This paper describes an inquiry-based, student-centered mathematics, science, and technology curriculum guide. It features activities addressing such environmental science topics as groundwater modeling, water filtration, soil permeability and porosity, water temperature and salinity, and quadrant studies. Activities are organized so that the concepts and techniques are first developed in the classroom, then reinforced in the schoolyard. The concepts are then carried out into the field, the Pine Barrens, or other parts of the ecosystem. This structure encourages the learner to discover the scientific principle and test it, thereby performing individual research. Results are reported from a survey of teachers, non-formal science educators, and students who had completed learning activities based on the curriculum guide. (CCM)
An Ecological System Curriculum: 
An Integrated MST Approach to Environmental Science Education

Nina A. Leonhardt
Suffolk County Community College
Selden, New York

Introduction

During the 1990's, developments in the worlds of education and environmental protection have led to a confluence of new initiatives. This provides a unique opportunity for the educational community, with significant implications for teaching and learning about the environment.

The National Science Education Standards (National Research Council, 1996) advocate inquiry-based, student-centered learning environments that go beyond "science as process" to educational systems in which students use reasoning and critical thinking skills to understand the world around them. In addition, the Curriculum Frameworks for Mathematics, Science and Technology (New York State Education Department, 1994) and the Learning Standards for Mathematics, Science and Technology (New York State Education Department, 1996), stress the integration of mathematics, science and technology (MST) in science teaching and learning.

Since the late 1980's, an appreciation of fragile ecological systems has led to the protection of such areas. Often, appreciation has resulted in the need to seek legal remedies for protection as business, industry and government entities seek to enhance the economic base. With preservation created by legislation and upheld by the courts, these ecosystems are now public lands that can serve as natural learning laboratories.

One area that is now preserved, after a protracted battle between developers and environmentalists, is the Long Island Pine Barrens, an area of approximately 100,000 acres, situated in Suffolk County, the easternmost county on Long Island, New York. This ecosystem is essentially a huge watershed that sits atop an aquifer system that is the sole
supply of drinking water to the three million Long Island residents (Englebright, 1980). In addition, the Pine Barrens is home to diverse and unusual species, many of which are endangered or threatened (Turner, 1994).

The Problem

The effort to preserve the Long Island Pine Barrens, was a grassroots one, initiated and driven by the Long Island Pine Barrens Society, a non-profit organization originally organized to raise educational awareness about the importance and uniqueness of the Pine Barrens, a natural, non-formal science education resource. In 1995, the U.S. Environmental Protection Agency (EPA) provided funding for the development and the dissemination of a curriculum guide for teachers that would serve as a resource for area teachers. The challenge was to develop a document that addressed the standards and frameworks, built upon constructivist teaching and learning principles. Such a guide would encourage students to develop and apply higher order critical thinking and science reasoning as they explore their outdoor “laboratory.” A secondary goal, although a more comprehensive one, was to create a curriculum guide that would be easily adaptable to any age learner exploring any ecosystem.

Methodology

The central element in the curriculum guide is a set of lesson plans that generally describe inquiry-based, student-centered MST activities. These activities address environmental science topics such as groundwater modeling; water filtration; soil
permeability and porosity; water temperature and salinity; and quadrat studies. They are organized so that the concept and technique is first developed in the classroom. Reinforcement occurs in the school yard or in front of the school. Finally, they are carried out in the field, i.e., the Pine Barrens or other parts of the ecosystem. Simple materials are used in most cases. This structure encourages the learner to “discover” the scientific principle and then test it, thereby “doing” individual research. It is also constructivist in nature; each activity builds on the learning and understanding previously developed.

Many of the lesson plans provide a “sketch” of the activity. This allows the teacher to easily tailor it to the audience and encourage student participation in the design of the experiments. These characteristics therefore, also encourage the teacher to use the activities as a basis for action research.

In addition to the lesson plans, the guide includes comprehensive science and legislative background sections. It also contains a resource guide with extensive listings of public access areas of environmental interest on Long Island; environmental organizations; print and video resources; and Internet sites.

Following completion in late 1996, the curriculum guide was distributed to Long Island schools. It was also field tested with 185 learners, representing several populations:

- in-service K-12 teachers attending an EPA-sponsored Pine Barrens workshop;
- in-service science, mathematics and/or technology teachers paired with K-6 teachers completing a science research experience at Brookhaven National Laboratory;
• graduate students enrolled in a Science-Technology-Society (STS) course at the State University of New York at Stony Brook, approximately 60% of whom are in-service K-12 teachers;
• non-formal environmental science educators;
• undergraduate students enrolled in an elementary-level science methods at New York University; and
• middle school students (grades 7-9) participating in the Science and Technology Entry Program at Suffolk County Community College, a state-funded program designed to increase the numbers of minority and educationally disadvantaged students to continue to study science, math and technology to prepare for careers in the sciences and the licensed professions. A summary of participants is presented below.

<table>
<thead>
<tr>
<th>Cohorts of Participants</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-service teacher attending workshop</td>
<td>23</td>
</tr>
<tr>
<td>In-service teacher in science research prog.</td>
<td>9</td>
</tr>
<tr>
<td>Graduate student</td>
<td>49</td>
</tr>
<tr>
<td>Non-formal science educator</td>
<td>12</td>
</tr>
<tr>
<td>Undergraduate student</td>
<td>36</td>
</tr>
<tr>
<td>STEP student</td>
<td>56</td>
</tr>
</tbody>
</table>

Results

Teachers attending the EPA workshop spent four hours as learners. They constructed groundwater models, performed porosity tests in the classroom and the school
yard and participated in quadrat studies. The teachers involved in the science research experience at Brookhaven National Laboratory completed these activities and also performed temperature studies in a two-day experience. The Stony Brook at New York University students performed quadrat studies for 2 hours as did the STEP students, who collected samples in the school yard and in the Pine Barrens. The non-formal educators experimented with the field activities for about two weeks.

Following each learning experience, participants were asked to comment on their perception of the value of their participation. In each case, over 90% of learners reported a heightened awareness of their environment. A majority (75%) of the teachers/educators felt empowered to use MST inquiry strategies to teach about the Pine Barrens ecosystem. Students (79%) enjoyed the opportunity to “discover” in the classroom and then apply their new skills and knowledge in the “real world.”

<table>
<thead>
<tr>
<th>Question</th>
<th>Cohort</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>After completing these activities, you are more aware of the diversity of species in your environment</td>
<td>In-service teacher attending workshop</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>In-service teacher in science research</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Graduate student</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Non-formal science educator</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Undergraduate student</td>
<td>33</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>STEP student</td>
<td>50</td>
<td>6</td>
</tr>
</tbody>
</table>
I understand the value of MST inquiry activities in teaching
(asked of all cohorts other than STEP students)

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Group</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>I understand the value of MST inquiry activities in teaching</td>
<td>In-service teacher attending workshop</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>In-service teacher in science research</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Graduate student</td>
<td>30</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Non-formal science educator</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Undergraduate student</td>
<td>26</td>
<td>10</td>
</tr>
</tbody>
</table>

I enjoyed discovering science concepts and then using them to do experiments in the Pine Barrens

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Group</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoyed discovering science concepts and then using them to do experiments in the Pine Barrens</td>
<td>In-service teacher attending workshop</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>In-service teacher in science research</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Graduate student</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Non-formal science educator</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Undergraduate student</td>
<td>34</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>STEP student</td>
<td>50</td>
<td>6</td>
</tr>
</tbody>
</table>

Implications

The field tests indicate a general level of satisfaction with the program. The next step is to revisit participants to determine if they are using the knowledge that they seemingly acquired and internalized. Are teachers comfortable with MST inquiry-based teaching? Are students comfortable with MST inquiry-based learning? Are both groups continuing to explore the Pine Barrens and other ecosystems?

As explained above, although this guide was developed to study a specific ecosystem, it is applicable to the study of any ecosystem. The major topics are central to the environmental science, and, hence, to the study of the environment anywhere. It has been
field tested in the urban environment of New York City, awakening students to the diversity of urban park lands. Similarly, it could be easily adapted to a Caribbean island such as Trinidad or a mountainous region such as Colorado. This flexibility makes this approach to MST environmental education a particularly valuable one.

References

I. DOCUMENT IDENTIFICATION:

Title: An Ecological System Curriculum: An Integrated MSt Approach to Environmental Science Education

Author(s): Nina A. Leonardt

Corporate Source: NA

Publication Date: 1998 (prepared, presented)

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, Resources in Education (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

[ ] Level 1

The sample sticker shown below will be affixed to all Level 2A documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY, HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

[ ] Level 2A

The sample sticker shown below will be affixed to all Level 2B documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

[ ] Level 2B

Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archive media (e.g., electronic) and paper copy.

Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC without restrictive notices only.

Check here for Level 2B release, permitting reproduction and dissemination in microfiche only.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

[Signature]

Nina A. Leonardt

Suffolk County Community College

533 College Rd.

Selden, NY 11784

BEST COPY AVAILABLE