Figure 1. Example of a content page on remote sensing.

4.2 Navigation through menus

Navigation through the CDs is simple. There are up to four levels of menus starting from the main menu then branching to each three of the main sections (i.e. Preservation and Conservation, Remote Sensing, and Case Studies). In each section there is a menu for the main topics listed on Tables 1 and 2 then a submenu whenever necessary. At the end of each topic the student might get a different menu that leads to a quiz or activity, when present, or takes him or her back to the menu from which they started that topic. Figure 2 shows one of the remote sensing submenus. Menus also give the option of exiting the program at any time.

4.3 Index page

Students have access to a general index page with hyperlinks to all topics in CD1. The index page allows them to go back to topics already covered but do not allow them to jump to new topics without following the sequence determined by the curriculum setting. This way a teacher can establish a curriculum with a certainty that students will get the material in the most effective sequence. Figure 3 shows an example of the index page in the original Wetlands CD. Topics in gray are disabled for the student at that time and only topics in red can be accessed. CD1 will have a similar version of this index page although improved with drop down menus and enabled-disabled topics according to the teacher's curriculum configuration on each computer.

Figure 2. Example of navigation menu.

4.4 Note taking

In CD1, as introduced in the Wetlands CD, students have access to a note-taking tool in which they can type notes that are saved on the computer and read later prior to taking a quiz or doing an activity. Note-taking has proven to be a very important tool in the Wetlands CD by its function and innovative approach. One of the main functions of this tool is to help students to learn how to take notes. Some students would simply copy the text presented in each page while other would synthesize the content and take notes on the most important information. The ones who copy the entire text end up getting behind other students because they go through the material too slow. This gives an opportunity for the teacher to intervene and teach them how to improve their note taking skills. Figure 4 shows the note-taking tool from the Wetlands CD.

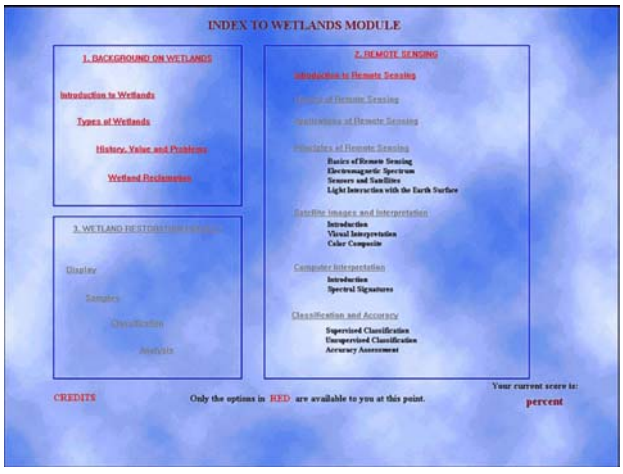

Figure 3. Example of an index page from the original Wetlands CD.

4.5 Interactive quizzes

A total of 29 quizzes with five questions each is available for evaluating content retention by the students. Each quiz include three multiple choice questions, one column match question and one fill the blank question. A total of forty questions address

remote sensing concepts and principles and one hundred and five questions address preservation and conservation concepts. All questions provide instant feedback

Figure 4. Example of note taking tool from the original CD.

so the students will know instantly what the correct answer was in case they get it wrong. A score is calculated for each quiz and transferred to the database. Figure 5 shows an example of a column match question with appropriate feedback.

4.6 Interactive activities

There are ten interactive remote sensing activities available in CD1. The activities range from topics such as History of Remote Sensing to The Electromagnetic Spectrum and Supervised Classification. Activities include drag-and-drop objects that must be placed in the correct position and additional tasks. There are thirteen activities planned for the preservation and conservation section ranging from virtual trips

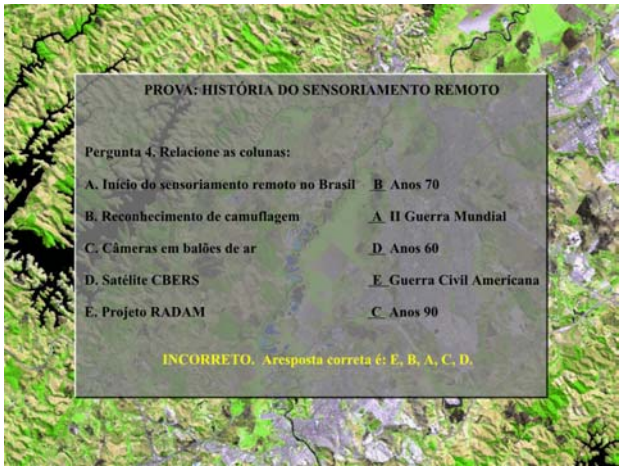

Figure 5. Example of column relate question of a remote sensing quiz with instant feedback.

in Amazon sites to drag-and-drop and puzzle formats. Most activities keep track of the score where fewer points are taken from the student if incorrect answer than added if the answer is correct. The final score of each activity is saved to the database. Figure 6 shows one of the remote sensing activities – The Electromagnetic Spectrum.

4.7 Database tracking

A database application is built-in to keep track of student related information. Every score from quizzes and activities is saved in the database as well as the elapsed time in each topic, quiz and activity. The teacher can access the database through a password-protected interface. Once logged in, the teacher can retrieve the information available in the database through an interface in the CD and have it displayed in two formats, the entire class or per student. The database also has the function of tracking student progress. This way when a student logs back in, the system consults the database to see what topic that student covered the last time, before exiting the program, and takes the student to the menu from which the next topic can be accessed.

4.8 Curriculum customization

The ability to customize multimedia instructional material content is considered very important by many professionals in the field. This ability is especially important when the amount of material provided is significantly extensive. Many teachers may not want their students to go over the entire CD rather they like to be able to configure each CD in the way they want. In order to provide that ability to teachers, CD1 includes a curriculum customization tool available to the teacher after

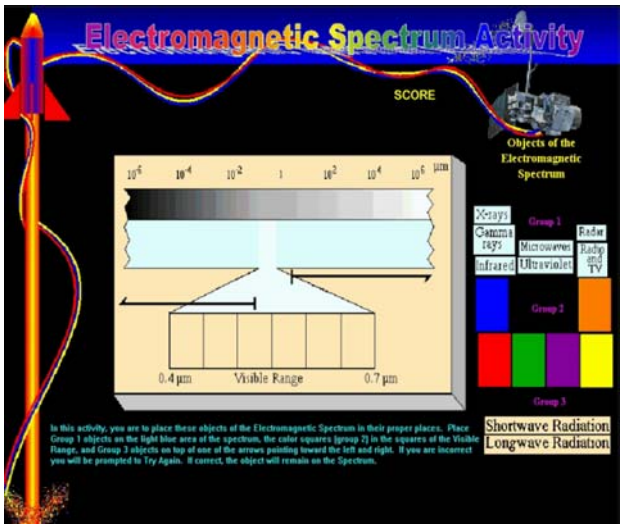

Figure 6. Example of a drag-and-drop activity. Students are asked to place the objects on the right in their respective position in the electromagnetic spectrum.

entering the password-protected gateway. In this tool the teacher can select the topics wanted by selecting or unselecting the options provided. Once the topics are chosen the teacher clicks on the accept button and only the topics selected will be available for the students on that computer. Since the customization works for each computer the teacher can have different computers running different curriculums in the classroom or all running the same curriculum.

5. TARGET AUDIENCE AND DISTRIBUTION

The Brazilian CD-ROM set is currently under developed and is planned to be ready for distribution by mid-2003. The target audience of this product is public and private universities and colleges throughout Brazil. Since the topics covered in the CD set vary from broad preservation and conservation concepts to

Amazon issues and remote sensing principles, a wide range of undergraduate courses can take advantage of this material. The most complete example would be an introductory course to remote sensing applied to environmental problems. However, a pure remote sensing course, a general introduction to ecology course, a course on Amazon development issues, or a geography course can benefit from using these CDs.

INPE/MCT will be the leading institution distributing this CD set in Brazil. The CD sets will be distributed free of charge to any institution interested in having them. Future additional support and updated material are planned to be published on-line and available through INPE's website. This is the first CD set of this kind being developed and distributed in Brazil and, ideally, will not be the last one. There are plans for expanding this effort for building a family of products related to the research developed by INPE and making that knowledge available to university students in Brazil. Two possible areas of future product development include: (1) more specific remote sensing applications in different Brazilian environments and different types of application; and (2) integrated remote sensing and GIS applications in which GIS is the main focus with expanded content material on GIS concepts and principles.

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