This article reprinted from:

Laposata, M., and J. Pratte. 2005. The ESA21 project: Environmental science activities for the 21st century. Pages 402-405, *in* Tested Studies for Laboratory Teaching, Volume 26 (M.A. O'Donnell, Editor). Proceedings of the 26th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 452 pages.

ISBN 1-890444-08-1

The ESA21 Project: Environmental Science Activities for the 21st Century

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Introduction

With its emphasis on interdisciplinary science and real-world relevance, environmental science has gained popularity as an alternative to courses in the traditional science disciplines in non-majors science. While a change to an environmental narrative can increase student interest in science content, supplementary materials (laboratory exercises, course activities) in this discipline have historically suffered from a lack of identity. Most of the commercially-available materials have been modified versions of exercises from biology, chemistry, physics, and geology, and aimed to teach the laboratory skills and analytical techniques needed by science majors. While appropriate for future scientists, such exercises do not provide non-science majors with the skills and knowledge they need to be informed citizens in an increasingly scientific world. To complement the focus of environmental science courses, supplementary materials should emphasize lifestyle examination, ethical considerations, and critical analysis of individual contributions to large-scale regional and global impacts. This allows students to see their place in the environment and how lifestyle changes can facilitate greater environmental sustainability. In this paper, we will describe a collection of activities for environmental science courses that were developed to provide a targeted, relevant, and meaningful experience for non-science majors in introductory courses.

The Library of Activities

The activities are designed to supplement environmental science courses with existing laboratory components or provide course activities for traditional and online courses that lack a laboratory component. The activities hybridize online and wet-lab exercises, as many issues in environmental science lend themselves to examination through Internet-based activities. Students can use the Internet to: conduct simulations of air pollution and population growth; take virtual tours of wastewater treatment plants and power generation facilities; and use online "calculators" to analyze their water usage, personal emissions of carbon dioxide, and home energy efficiency. The activities utilize existing, high-quality materials from the Internet, and many of these elements are mirrored on the project web site to minimize accessibility issues. The online activities are coupled with hands-on

activities that enable students to examine topics in a wet-lab environment. Through this combination of exercises, the materials can be utilized by any environmental science course, regardless of format.

The activities afford students comprehensive exposure to topics in environmental science. Activities are organized into "modules" of two to four activities on a common topic that culminate with a synthesis (Capstone) activity. This provides in-depth examination of complex topics, and creates an organizational framework that allows students to see the connections between related activities. The activities are alternatively arranged as "pods" of related activities centered on broad topics such as air, earth, energy, and home life. The activities within the pods are drawn from different modules, and present an alternative approach to organization that may be more appropriate for some courses.

The materials are digitally delivered over the Internet through the project web site at <http://esa21.kennesaw.edu>. The activities are presented as PDF format pages, viewable in any web browser with the free Adobe Acrobat Reader plug-in. Links in the PDF document take viewers to multimedia elements, virtual tours, online environmental calculators, and interactive simulations. To the greatest extent possible, the content is designed to load quickly (for students with slower Internet connections) and it utilizes only free and common browser plug-ins (Macromedia Flash, RealPlayer, and Adobe PDF Reader) to minimize potential technology problems. Experience has shown these efforts to be successful, as the activities have been used by thousands of students at Kennesaw State University for several years with negligible numbers of technology problems.

The currently available activities are described in Table 1. Additional activities will be added to the project web site as development continues through 2005. Instructor resources with activity objectives, lists of materials, apparatus construction procedures, common student questions, and quiz questions may be obtained by registering with the project coordinators through the web site. Instructors are encouraged to link directly to the activities and all the materials can be used free of charge. We hope this project will address a long-standing deficiency in environmental science courses by providing in-depth, engaging activities that promote lifestyle analysis and environmental introspection in students. We welcome feedback from instructors on the existing exercises and directions for future development.

Acknowledgements

The authors are indebted to the following for funding this project: the National Science Foundation's Course, Curriculum, and Laboratory Improvement Program (DUE-0088723 and DUE-0231171); Kennesaw State University's Master Teaching Grant Program; and the College of Science and Mathematics at Kennesaw State University.

Table 1. Activities currently available through project web site (http://esa21.kennesaw.edu). [WL] = Wet Lab activity, [ON] = Online activity.

Module	Activity	Description
Basic Science	Experimental Analysis	Use software program *Fish Farm* to design and conduct simulated experiments in aquaculture. [ON]
	Statistics and Graphing	Use descriptive statistics and graphing to analyze data. [ON]
	Measurement	Practice metric measurements and use inferential statistics to interpret experimental data. [WL]
	Capstone	Collect and evaluate data using descriptive and inferential statistics. Critique elements of experimental design. [WL]
Home Energy	Home Energy Audit	Measure dimensions of exterior components of home and identify materials used in construction. [ON]
	R-Factor	Calculate R-factor by examining the rate of heat transfer in typical materials used in home construction. [WL]
	Synthesis and Analysis	Analyze home energy usage with online home energy audit calculator using data gathered in first activity. [ON]
	Capstone	Propose and economically evaluate three improvements to home energy efficiency. [ON]
Biogeochemical Cycling	Trees and Carbon	Use equations to estimate CO_2 sequestration in forests. Determine CO_2 storage capacity of developed areas. [ON]
	Photosynthesis & Respiration	Examine the processes of photosynthesis and respiration and their effects on carbon cycling. [WL]
	Carbon Dioxide Calculator	Estimate personal CO_2 emissions using online CO_2 calculator and evaluate emission-reducing lifestyle changes. [ON]
	Capstone	Calculates acres of forest needed to sequester individual emissions of CO_2 and evaluate "carbon credits" for forests. [ON]
Ozone	Ground-level Ozone: Smog City	Use *Smog City* computer simulation to investigate the parameters that affect ground-level ozone concentrations and evaluate competing scenarios for improving air quality. [ON]
	Stratospheric Ozone	Study the relationship between stratospheric ozone level and the UV index using satellite and ground-based measurements. [ON]
	Ground-level Ozone: Your Vehicle	Estimate personal ozone precursor emissions from current vehicle and see changes with a more fuel-efficient vehicle. Examine ozone effects on respiratory system. [ON]
	Capstone	Estimate personal ozone precursor emissions from all sources and evaluate lifestyle changes that reduce emissions. [ON]

Table 1. (con't)

Fossil Fuels	Oil	Measure the porosity and permeability of sedimentary rock analogs. [WL]
	Coal	Measure the ash/residue content of various forms of coal. [WL]
	Natural Gas	Use a computer simulation to study the process of exploration and seismic surveying. [ON]
	Capstone	Calculate fossil fuel usage and pollutant emissions. [ON]
Nuclear Energy	Decay	Use a dice analog to study the relationship between half-lives and nuclear activity. [WL]
	Power Plant	Use a computer simulation to study the workings of a nuclear power plant. [ON]
	Exposure	Measure the amount of radiation exposure received by various environmental and lifestyle factors. [ON]
Renewable Energy	Hydroelectric	Use a turbine generator to study the relationship between height of water and energy output. [WL]
	Solar	Study the effect of size and color on solar collector output. [WL]
	Wind	Use weather data to map the relationship between isobars and wind speed/direction. [ON]
	Capstone	Investigate the economics of using renewable energy in student's region. [ON]
Water	Drinking Water Treatment	Construct and test a model drinking water treatment plant with a two-liter soda bottle. [WL]
	Home Water Use	Use online calculator to analyze home water use. [ON]
	Wastewater Treatment	Take a virtual tour of two wastewater treatment plants. [ON]
Biodiversity	Ecological Footprint Calculator	Determine ecological footprint with online calculator and examine implications for biological preserves. [ON]