Cover Images

WHITESIDE MOUNTAIN, SOUTHEAST PROFILE, NORTH CAROLINA. (See p. 21.)
INTRODUCTION

2009 marks a number of significant anniversaries — among them the bicentennial of the births of Charles Darwin, Abraham Lincoln, and Edgar Allen Poe, the 20th anniversary of the fall of the Berlin Wall, and, closer to home, the 75th anniversary of the founding of Great Smoky Mountains National Park. The Smokies have served as a sort of touchstone for us in the IE program this year, as they did long ago for Horace Kephart, woodsman, author, and tireless advocate for the establishment of the Park.

Kephart came to the Smokies 105 years ago, in 1904, seeking, in his words, a "back of beyond." It was the balm of wildland, rugged terrain, and people with a sense of place that Kephart sought, and his passion and labors, together with the labors of many others, came to fruition 75 years ago this year with the Park’s establishment. Local naturalist and Kephart scholar George Ellison calls the Smokies a "place of refuge," and it has indeed been such a place for many others besides Kephart — in a very literal sense for the Cherokee historically, and in a figurative, emotional sense for many people today.

The Smokies changed radically in the period between the first publication of Kephart's book *Our Southern Highlanders* in 1913 and the revised edition in 1922. "Nine years have passed since this book first came from the press," Kephart wrote, continuing:

> My log cabin on the Little Fork of Sugar Fork has fallen in ruin. The great forest wherein it nestled is falling too, before the loggers' steel. A railroad has pierced the wilderness. A graded highway crosses the country. There are mill towns where newcomers dwell. An aeroplane has passed over the county seat. Mountain boys are listening, through instruments of their own construction, to concerts played a thousand miles away..."

Those changes have continued at an ever-accelerating pace since then, and the greater southern Appalachian landscape today is a mosaic of public and private land; wild, farmed, and built land; land supporting astounding biodiversity and land that has been compromised. It is a land with a unique history that reflects the interplay of geology, biology, and human culture. It is no longer "back of beyond," but it is still alluring, and as instructive as it is beautiful. It is our hope that our students will take what they have learned this fall about how a rich confluence of circumstances creates "place," and apply this knowledge to achieve a deeper appreciation of the "places" they will call home in the future.

The work presented in this book represents the culmination of each student's semester-long effort at tackling a particular problem pertaining to *this* place, situated in western North Carolina, near the southern terminus of the Blue Ridge Physiographic Province.
ACKNOWLEDGEMENTS

On behalf of the IE-HFS class of 2009, we would like to thank the many individuals who took the time out of their already busy professional lives to help develop and guide the students’ courses and projects this year. Thanks to internship mentors Jenny Sanders (Little Tennessee Watershed Association), Brent Martin (The Wilderness Society), Curtis Smalling (North Carolina Audubon Society), Hillrie Quin (The Highlands Plateau Greenway), and Jason and Jennifer Love (Coweeta Hydrologic Laboratory). Other individuals that assisted with the internships included Ed Schwartzman (NC Department of Environment and Natural Resources), Patrick Brannon (Highlands Biological Station), Doug Landwehr (Highlands Plateau Audubon Society), Bill Alexander (Biltmore), Robert Tucker (Inside-Outside), and Jeff Zahner (Chattooga Gardens). We also thank Brennan Bouma and Lindsay Leonard of the IE for their assistance organizing and overseeing the internships, and Larry Band for facilitating this year’s capstone project.

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Jim Costa and Anya Hinkle
IE-Highlands Field Site Directors
December 2009
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THE COWEETA LTER SCHOOLYARD PROGRAM STUDY BOXES: A MODEL FOR HANDS-ON SCIENCE TEACHING RESOURCES

SARA-ELIZABETH C. SENSENEY

Abstract. The effects of hands-on teaching strategies on science achievement have been debated among educators. Scholarship from the past two decades has shown that hands-on experiences increase students’ problem-solving abilities, raising overall science achievement. In this paper, I provide the procedure used to assemble the Coweeta LTER Schoolyard Program study boxes, which provide equipment and activities to teachers in schools with limited resources. The study boxes provide a model for teacher resource kits that can be replicated in other counties to encourage hands-on science teaching, which will ultimately improve science achievement among primary and secondary school students.

Key words: constructivism; Coweeta LTER Schoolyard Program; hands-on; science education; teaching resource.

INTRODUCTION

The proper role of hands-on activities in science teaching is a topic of debate in the field of education. Teaching strategies for science education change as new educational theories emerge. Although perspectives on the objectives of teaching science have fluctuated with the changing tides of educational philosophy over time, the goal of science education being put forth by current reformers is one of scientific literacy. The definition of scientific literacy is age dependent, changing with each grade level. For the goals of scientific literacy to be met, however, students should acquire knowledge of the process of conducting science in addition to core concepts and facts required for their particular grade level (Stohr-Hunt 1996).

Lumpe and Oliver (1991) define hands-on science as a learning experience during which the student uses materials to observe the scientific process. Although hands-on strategies are being promoted in all subjects, science, by nature, lends itself to hands-on activities. Hands-on teaching is aligned with the educational theory of constructivism, which proposes that students construct knowledge based on their understanding of scientific phenomena (Tobin 1993). During hands-on activities, students are often confronted with observed results that may be in conflict with their preconceived notions. The student’s resulting conundrum promotes higher order thinking and problem-solving skills, which are important for becoming scientifically literate (Lumpe and Oliver 1991).

Stohr-Hunt (1996) studied the effects of hands-on teaching strategies on science achievement in eighth-grade students in public and private schools. She found that the frequency of hands-on experience improved student achievement. Students that conducted hands-on activities at least once per week had higher science achievement scores than students who conducted hands-on activities less frequently (Stohr-Hunt 1996). Glasson (1989) investigated the type of learning benefited by hands-on experience. He found that while hands-on activities did not significantly affect factual or conceptual knowledge, students who conducted activities scored higher on tests of problem-solving abilities than students who watched a teacher demonstrate the same activity. The studies by Stohr-Hunt (1996) and Glasson (1989) show that
students who are able to construct their understandings of scientific phenomena through physical manipulation of materials develop higher order thinking skills that contribute to scientific literacy.

The extent to which hands-on strategies are implemented in the classroom depends partially on the availability of lab materials. School budgets for science materials, particularly in elementary and middle schools, are often very small, limiting the resources teachers have for hands-on activities and labs in science. In this paper, I provide the procedure used to compile and advertise the Coweeta Long Term Ecological Research (LTER) Schoolyard Program study boxes, teacher resource boxes aligned with the North Carolina and Georgia standards for middle grades science. The study boxes are meant to provide teachers with equipment and activities for teaching major curriculum units using hands-on methods. Although the Coweeta LTER boxes provide valuable resources to teachers in Macon County, North Carolina and Rabun County, Georgia, there is a need for the boxes to be replicated elsewhere in order to benefit teachers and students in other areas.

**METHODS AND MATERIALS**

*Conception and Funding*

The Coweeta LTER Schoolyard Program study boxes were modeled after the science boxes created by the Georgia Museum of Natural History (http://naturalhistory.uga.edu) and the discovery boxes available from the Sandy Creek Nature Center in Athens, Georgia (www.sandycreeknaturecenter.com). Like the science and discovery boxes, the Coweeta study boxes were designed to provide teachers with free equipment and activities to conduct hands-on scientific studies. Funding for the purchase of materials was acquired from the National Science Foundation through a supplemental grant for education and outreach to the core grant for the Coweeta LTER.

*Assembling the Boxes*

Equipment and activities were selected based on their correspondence to the North Carolina and Georgia middle school science curricula. Equipment was obtained from scientific supply companies, such as Carolina Biological Supply Company. Upon receipt, the equipment was divided into six categories: geology, soils, biodiversity, stream study, light and sound energy, and heat energy. The equipment was placed in six separate large plastic storage boxes. At least one activity was selected for each piece of equipment. The activities included with the boxes are designed to promote hands-on manipulation of scientific equipment and ask students to formulate hypotheses. The activities were taken from teacher resource books, including Friedl and Koontz’s *Teaching Science to Children: An Inquiry Approach* (2004), and websites like LEARN NC (http://www.learnnc.org). Activities were divided according to subject, organized in three-ring binders, and placed in each box. Inventory checklists and study box evaluation forms were added to the activity notebooks in each box.
RESULTS

Study Boxes

Each of the six study boxes contains equipment and activities to promote hands-on teaching (Fig. 1). A complete list of the equipment and activities in each box is included in Appendix A. The notebooks provide teachers with ready-to-use, flexible activities that use the equipment found in each book. Containing activities and equipment, the boxes will enable teachers to use hands-on strategies with reduced planning time and cost.

Outreach, Accessibility, and Improvement

The Coweeta LTER Schoolyard Program study boxes are accompanied by an advertising plan to reach teachers, a system to ensure convenient access to the boxes, and an evaluation procedure for future improvement. Information about the contents and purpose of the study boxes are available via the internet and a brochure, which is included in Appendix B. The brochure has been distributed at teacher conferences, including the North Carolina Science Teachers Association Professional Development Institute in Greensboro. Teachers can read the brochure for a short summary of each box or visit the website for a complete list of the equipment and activities in each box. A press release was published in local newspapers to raise awareness about the study boxes. Teachers can reserve a study box by phone or email. Depending on the teacher’s location, the boxes can either be delivered to the teacher or picked up from the Coweeta Hydrologic Lab, which is located in Otto, North Carolina approximately equidistant from schools in Macon County, North Carolina and Rabun County, Georgia. Each box has an evaluation form to be filled out by teachers that use the resource. The evaluation seeks to identify the equipment and activities that are being used most often and those that are used occasionally or not at all. The feedback from teachers given through the evaluations will be used to improve the existing boxes. The evaluations will also be helpful if the Coweeta LTER Schoolyard Program chooses to replicate portions of the boxes by forming mini-boxes that would reach more students at a lower cost.

DISCUSSION

The Coweeta LTER Schoolyard Program study boxes provide teachers with the necessary equipment for hands-on teaching at no cost to schools. Having free equipment available to teachers will likely increase the frequency with which students in Macon and Rabun Counties have hands-on experiences in science class. Based on the conclusions of Glasson...
(1989) and Stohr-Hunt (1996) regarding the positive effects of hands-on learning on science achievement and the theory of constructivism proposed by Tobin (1993), the Coweeta LTER Schoolyard Program study boxes should improve science achievement, particularly problem-solving abilities, by allowing students to personally observe scientific phenomena.

The scope of the study boxes is limited, however. With only one set of six boxes, the resource benefits a fairly small number of students, serving middle school students in only two counties. There is a need for similar teacher resource kits to be developed by organizations in other areas in order to support the goal of scientific literacy on a broader geographic scale. Federal funding requires that the Coweeta LTER conduct outreach work. The Schoolyard Program serves as an outreach arm of the Coweeta Hydrologic Laboratory, thereby helping the Coweeta LTER maintain its federal funding. The Coweeta LTER Schoolyard Program study boxes could be replicated by other science research groups, which would satisfy their outreach requirement and further the goals of science education by connecting education to research.

Transportation of the study boxes to teachers wishing to use the resources, particularly in rural areas where the distance between schools can be great, poses a challenge to replication of the study box idea and is an area of the program that needs to be improved. The transportation procedure currently being used by the Coweeta LTER requires time and energy of Coweeta employees or teachers, which may reduce the number of teachers who choose to use the resource. The Coweeta LTER Schoolyard Program study boxes, though limited in their scope, serve as a model for science education programs serving elementary and middle school students in other areas.

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LITERATURE CITED

APPENDIX A

Goals, equipment, and sample activities for each of the six Coweeta LTER study boxes.

I. Geology box

A. Description and goals

The geology box includes materials and activities for students to explore topics outlined in the North Carolina Standard Course of Study for middle school science. The study box covers topics that are included in the sixth grade Competency Goal 3, which include plate tectonics, the rock cycle, and earthquakes. Like the other study boxes, the geology box will help teachers meet Competency Goal 1 for sixth, seventh, and eighth grades, which states that students should develop an understanding of the process of scientific inquiry.

B. Equipment included

- Metamorphic Rock Collection
- Sedimentary Rock Collection
- Igneous Rock Collection
- Mineral Study Kit
- Mineral Test Kit
- Foam Cross Section Earth Model
- Sedimentator Demonstration
- Plastic Ware Kit
- Earth Science Skills Game
- Common Minerals Poster
- Pangaea Puzzle Kit
- The Southern Appalachians DVD and Guide
- Geoblox Plate Tectonics Block Models
- Paint Tray
- Watering Can
- Earthquakes Hands-on Activity Book
- Become a Rock Detective
- AIMS Earth Book
- Easy Science Demos and Labs Book

C. Sample activities

- Rock Stories – students examine rock samples and group them according to shared traits
- Metamorphic Rocks – cookie baking activity that models the formation of metamorphic rock
- Crayon Rock Cycle – crayons are melted and cooled to show how different rocks form
- Making Sandstone – activity using sand and Epsom salts to model the formation of sandstone
- Paper Crystal Models – investigation of the crystal forms of minerals by building paper models
- Mountain Building – simulation using clay to model tectonic plate movements
- Plants Make the Difference – demonstration of the effects of vegetation on soil erosion
- Build a Seismograph – students build a seismograph and record vibrations

II. Soils box

A. Description and goals

Activities in the soils box focus on determining the origins of different types of soils and how the attributes of various soil types affect plants and animals. The equipment and activities in the box will help teachers reach the objectives in Competency Goal 3 for the sixth grade, which relate to soil properties, including pH, particle size, erosion, temperature, and soil moisture. The study box helps students develop an understanding of scientific inquiry and experimental variables.

B. Equipment included

- Screen Sieve Set
- Bi-metal Dial Thermometer
- Light and Moisture Meter
- Winogradsky Column Set
- Soil Sampling Tube
- Lo Ion Test Kit
- Soil and Life Earth Science Source Book
- The Globe Soil Color Book
C. Sample activities
Soil Study – students observe the color, grain size, and living organisms in a soil sample
Looking for Life – students survey and record the organisms in a soil sample
Critter Guide – a field guide to insects and worms found in soil
Soil Temperature – students measure soil temperature at a field site over time
Soil Analysis – students observe soil contents, look for organisms, and measure soil pH
Dirt Pudding – a cooking activity to explore soil profiles with pudding and cookie crumbs
Digging Up Clues – students solve a mystery with their knowledge of soil types
The Sand-trap Blues – students investigate the source and quality of sand at a golf course

III. Light and sound energy box
A. Description and goals
The light and sound energy box groups light waves and sound waves together, so that students may understand the commonalities between the two forms of energy. The study box corresponds to the sixth grade Competency Goal 6, which addresses the topic of energy transfer. The equipment and activities in the study box will help students develop an understanding of properties of sound energy and the anatomy of the ear. Additionally, the box includes aids for teaching about light waves, color, and the anatomy of the eye.

B. Equipment included
- Buzzy Bee Sound Investigation
- Human Ear Model
- Tuning Fork Kit
- Physics Essentials DVD
- Human Eye Model
- Acrylic Prism Set
- Acrylic Lens Set
- UV Intensity Meter
- UV Changing Beads
- Purple and White Tube
- Light, Lenses, and Lasers DVD
- Slinky
- Spectroscope
- Concave and Convex Mirrors
- Diffraction Grating Glasses
- Ray Box and Color Filter Set
- Slide Whistle

C. Sample activities
Which Way? – students test their hearing ability with only one ear versus two
The Phenomenon of Sound – students observe how sound moves through different materials
The Big Splash – sound vibrations are demonstrated by placing a tuning fork in water
Inside My Eye – a printed handout of a labeled eye to accompany the human eye model
Looking at Lenses – students test convex and concave lenses to see which will serve as a projector
Internal Reflection – a demonstration of the reflective properties of water
Just Passing Through – students observe objects with differing degrees of translucency
Groovy Guitar – students construct a mini-guitar with a rubber band

IV. Heat energy box
A. Description and goals
The heat energy box is correlated with topics covered in the sixth grade Competency Standard 6, including thermal radiation, expansion, thermal conductivity, and convection. The equipment and activities in the box help students experience the scientific phenomenon associated with heat energy.
B. Equipment included

- Ball and Ring Apparatus
- Thermal Conductivity Bar Set
- Convection Apparatus for Gases
- Thermal Radiation Kit
- Changing States of Matter DVD

C. Sample activities

- Hot-Air Balloon – air trapped in a cold bottle inflates a balloon as it warms
- Magic Needle – a demonstration of metal contraction and expansion
- When Hot and Cold Meet – students observe dyed hot and cold water mixing by convection
- The Heat Race – a demonstration of conduction of heat through metal
- Smoke-a-Risin’ – smoke moves within a convection cell made with a jar
- Seeing the Invisible – an activity to show the connections between light and heat energy
- When You’re Hot, You’re Hot – an experiment to test the effect of color on heat absorption
- Energy on the Move – an investigation into the transfer of kinetic energy to heat energy

V. Stream study box

A. Description and goals

The stream study box includes materials to explore stream hydrology, biodiversity and indicator species, and water chemistry. Students can use the material to measure stream flow, water pH, and dissolved oxygen. Additionally, the box includes materials to conduct a macro-invertebrate study to assess the health of a stream. The stream study box corresponds to the eighth grade Competency Goal 3, which states that students should understand the hydrosphere on a global and local level, be able to assess water quality, and understand human impacts on water quality.

B. Equipment included

- Knowing the Health of Small Streams packet
- 200' Measuring Tape
- Laminated Fish Cards
- Orange Flags
- Leaf Pack Macroinvertebrate ID
- Flashcard Set
- Small Magnifying Sample Box
- Yellow Lidded Magnifying Sample Containers
- Stopwatch
- Laminated Macroinvertebrate Cards on Strings
- Macro Lens
- 10 Meter Measuring Tape
- Hand Lens
- Plastic Magnifying Glass
- Forceps
- Plastic Spoon
- White Plastic Tray
- Markers
- Meter Sticks
- Brushes
- Graph Paper Notebook
- Stream Studies Folder
- Curriculum Studies Folder
- Upper Little Tennessee Watershed Curriculum
- 60 cm Turbidity Tube
- 120 cm Turbidity Tube
- The Science Source Water Sampler
- Turbidity Box
- Bag of Plastic Petri Dishes with Lids
- Dissolved Oxygen Box
- pH Box
- Nutrients Box
- Yellow Seine Net
- Square Dip Net
- Field Sieve / Gravelometer
- Stream Macroinvertebrates Posters
- Laminated Watershed Maps
- Hip Waders (available for check out separately)

C. Sample activities

- The Water Molecule – explanation of the water cycle that traces a single molecule
All the Water in the World – an activity to explore the major stores of water in the world
Intro Lesson on Water Quality – a general lesson on topics related to water quality
How healthy is your stream? – an activity that incorporates several stream health indicators
Arthropod – an activity that explains the general anatomy of arthropods
Stream Insects and Crustaceans – a field guide to common macroinvertebrates
Where does water run off after school? – a study of water runoff that uses the school as a reference
pH Packet – a packet to give background for stream pH testing

VI. Biodiversity box
A. Description and goals
The biodiversity box includes equipment to explore the vast array of life outside of the classroom. The activities will get students excited about the life outside their classroom and teach them the importance of biodiversity in maintaining the health of ecosystems. The biodiversity box is correlated to the sixth grade Competency Goal 7, which specifies that students will investigate the interactions between organisms and the factors that affect populations of organisms.

B. Equipment included
Aerial Nets
Sweep Nets
Canvas Beat Sheets
Aspirators
Insect Viewing Jars

C. Sample activities
Biodiversity Blitz – students survey the biodiversity in their schoolyard
Children Collecting Bugs! – students survey all of the insects found within a certain area
Monarch Watch Citizen Science – a monarch tagging program to track butterfly migration
Sweep Net Experiment – students collect insects with nets and compare their locations
APPENDIX B

The brochure for the Coweeta LTER Schoolyard Program study boxes.

**Coweeta LTER Schoolyard Program**
The Coweeta Long Term Ecological Research (ILTER) Schoolyard Program engages local school children in conducting their own field research into weather, biodiversity, stream quality, and human use of natural resources in the southern Appalachian Mountains. As in the Coweeta LTER Program, the emphasis in the Schoolyard Program is on collaborative, comparative, and synthetic research and the local and regional application of research results. If you would like additional information on the Coweeta LTER Program, please visit our website at: [http://caweeta.uga.edu](http://caweeta.uga.edu)

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**Study Box Overview**

**Geology Box**
The geology box includes materials and activities for students to explore plate tectonics, rock formation, rock identification, and erosion. Sample activities include: Rocking the Rock Cycle, Layer of Earth, and Build a Seismograph.

**Soils Box**
Activities in the soils box focus on determining the origins of different types of soils and how the attributes of various soil types affect plants and animals. The box includes materials for testing the soil temperature, moisture content, pH, and nutrient content. Dirt Pudding, Looking for life, and Digging Up Clays are some of the activities.

**Light and Sound Energy Box**
The light and sound energy box groups light waves and sound waves together, so that students may understand the commonalities between the two forms of energy. The light materials include UV intensity beads and prisms. Tuning forks are available for students to explore sound vibrations. Activities include: Nothing But Blue Skies, A Buzzy Bee, and the Phantom of Sound.

**Heat Energy Box**
The heat energy box materials give students hands-on tools to explore the topics of thermal radiation, expansion, thermal conductivity, and convection. Some of the activities in the heat energy box are Energy on the Move and Smoke-a-Rama.

**Biodiversity Box**
The Biodiversity Box includes equipment to explore the vast array of life in your schoolyard. Equipment includes aerial roots, heat sheets, and various field guides. Activities such as Biodiversity Blitz will not only get students excited about all the life outside their classroom, but will also teach them the importance of biodiversity in maintaining the health of ecosystems.

**Study Box Availability**
The study boxes are based on the North Carolina and Georgia standards for middle school science. Boxes may be checked out for up to three weeks. For more information on the Coweeta LTER Schoolyard Program or to reserve a study box, visit: [http://caweeta.uga.edu](http://caweeta.uga.edu) Or email: cwy@uga.edu