Using Undergraduate Students and the Internet to Enhance Middle School Science Education

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Abstract

The Internet has created new and innovative opportunities for natural resources education. At Virginia Tech we have developed a multi-faceted program for use by middle school students. The program involves web-based instructional material; classroom visits by undergraduate students and faculty from the College of Natural Resources; and facilitates data collection and reporting over the internet by the middle school students. The results of six years experience with the program are discussed in detail. Pre-testing of middle school students indicates a need for outreach programs, based on their lack of knowledge about natural resources, and attitudes that are incongruent with natural resources management.

Introduction

International studies of K-12 math and science achievement over the past 30 years show that US students have not performed as well as might be expected in comparison with their peers in other nations (NCES, 2004). The Third International Mathematics and Science Study (TIMSS), conducted in 1995, and involving over a half-million students from 41 countries, provides a benchmark for comparing math and science achievement across five grade levels. It reveals a pattern of declining science achievement as US students progress from elementary to high school (Calsyn et al., 1999).

The 1995 TIMSS study revealed that U.S. fourth graders scored above average in both mathematics and science compared with 26 nations, and were surpassed by only one country—Korea—in science (Beaton et al., 1997). U.S. eighth graders, on the other hand, scored below average in mathematics achievement and above average in science achievement, compared to 41 nations (Peake, 1996). By the time US students reached their final year of high school they were significantly below their peers in 21 countries (Mullis et al., 1998). However, TIMSS benchmarks have been criticized for not controlling such factors as student selectivity, curriculum emphases, and the proportion of low-income students in the test taking population (Rotberg, 1998).

The latest TIMSS study, now referred to as Trends in Mathematics and Science Study, (Martin et al., 2004) finds that US student achievement has increased in grade eight and decreased in grade four, since the original benchmarks were taken. Interestingly, the study shows a shrinking achievement gap between white and minority students in science in the US (Bhattacharjee, 2004). The original benchmarks show no direct correlation with factors commonly associated with student achievement-time spent in class, amount of homework, hours spent watching TV (Vogel, 1996, 1998).

Along with performance in science, environmental literacy in the US has much room for improvement. A study of US adults (NEETF 1997) shows that two-thirds cannot correctly answer 12 questions about the environment, including 23% who are unable to identify run-off as the leading cause of water pollution, and 33% who do not know that burning fossil fuels is America's primary method for generating electricity. Furthermore, misinformation may be as big a cause of the problem as lack of information. In a study of US schoolchildren, researchers found that television was the most pervasive source of environmental information (NEETF 1994; Roper 2002).

In 1998 the Virginia Tech Department of Forestry began an outreach program to middle schools that involved a web site, undergraduate student presentations to middle school classrooms, and scientific investigations conducted by middle school students and reported over the internet. The program began in part to meet the national need for science education in the middle school years, as evidenced by the TIMSS rankings, which drop precipitously between elementary and high school, and to help Virginia teachers meet their state Standards of Learning (SOL) (Board of Education, 2004). Like many states, Virginia has adopted standards that describe expectations for student learning and achievement and detail the specific knowledge and skills students must possess in order to graduate from high school.

Virginia Cooperative Extension is involved with the delivery process. County 4-H Extension Agents are asked to nominate teachers with whom they have some existing or planned contact. The campus-based Extension Specialist visits schools to assess middle

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school student knowledge of forestry and teacher acceptance of the program. Virginia Cooperative Extension has a comprehensive 4-H natural resources program that makes use of information technology (Kirwan and Burcham, 2002).

The purpose of this paper is to describe our outreach program and relate what we have learned about middle school student knowledge of life sciences and the types of scientific investigations they are capable of completing over the Internet. We will also share what we have learned about how teachers adopt new technology, and how we intend to use that information to modify our outreach program in the future.

Materials and Methods

The web site, FORSite (Forestry OutReach Site) contains detailed information on forests, tree identification and scientific investigations (Seiler et al., 2003). It also provides access to experts at Virginia Tech. Middle school students use the site to identify trees as part of their scientific investigation on biodiversity. Results of scientific investigations are posted on the web. The site is divided into nine chapters: Introduction, Forestry Equipment, How a Tree Grows, Scientific Investigations, Tree Identification, The Forest Community, Participating Schools, Ask Our Experts, and Links. Much of the web site content originated from a multimedia instructional program developed for undergraduate teaching (Seiler et al., 1997, 2002).

Student Evaluation

To the teacher: We would appreciate your feedback. This information will be used to improve these presentations as well as to grade the participating Virginia Tech student. Please fill out by circling your responses and place in the enclosed envelope. Seal it and sign across the seal before returning it to the student. Thank you.

School: ____________________

Instructor: ____________________

Visiting Student/Presenter: ____________________

	problem			strength
Voice could be easily heard	1	2	3	4
Voice was raised or lowered for variety and emphasis	1	2	3	4
Rate of speed was neither too fast nor too slow	1	2	3	4
Established and maintained eye contact with the class	1	2	3	4
Speech fillers ("okay now," "ahm," were not distracting	1	2	3	4
Speech was neither too formal nor too casual	1	2	3	4
Examples were easily understood by students	1	2	3	4
Material presented is important for this group of students	1	2	3	4
Presented examples, illustrations, or demonstrations to clarify difficult ideas	1	2	3	4
Order of presentation was logical	1	2	3	4
Overall presentation was very understandable	1	2	3	4

Figure 1. Evaluation Form for Undergraduate Student Presentations. Teachers scored undergraduates consistently high across all categories (average 3.85; N = 128).

Each year a select group of undergraduate students visit middle school science classes to make presentations on forestry topics. Each presentation is based on a Life Science SOLs that teachers are required to teach. Topics covered to date include what foresters do, forest regeneration, forestry equipment, fire ecology, cell structure and the uses of wood, food webs, classification, impacts of insects and diseases, and photosynthesis. The undergraduate students are concurrently enrolled in an independent study course called Leadership Skills Enhancement. Middle school teachers are asked to evaluate the student presentations (Figure 1), and this forms the basis for 65% of their grade. Undergraduate students are also required to add content to the web site, and this forms 15% of their grade. The remaining 20% is based on their communication skills in scheduling with teachers, and participation in classroom activities.

Scheduling presentations was facilitated by a web page where middle school teachers see pictures of each undergraduate student, an outline of their presentation, and the student's schedule and contact information. Teachers contact undergraduate students directly, confirm a date, and prepare their middle-school students for the classroom visit. The presentation outline is linked to original content created by the undergraduate student, so it becomes a virtual presentation that can be viewed in advance of the classroom visit, or as a review. Funds for supplies, and automobiles from the campus motor pool are made available to undergraduate students who need them, the result of an annual mini-grant provided by the Virginia Forestry Educational Foundation, a branch of the state forestry association.

Initially, all schools were asked to conduct a scientific investigation on campus biodiversity. In this investigation, middle school students identify and count trees on their school campus or at a nearby natural area, and send their data to Virginia Tech where we compile and organize it for analysis. Middle-school students are then asked to develop histograms and calculate Simpson's Diversity Index. Over the years we have added scientific investigations on wildlife road kill, tree growth and a study of American chestnut seedling survival.

To assess middle school students' knowledge of biodiversity and attitudes toward forestry practices, the following questions were asked of students at the beginning of a class period: (1) name as many Virginia forest trees as you can; (2) do you think it is OK to cut trees

Table 1. Summary participation data for the FORSite program.

Category	1998	1999	2000	2001	2002	2003	Total
Undergraduate students	2	3	6	5	6	7	29
Presentations	15	33	113	87	125	188	499
Schools	4	7	15	16	17	19	78
K-12 Students	300	658	2260	2110	2409	3739	11476
Counties	4	5	7	11	12	10	35 (unique)

(yes, no, maybe) and (3) why. Students are given approximately five minutes to complete the questions so that most of the class period could be devoted to instruction. We did not attempt to return to administer questions at a later date to assess changes in attitude and knowledge as a result of our program.

Results and Discussion

Teacher Participation

The program started with nine teachers at four schools, and two undergraduate students giving classroom presentations (Table 1). In 2003 we had 26 teachers at 19 schools, with seven undergraduate students giving presentations. Nearly all teachers are taking advantage of the student presentations and about two-thirds are sufficiently pleased with the quality to continue the following year. Teachers scored undergraduate presentations consistently high across all evaluation categories (average 3.85; N=128). Participating schools range from 1 to 150 miles from the Virginia Tech campus.

Preliminary results from the outreach program show that there is a high demand for undergraduate student presentations and that schools and teachers vary widely in their use of computers in teaching (Kirwan and Seiler, 1999). Although there was some initial reluctance by teachers to use e-mail to schedule undergraduate student presentations, this is now accepted as standard operating procedure. One unexpected result was middle school students' excitement at having their data presented over the internet.

Participation in scientific investigations and reporting data over the internet has been slower to evolve. Follow-up telephone interviews with teachers indicate that a lack of in-school computer facilities and internet connections restrict participation. Timing is another impediment. By the time data are entered over the internet and results are posted, many teachers have moved onto another instructional unit, and their interest in the project has waned. To remedy this, we developed a protocol where teachers can enter data, and a software program automatically generates tables and graphs with results.

What Middle School Students Think about Forestry Practices

When asked if it was OK to cut trees, middle school students were about equally split between those who were opposed and not opposed to cutting trees, or who were somewhere in between (Table 2). The most frequently cited reason for not opposing tree harvesting was society's need for forest products, which was mentioned by nearly half the students. What surprised us were the reasons why young people are opposed to harvesting trees. Over one-fourth of middle school students believe harvesting trees will deplete oxygen in the atmosphere. A much smaller proportion of students (< 14%) were concerned about its impact on wildlife habitat. The questions on this section were open-ended, so students were not prompted to answer any particular way.

These results indicate a real need for outreach efforts in forestry. Virginia is 63% forested, its forest industries contribute over $11.5 billion to the economy, and they represent the largest manufacturer in terms of employment. We believe that having one-third of young people opposed to industry practices, based on invalid science (loss of atmospheric oxygen as a result of cutting trees), is a potential future threat to the economic well being of Virginia. There are, of course, valid reasons for preserving trees and restricting timber harvest in certain situations. However, it appears that teachers are doing a good job of teaching photosynthesis, but not decomposition and the cycling of oxygen. We are now including this information in our presentations about photosynthesis, along with a discussion of the Co_2 cost of producing alternative products to wood

Table 2. Middle school student responses to questions about forestry. (N=86). Only those responses that were mentioned by two or more students are listed.

Question	Number of Students Responding
Is it OK to cut trees?	
Yes	30
No	26
Maybe	29
Why is it OK to cut trees?	
Need forest products	37
Trees are renewable	9
Good for economy/jobs	2
Why is it not OK to cut trees?	
Deplete oxygen in atmosphere	22
Loss of homes for wildlife	12
Scarcity of trees	5
Too much waste	4
Urban sprawl	2

(concrete, aluminum, steel) and the benefits of using a renewable resource.

What Middle School Students Know about Biodiversity

Knowledge of species is foundational to the understanding of biodiversity. One way to assess this knowledge is to ask students to list as many species as they can recall from experience. Most of our middle-school students could name only three or four trees (Table 3), and even then they were naming only genus-level groups of trees and not species (e.g., oaks and pines, not white oak or loblolly pine). The species with the greatest biomass in Virginia, the yellow-poplar (*Liriodendron tulipifera*) (Johnson, 1992) was named by less than 5 percent of students. Another important Virginia tree, sweetgum (*Liquidambar styraciflua*), was not named by any student. Most students logically listed oak and pine, which as a group have the greatest biomass in Virginia. Dogwood (*Cornus florida*), the Virginia state flower, was named by just under half of the students. A large number of students apparently had difficulty distinguishing between wild and domesticated species, as represented by the inclusion of apple as a forest tree.

These results indicate that middle school students have little knowledge of biodiversity or are not connecting what they learn about biodiversity with local examples. We believe that our emphasis on learning to distinguish between species on school campuses is valid. When middle-school students report school biodiversity data on our website (number and species of trees) their school's Shannon-Weaver index and species richness is automatically generated. They can then compare their school with others, and formulate hypotheses for why one school is higher or lower biodiversity than another. The website also provides information on how biodiversity indices are calculated.

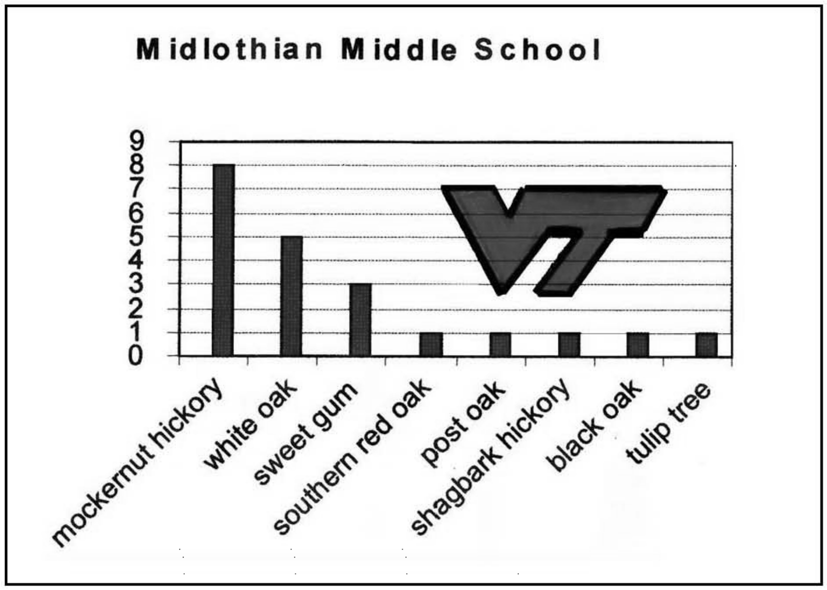

Figure 2. Example of a graph sent to us by a 7th grade student. Students identified trees using an on-line identification key. VT = Virginia Tech. Vertical axis should be labeled "number of trees."

Table 3. Middle school student knowledge of forest trees. Students were asked to name as many Virginia forest trees as they could. (N= 65)

Most Common Answers	Percent Answering
Oak	78
Pine	77
Maple	52
Dogwood	43
Apple[z]	18
Walnut	17
Redwood[z]	15
Cedar	12
Average number of correct answers = 3.46	

[z]counted as incorrect

What Middle School Students Are Capable of Learning and Doing over the Internet

Students correctly identified 16 trees species found on their study sites using the on-line identification key, and reported their data to us over the internet. We know this because our undergraduate students tagged and recorded trees when they visited school sites. The 16 species included hard-to-differentiate species such as white oak (*Quercus alba*) and post oak (*Q. stellata*), red oaks (*Q. rubra and Q. falcata*) and black oak (*Q. velutina*). Many students sent us graphs prepared with computer spreadsheet programs (Figure 2).

The web site concept described above is one that is potentially available to any school or individual with Internet access. We are currently receiving inquiries from across the United States, many from teachers. The SciLinks program, a service of National Science Teachers Association, selected the FORSite tree identification chapter as its on-line reference (NSTA, 2003). As schools expand their computer and internet-related capabilities, the use of technology in teaching will become increasingly important

Middle-school students are capable of proposing and testing hypotheses, collecting and analyzing data, and making conclusions, based on our experience with their scientific investigations of biodiversity and wildlife road kill. These basic scientific skills are included in our state science standards of learning across all grades. However, these activities require time outside of the classroom, and teachers may find them difficult to organize or are uncomfortable teaching in the outdoor classroom. In 2003, for example, only eight of the 26 teachers (31%) followed through with scientific investigations. When follow-up assistance was given, teachers were more likely to participate in investigations.

Summary

New technologies offer great potential to expand outreach activities to schools and communities, meeting a need for improved knowledge about forestry. A combination of web-based instruction, presentations by college students, and investigations conducted over the internet has been well received by a growing number of middle school students and teachers in Virginia. Involving teachers and students to follow through with scientific investigations has been a challenge. Providing internet protocol with immediate feedback of results will potentially increase the level of participation, as will follow-up assistance when the outdoor investigation is conducted. Future studies should access whether our program increases student performance on state standards of learning, and increases environmental literacy.

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