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Evaluating Multimedia-Learning Tools Based on Authentic Research Data That Teach Biology Concepts and Environmental Stewardship

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Abstract

High school science teachers and students need interactive, multimedia research-based learning objects that (a) support standards-based teaching, (b) enforce complex thinking and problem solving, (c) embrace research skills, (d) include appropriate assessments to measure student performance, and (e) show "real-world" uses. To meet these five criteria, the CHANCE modules have been purposefully designed to allow students to "learn how things work" using real-world research data. These modules pace students through images and text that help them to interpret biological and ecological principles. Indeed, each module has been carefully field tested with practicing in-service and preservice science teachers and real students to assure its effectiveness. Notably, the integration of authentic scientific research with sequenced, interactive computer simulations create a solid curriculum base of national interest that has laid the groundwork for additional materials collections that capitalize on the resources of communities that surround schools in particular regions of the country.

NCLB is like a one-size-fits-all dress made for women who range from a size 4 to a size 2x; the dress looks right on the woman who wears a size 2x, but when the woman who wears a size 4 or size 8 puts on that dress, it falls off her shoulders. NCLB and the one-size-fits-all dress will need to be altered to fit all consumers.

-Mildred L. Taylor, high school biology teacher
(National Education Association, 2007, p. 188)

Most environmental education at the secondary level occurs inside classroom walls, focusing on textbook content and packaged laboratory activities with only an occasional outdoor activity. Worse yet – this material consists of one or two chapters in a general biology book, which may or may not even be covered in its entirety during a short allotted time period in one academic year. Moreover, the science underlying this curriculum, in general, remains watered down as mere vocabulary words with definitions and color-coded diagrams, graphs, and tables in order to mass produce textbooks and "cookbook" lab manuals and to meet "the standards." According to Schmidt, McKnight and Raizen (1997), American science curricula are a "mile wide and inch deep" for their "jumble of topics" and lack of depth (cited in Beatty, 1997, p. 10). By the time preservice science teachers come to their supervised field experiences, they face the daunting tasks of preparing lessons with suboptimal materials and methods. By perpetuating these deficits, schools are "producing a society with little scientific literacy at a time when such literacy is needed more than ever" (Wubbels & Girgus, 1997).

Real science teaching should involve "scientific teaching," active learning strategies to engage students in the process of science itself, and teaching methods that have been systematically tested and shown to reach diverse students (Handelsman et al., 2004). According to physics Nobelist Carl Wiemen, one of the best ways for teachers to implement scientific teaching is to bridge the crucial gap between teaching and basic research. However, in an age where the costs of complying with unfunded mandates such as the *No Child Left Behind Act* fall to already overburdened school budgets, in-service teachers find themselves without resources to create scientific teaching approaches that will help their students master science content standards, approaches that they would also want to share with their preservice colleagues.

Reconciling Standards to Classroom Creativity: A National Beginning

According to the authors of the *National Science Education Standards* (National Research Council, 1996), students need "access to skilled professional teachers, adequate classroom time, a rich array of learning materials, accommodating work spaces, and the resources of the communities surrounding their schools." Although national, state, and local budget cuts continue to constrain students' access to all of these resources, curriculum developers nationwide have been collaborating with skilled teachers and scientists to create effective, integrated learning strategies that strengthen teachers' professional skills, make optimal use of classroom time, and broaden student access to learning materials via the Internet.

Guidelines have been proposed by leading national science education organizations for the integration of technology into science classrooms and for the preparation of science teachers (Flick & Bell, 2000). These guidelines include the following:

1. Technology should be introduced in the context of science content.
2. Technology should address worthwhile science with appropriate pedagogy.
3. Technology instruction in science should take advantage of the unique features of technology.
4. Technology should make scientific views more accessible.
5. Technology instruction should develop understanding of the relationship between technology and science.

Although textbook publishers have produced rich arrays of highly interactive CD-ROM materials for several decades, they are often priced outside the reach of many public school district budgets, particularly when teacher training ancillaries and workshops impose additional fees before the materials are even useable in the science classroom.

Science teachers need more affordable options for accessing highly interactive science materials. Federal attempts over the last decade to close the digital divide through an estimated $3 billion annual e-rate Internet funding (Universal Services Administrative Company, 2007) and the concurrent “Moore’s Law” (Moore, 2003) of halving prices while doubling computing power have rendered the Internet a far more accessible medium for many public school science teachers and students. The project discussed in this article takes advantage of the increasingly more affordable Internet to deliver highly interactive science materials.

In response to increased public school access to the Internet, the Office of Science Education (OSE) at the National Institutes of Health (NIH) has recently launched a Curriculum Supplement Series of web-based materials that continues to grow as funding and expertise are allocated to this project (OSE, 2006). The major advantages of these materials for teachers can be summarized in four key points:

1. Access to the materials in print or multimedia formats is free via the Internet.
2. Practicing science teachers and NIH scientists co-author the materials.
3. Each learning module is aligned to national and state science standards.
4. Teacher guides and complete lesson plans are also included at no charge.

The modules already available from the growing collection at the NIH Web site follow an adaptation of the classic Atkin-Karplus (and later Lawson) model of sequenced instruction, applying a Piagetian learning cycle. Recent cognitive research on how people learn and, particularly, on how children learn science has refined the earlier Piagetian cycles to occur much earlier and more iteratively in young learners’ brains (Bransford, Brown, & Cocking, 1999; Donovan & Bransford, 2005; Duschl, Schweingruber, & Shouse, 2007).

Observing the integration of conceptual frameworks to existing semantic maps and conceptual frameworks recommended in this updated work on learning science, the authors of the NIH-sponsored curriculum have developed a “5E” instructional model that encourages learners to Engage, Explore, Explain, Extend, and Evaluate (Bybee et al., 2006). Teacher education programs should have access to these materials via the Internet, which is increasingly available in schools at lower costs than many packaged textbook ancillaries. Furthermore, faculty members who design curriculum for these programs should consider incorporating these resources into their required curricula.

The interactive environmental science modules created by the authors of this article have expanded on the NIH 5E model to incorporate the most current knowledge of how students learn science. Notably, we will show how we have carefully aligned the four perspectives of learning environments: learner centered, knowledge centered, assessment centered, and community centered (Donovan & Bransford, 2005).

Leveraging the low-cost Internet delivery and the integrative curriculum design model, the multimedia materials were field tested among preservice and in-service teachers. These materials are high-quality, richly interactive curricular tools that many science teachers have said they find useful and intend to use in their classrooms. The preliminary field test results described in this article have laid the groundwork for follow-up research that will be underway with a larger sample of teachers in the near future to determine whether particular groups of teachers may be predisposed to using Internet-based materials in their classrooms. This article, however, presents the initial findings among those current and prospective teachers who have tested the materials.

A CHANCE for Pennsylvania Science Materials

Even as the NIH materials have begun to meet the national needs for multimedia science education tools integrating authentic research, a similarly engaging Internet-based project of regional interest to the mid-Atlantic region of the United States has simultaneously been reaching these same consistently high standards by integrating authentic scientific research from Pennsylvania communities into sequenced learning materials. Just as the NIH modules have been co-authored and field tested by science teachers, so too, have the CHANCE modules begun to be field tested, as this article will demonstrate.

CHANCE (Connecting Humans and Nature Through Conservation Experiences) is a collaborative project between the Pennsylvania Department of Education (PDE) and Pennsylvania State University (PSU) to (a) train biology teachers via authentic field work, and (b) develop a clearinghouse of engaging, standards-based, multimedia science teaching tools that integrate authentic research and inquiry-based teaching methods. One important distinction between CHANCE research modules and other materials currently available on the Internet is that CHANCE materials are authored by either in-service teachers or preservice Pennsylvania high school teachers who have participated in the CHANCE course component, Environmental Science and Conservation Biology: A Field Course in the Biodiversity of Costa Rica, working in the field alongside researchers for 3 weeks (McLaughlin, 2006).

Following their return to the United States , preservice and in-service teachers attended an all-day workshop where they learned to use Web-based interactive multimedia research modules, freely available at https://teamworks.campuses.psu.edu/psu/lv/chance. Teachers who wished to design a module of their own then vied for a competitive opportunity to outline a storyboard (a written description of a module's page-by-page content, including text and intricate details of all animations and activities), the key element of module development. This carefully constructed professional development course allowed preservice and in-service science teachers to focus on how people learn science: from learner-centered preconceptions that must be pre-assessed and addressed by the learning environment to knowledge-centered presentations of materials that must consist of both a conceptual framework and a set of coherent facts for learners. The CHANCE participants then learned how to integrate formative assessment that allows their learners to engage in interactive manipulation of new knowledge on screen and on paper with those community-based experts in authentic field research, making CHANCE modules a uniquely balanced curricular approach (Bransford et al., 1999; Donovan & Bransford, 2005; Duschl et al., 2007).

Selected teachers were then paired by the director with CHANCE mentors, research scientists, and/or specialists in the selected field of study, in order to acquire current and relevant data, expert advice, and guidance pertaining to their module. All storyboards were edited by the director and, when finalized, sent to the CHANCE instructional design staff for actual Web creation and uploading to the Internet. All modules were then extensively reviewed for scientific content by CHANCE mentors and other research scientists. Whether selected to author materials or not, after they return from a CHANCE field experience, preservice biology teachers in Pennsylvania receive classroom training in using the modules. Furthermore, all CHANCE modules are freely available to any preservice biology teacher via the Internet.

The CHANCE to Improve: Preliminary Field Tests by Teachers

The interactive multimedia CHANCE research modules aim to improve environmental literacy and stewardship among high school students in the state of Pennsylvania and the nation and are one part of the professional development program, CHANCE (McLaughlin, 2006). These interactive multimedia research-based modules support standards-based teaching (Pennsylvania Department of Education, 2002), enforce complex thinking and problem solving, embrace research skills, include appropriate assessments to measure student performance, and portray real-world environmental issues.

The module, “Invasive Plant Species in Pennsylvania,” was authored by Pennsylvania teacher Melanie Hoskins, William Allen High School, Allentown Pennsylvania. This 8-year veteran teacher worked with Art Grover, Research Associate for the Roadside Vegetation Management Research Project with the Department of Horticulture at The Pennsylvania State University. His research efforts include management of specific weed species, such as Tree of Heaven, Japanese knotweed, and Canada thistle; evaluation of alternative plant species for roadside conservation plantings; and comparisons of equipment, herbicides, and procedures for managing roadside vegetation. Art is a also a member of the Pennsylvania Invasive and Noxious Plant Working Group, a past-president of the Mid-Atlantic Exotic Pest Plant Council, and a member of the Executive Committee of the Northeastern Weed Science Society.

Sixty-eight teachers (10 preservice and 58 in-service teachers) evaluated this module using both the cyberguide for Web Site Design, and the cyberguide for Content Evaluation (MacLachlan, 1996). These two instruments primarily elicit teacher responses to the content of a Web site. Based on the responses that follow, we are now planning a follow-up study that will test a hypothesis of whether and to what extent teacher characteristics correlate to their evaluation of module content and to their likelihood of classroom adoption. To gauge the likelihood of adoption in this first study, a subset of 46 teachers (10 preservice teachers) also completed a brief Implementation Survey noting their likelihood to use the module in the future. The teachers’ responses to the Invasive Plant Species in Pennsylvania module served as a feedback mechanism for the module design team. Although responses to the cyberguide modules were equally strong among both preservice and in-service teachers, the preservice teachers were far more likely to select CHANCE materials for definite future implementation than were the in-service teachers, a conclusion which suggests some difference between these populations that will form the basis for a future study. A complete discussion of the module and accompanying survey results in this first study follows.

Results of the Teachers’ Evaluations to the Invasive Plant Species Module

In this module students are first asked to observe and read about native plant species of Pennsylvania by viewing a slide show of real images taken throughout the state. The objective is not only to learn what a native species is but also to identify ferns and clubmosses; grasses, sedges, rushes, and their kin; annual, biennial, and perennial wildflowers; woody trees and shrubs; and aquatic plants. They also learn how to differentiate these groups and common species of each found in natural habitats of Pennsylvania (see Figure 1).

Figure 1. *In the module "Invasive Plant Species in Pennsylvania," students examine and read about native plants of Pennsylvania, and how to identify and differentiate common species.*

Teachers' responses (*n* = 68) to the Evaluation of Content questions about this component were unanimous, as depicted in Table 1. Preservice teachers, in particular, appreciated the hyperlinked annotations on these introductory pages. Like the glossary in a textbook, these annotations assist new teachers in presenting concepts holistically, with a more dynamic pop-up capability for their students to double-check basic vocabulary. Informal comments from the group provide the basis for a future study investigating whether differences between these groups impact their rationale for approving of this content. For example, because a majority of preservice teachers have grown up with the Internet, the hypertext approach to presenting concepts is familiar and comfortable for them. For in-service teachers, the unobtrusive option to click on a key term or not takes only a few practice sessions to master quickly and easily.

Table 1
Teachers' responses to the Evaluation of Invasive Species Module Content Questions

Component	Description of Specific Component	% Yes	% No
Quality of Content:	Accomplishes module goals.	100%	0%
	Is complete.	100%	0%
	Is well organized.	100%	0%
	Easy to understand.	100%	0%
	Has sufficient information for goals.	100%	0%
	Has interactivity that increases its value.	100%	0%
	Appears to be accurate based on user's prior knowledge of content.	100%	0%
	Has related links to other sites that help to accomplish module goals.	100%	0%

The next phase of the module requires students to observe and read about invasive plant species of Pennsylvania. Using a virtual animated slide projector, which can be navigated with a click or the simple right or left movement of a mouse, images of common invasive plants spreading into Pennsylvania's fields, pastures, forests, wetlands, waterways, and natural areas at an alarming rate are projected as if sitting in an auditorium (see Figure 2).

Teachers (*n* = 68) who responded to the Web Site Design cyberguide noted the undivided observations about this module displayed in Table 2. Once again, although the responses to the survey were equally strong, the preservice teachers' comments indicated that they preferred the animated slide show with mouse navigation for its interactivity over a simple textbook explanation. As novice educators, the preservice teachers often struggle with the challenge of adjusting their pace of instruction to meet a wide variety of learners in their classes. The interactive slide show allows these new teachers to show students how to navigate forward and backward to accommodate their own pace as learners.

The module then presents an activity in which students learn about the structure and hierarchy of organization of an ecosystem by exploring a native pond/meadow plant community comprised of a diverse arrangement of native Pennsylvania plant populations. Then, students are asked to use a virtual field notebook to calculate and record the population density of selected native species – Eastern hemlock, red maple, red oak, and winterberry – in a specific area by doing some simple math (see Figure 3).

Figure 2. *Using a virtual animated slide projector, students observe and read about the negative impacts of invasive plant species of Pennsylvania.*

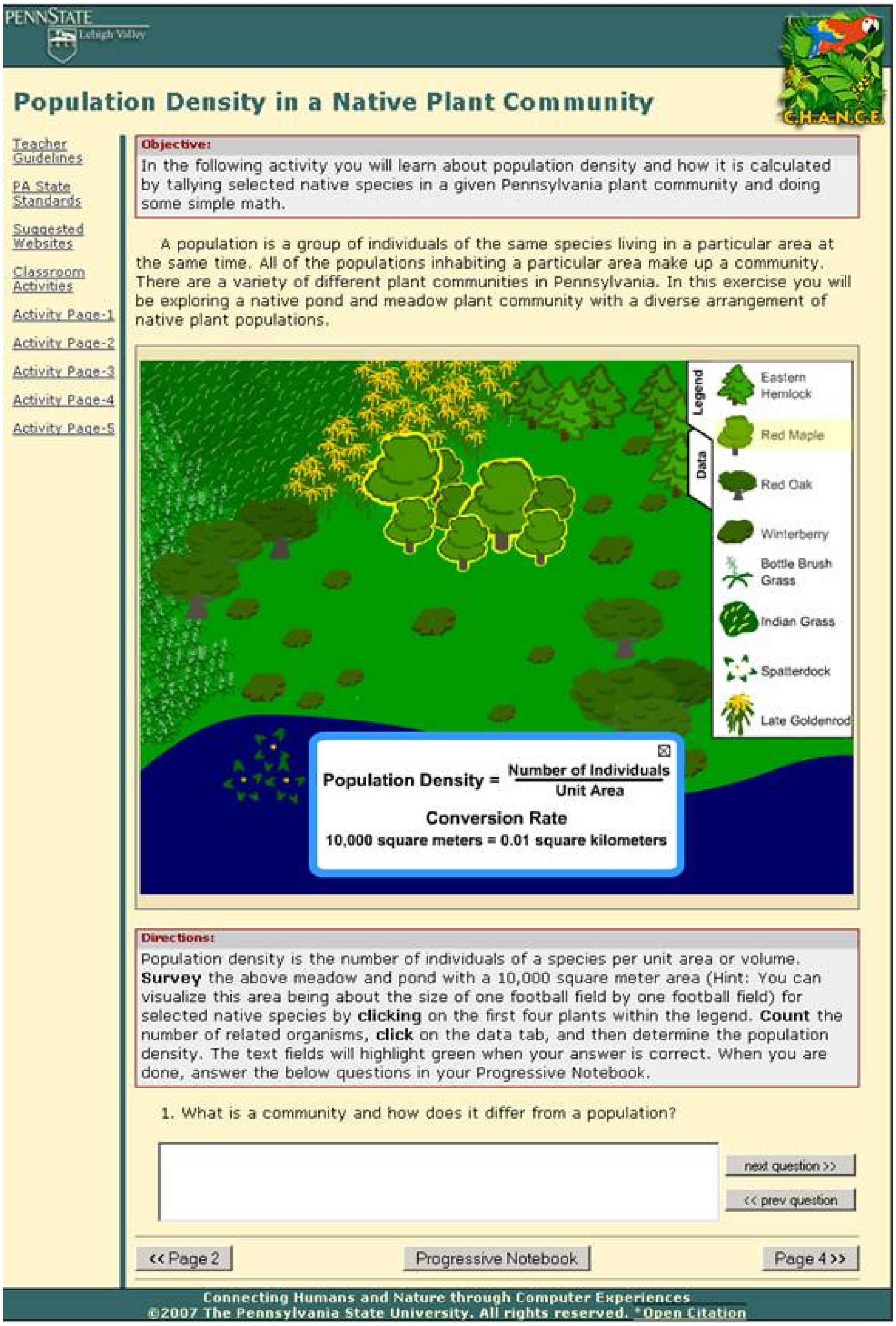

Figure 3. *Later in the module, students collect, calculate, record, and analyze data on the population densities of native species like the Eastern hemlock, winterberry and Indian grass in a Pennsylvania pond/meadow plant community—simulated here to help them learn about this common biological measurement that is often used by ecologists, foresters and conservationists to predict species survival.*

One objective is that students discover how population density is used by ecologists, foresters, and conservationists as an important field indicator to observe, measure, and study the negative effects of invasive species on an ecosystem. Low population densities may cause an extinction vortex, where critically low numbers lead to reduced fertility.

Table 2
Teachers' Responses to the Web Site Design Cyberguide for Invasive Species Module

Component	Evaluation of Design Considerations	% Yes	% No
Homepage	is attractive and appealing	100%	0%
	has clear titles, descriptions, and image captions	100%	0%
Navigation	is easy to move around the site	100%	0%
	has clear and easy instructions	100%	0%
	has properly working internal and external links.	100%	0%
Multimedia	has clear and purposeful graphics, audio files, video files, etc.	100%	0%
	has graphics, animations, sounds clips, etc., that make a important contribution to the site.	100%	0%
Content Presentation	provides adequate information to make visits to it valuable.	100%	0%
	has clear labeling and organization	100%	0%
	uses the same basic format consistently throughout site.	100%	0%

At this point in the module, the alignment of all four learning environment perspectives is complete: a learner-centered opportunity for students to gauge what they already know in their online journals; a knowledge-centered slide show and pop-up, context-sensitive glossary of terms that establish a coherent conceptual framework; an assessment-centered problem-based activity that requires students to apply new knowledge to semantic structures and conceptual frames; and a community-centered connection to an authentic research project in the state of Pennsylvania (Bransford et al,, 1999). This careful and comprehensive alignment of these perspectives makes the CHANCE modules unique among the curricula currently available to science teachers (see Figure 3).

In response to the design of this module, teachers (n = 68) were asked to select each summary statement that appears in Table 3 as a gauge of their likelihood and intended manner for using the materials in the future. Notably, the in-service teachers (n = 58) were far more likely than were the preservice teachers (n = 10) to select "worth bookmarking" rather than "very useful for my information needs," suggesting some differences between these populations worth investigating in a follow-up study.

In free response comments collected after the evaluation workshop, preservice teachers, in particular, noted that they will be using the CHANCE modules during their student teaching practicum experiences, indicating that this group will be more likely to adopt the CHANCE materials in their classrooms in the future; for example,

> The modules really are engaging. I felt an adrenaline rush as a teacher as I worked through the module. All I could think of was that my students will love this and actually learn something meaningful about the environment as they use it.
>
> Liked the animations, pictures, activities, and research scenarios. I can't wait to try the other modules.

Table 3
Teachers' Responses to Adoption Showing Difference Between Preservice and In-Service Teachers

Component	**Description of Component (select one statement)**	**% of Participants Selecting Each Summary Statement**	
		Preservice ***n* = 10**	**In-service** ***n* = 58**
Site Content	a. very useful for my information needs	100%	83%
	b. worth book marking for future use	0%	17%
	c. not worth coming back to	0%	
Web site design	a. very well designed and easy to use	100%	100%
	b. design needs to be improved but site is usable	0%	0%

Importantly, throughout this module, like all CHANCE modules, students are required to answer increasingly difficult questions. These lower to higher level thinking questions further their understanding and are the key to inquiry-based learning. For example, after working through an animation of a roadside disturbance students learn about the Tree of Heaven (*Ailanthus altissima*), also known as Ailanthus, an invasive trees species originally from Asia, which is having a devastating impact on many of the natural plant communities in Pennsylvania.

Students are asked to make a hypothesis as to what will happen if one Ailanthus tree seed germinates, takes root, and is allowed to grow for a period of 10 years in the pond/meadow plant community they studied in the preceding activity. Thus, students must consider not only what they now know about the population density and biology (life cycle) of the native species in this ecosystem, but also the biology of Ailanthus (life cycle) and the negative influences of invasive species, in general, to predict and explain how this plant will affect the survival of the native plant species already in existence (see Figure 4).

When asked about whether the CHANCE module served as a positive supplement to the textbook instructions, all 46 teachers who completed the brief Implementation Survey said "Yes," additionally noting that more of these modules should be developed for their classrooms (Table 4).

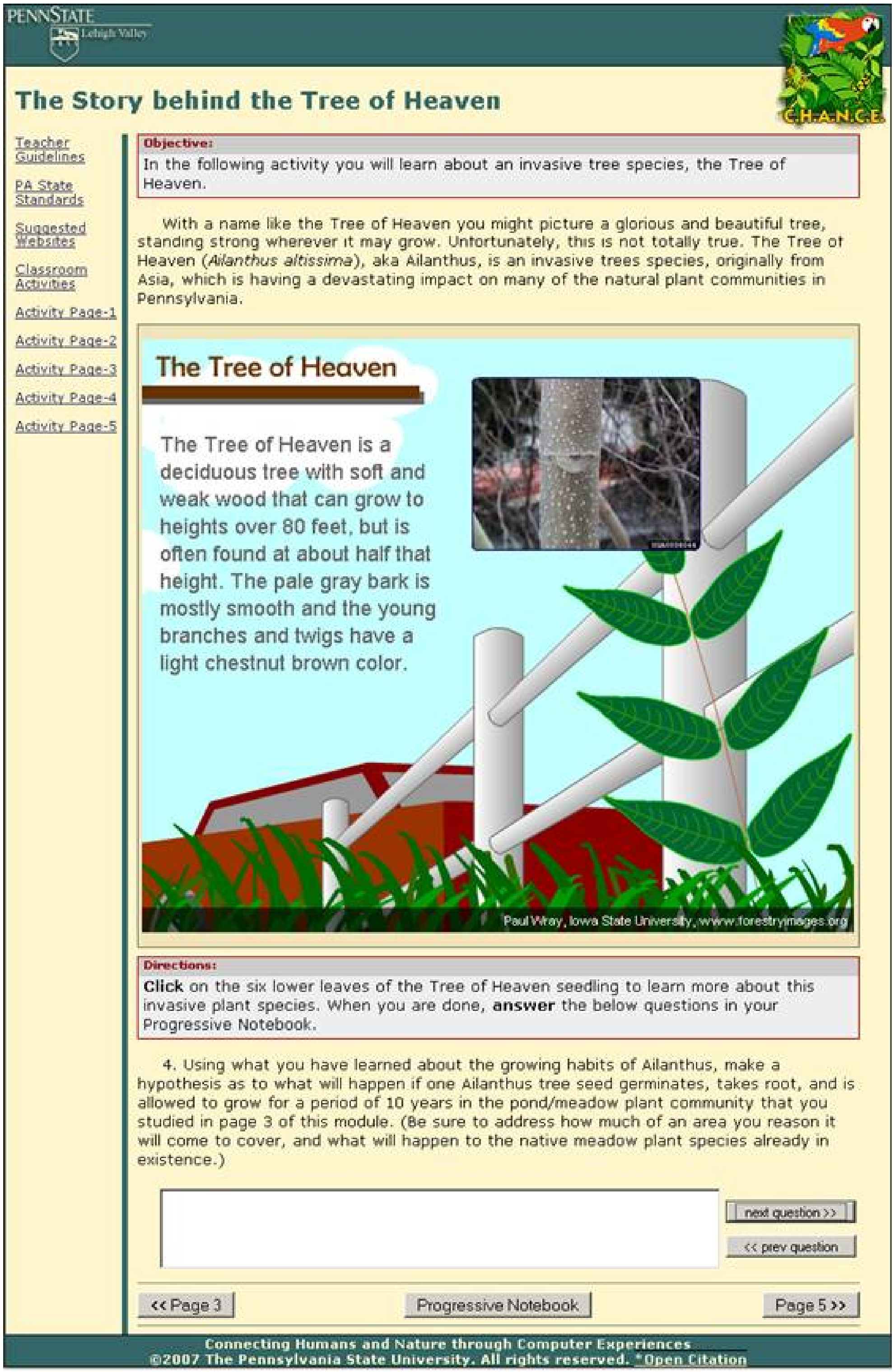

Figure 4. *In this activity, students learn about the invasive plant species, the Tree of Heaven (Ailanthus altissima).*

Table 4
Teachers' Responses to the Brief Implementation Survey (aggregated)

Implementation Question	**%Yes**	**%No**
Do you think that the CHANCE research modules are a positive supplement to standard textbook instructions?	100%	0%
After completing a CHANCE research module, do you feel that additional technology -based, research-oriented “learning materials” should be designed for today's high school science classroom?	100%	0%

Later in this module, students actually witness the invasive nature and negative effects of Ailanthus by examining how the given pond/meadow plant community changes over time after one Ailanthus seed is allowed to germinate and grow. After clicking on an Ailanthus an animation begins. An Ailanthus seed is released, which then floats, lands, and germinates in the pond/meadow community.

Students are again instructed to collect, calculate, record, and analyze data on the population densities of the given native plant species – Eastern hemlock, red maple, red oak, and winterberry – as the meadow changes over 0, 5, and 10 years; however, this time the invasive Ailanthus is also tallied. Overall, their objective is to learn, by working through simulated experimental data, ways this invasive plant species can and is negatively affecting Pennsylvania’s natural ecosystems over time, and the methods presently used for controlling and eliminating this invasive species (see Figure 5).

Completing the brief Implementation Survey about this Invasive Plant Species module, science teachers (n = 46) were asked about their inclinations to use the CHANCE modules in the future. Once again, the preservice teachers unanimously answered that they were “very likely” to use these materials in their future classrooms, while only 86% of in-service teachers chose the same response (Table 5). Again, the differences between these two populations provide the basis for future work to carefully examine teacher characteristics between these two groups.

Discussion

CHANCE research modules evolved from this bleak reality: On average, K-12 teachers use computers or engage in lab experiences with their students less than one time per week for little more than word processing, e-mail, or game and drill software (Becker, 2000; Singer, Hilton, & Schweingruber, 2005; Smith, Banilower, McMahon, & Weiss, 2002; Wetzel, 1993). Yet, today’s youth spend an average of 6 ½ hours a week using various forms of media—about a quarter of that time juggling more than one form of media at a time. The amount of time spent on computers has more than doubled over the last 5 years (Kaiser Family Foundation, 2005). Thus, using digital technology is second nature to the Millennial generation, students born between 1980 and 1994, and research shows that they prefer video, audio, and interactive media, and they prefer to learn by doing (Carlson, 2005).

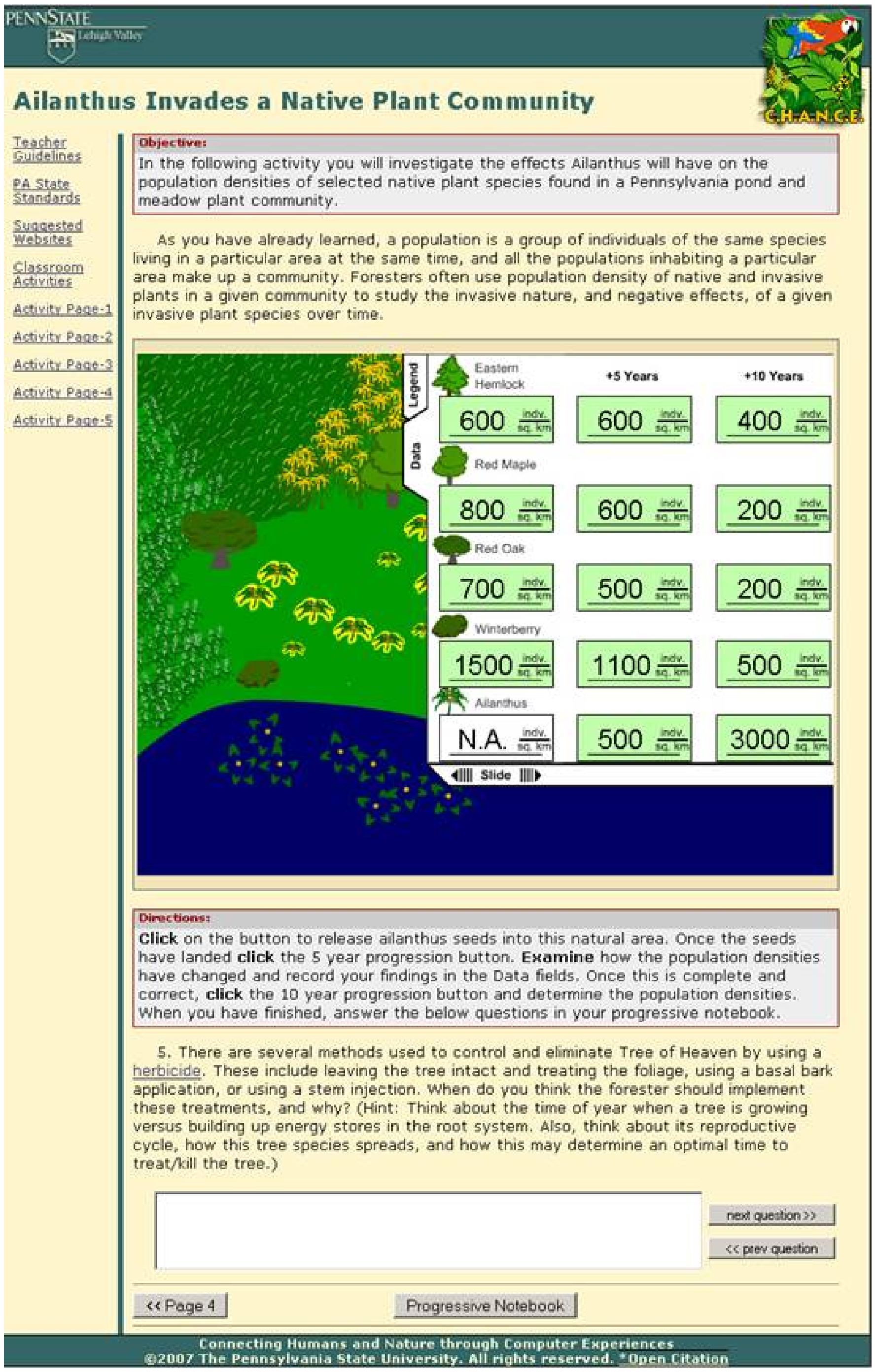

Figure 5. *In the last activity students investigate the effects Ailanthus has on the population densities of selected native plant species found in the given Pennsylvania pond/meadow plant community.*

Table 5
Teachers' Responses to Brief Implementation Survey (Preservice and In-service)

Implementation	**% of Each Response**					
			Likely		**Very Likely**	
Question	**Not Very Likely**	**Some-what Likely**	**Preservice *n* = 10**	**In-service *n* = 36**	**Preservice = 10**	**In-service *n* = 36**
After completing a CHANCE research module, how likely are you to use the CHANCE research modules in your classroom as "learning materials" to allow students to discover and understand environmental science and ecology concepts?	0%	0%	0%	14%	100%	86%
After completing a CHANCE research module, how likely are you to use the CHANCE research modules in your classroom as "learning materials" to allow students to delve into research?	0%	0%	0%	14%	100%	86%

In this field test of CHANCE materials by both veteran (in-service) and preservice teachers, the newer teachers showed more interest and likelihood to implement digital technology than their more experienced counterparts, demonstrating this generational preference. Because this study was focused on providing content feedback to the module authors, we collected only anecdotal differences between these groups in the form of their narrative comments illustrated in the preceding pages. Based on these preliminary findings, a follow-up study that includes demographic information and pedagogical inventory data will investigate these differences more thoroughly.

Complicating matters more are the facts that most students in high school are not reading their science textbooks, nor understanding the content (American Association for the Advancement of Science, 2000). Moreover, most preservice science teachers are taught to teach technology as a separate component of high school education rather than as a topic integrated into the curriculum (Willis & Mehlinger, 1996; The Milken Exchange & the International Society for Technology in Education, 1999; Thomas & Livingston, 2004), while over the past decade spending on technology in the United States tripled, now totaling more than $6 billion (WestEd Policy Brief, 2002).

Thus, it became obvious to us that a new type of interactive multimedia learning object needed to be developed for both high school science teachers and students that supports standards-based teaching, enforces complex thinking and problem solving, embraces research skills, includes appropriate assessments to measure student performance, and shows real-world uses. The CHANCE modules accomplish all of these goals in a way that balances what we know about how students learn science (Bransford et al., 1999; Duschl et al., 2007) and delivers these modules to teachers via the increasingly more affordable and student-favored medium of the Internet.

The CHANCE research modules take full advantage of the digital propensity of students and new teachers alike and promote inquiry-based learning by allowing students to explore, observe, question, hypothesize, manipulate, analyze, and think critically about real science data and information from accredited research programs in Pennsylvania and around the world. Experienced teachers embrace the authentic science that forms the basis for CHANCE modules and pick up easily on the interactive nature of the materials. This computer-based interactive approach is particularly attractive to secondary students, most of whom enjoy the virtual experiences today's technology affords. Best of all, CHANCE modules promote active learning by providing opportunities for students to participate as individuals directing their own learning process.

Conclusions

The CHANCE modules are purposefully designed to be more engaging and interactive than a textbook by allowing students to learn how things work. These modules cover key biological and environmental science concepts using inquiry-based activities that provide compelling animations, video, factual information, and research-based exploration that necessitate students working with real research data. Using the tools of science to teach science, the goal of these learning objects is to produce levels of understanding, knowledge retention, and transfer that are greater than those resulting from traditional lecture/lab classes by blending teaching and basic research through technology.

Thus, in addition to the likelihood of particular groups of teachers to use these modules, a point worthy of further consideration is the actual degree to which these modules exceed text-based instruction. In order to assess if the use of research modules enhance student learning of core biological concepts and required Pennsylvania Environmental and Ecological Standards, a research plan is underway to develop and orchestrate the use of standardized assessment tools before and after module use in selected Pennsylvania high school classrooms. Comparisons will be made on similar groups of students taught the same concepts using a textbook only.

At the core of the CHANCE modules and the larger professional program they represent is the underpinning objective to enhance environmental awareness in the U.S. high-school student population. Our environment faces serious threats resulting from human activity – water pollution, air pollution, loss of biodiversity, depletion of natural resources, and watershed depletion – all of which must be understood in the context of basic biological principles and solid research.

Thus, in order to help students understand the real world environmental issues that confront them and become informed citizens, it is time for teachers to understand by using research how science works, not just by textbook content. CHANCE's field component trains teachers in environmental science, ecology, and conservation practices on an international, eye-opening level via hands-on field work in Costa Rica. CHANCE's research modules equip teachers with technology-enriched pedagogical tools to provide inquiry-based activities in areas that foster their students' competencies in biological concepts and real world environmental issues like climate change, species extinction, water pollution, loss of wetlands, etc., while at the same time instilling an inclination toward environmental advocacy.

Thus far, seven modules have been developed and are already in use in high schools and by educational organizations throughout the Commonwealth and the world. Completed research modules include the following topics: invasive plant species in Pennsylvania; raptor migration – local, cooperative, and global; amphibians as indicators of environmental change; sea turtle nesting behaviors and survival; deciduous forest biodiversity; species extinction; and water and air pollution. Modules in the planning stages include topics on global climate change, watershed restoration, waste disposal, water pollution (treatment wetlands), and the newest technology in electricity production, burning culm, the main waste product of coal incineration.

The Pennsylvania Department of Education now recommends the CHANCE field course and research modules as ways of helping high school teachers and their students meet the nine state standards in environmental science and ecology. Because most states must meet similar standards, the CHANCE program provides a viable framework for improving or reforming high school biology education nationwide.

The impact of the CHANCE field course and its modules on teachers and their students has been overwhelmingly positive. Put simply, hundreds of teachers from all over Pennsylvania and the nation are embracing these resources. Free response comments by Pennsylvania high school teachers after completing the CHANCE field course and module training included the following:

> When I went to Costa Rica as part of the CHANCE program, I had just graduated college and was about to embark on my first year of teaching 8th grade science. Looking back, my experiences doing the field research with Costa Rica's rich beauty, such as working with nesting sites for Leatherback Sea Turtles and tagging female Green Sea Turtles who came to shore to lay eggs, truly molded my teaching philosophy. The wonderment and excitement I felt made me want to recreate that for my students. If I could evoke these same kinds of emotions and inspiration in my students, they would learn. Bringing biodiversity and inquiry to my classroom through the CHANCE program has been the most influential part of my teaching career. Jennifer Paukovitch, CHANCE 2004.
>
> CHANCE field course changed my life. Since that experience, I've become more passionate and enthusiastic about teaching biology. It is incredible how much I can now impact and influence my students about some serious ecological issues simply by sharing pictures and stories about my trip to Costa Rica. Melanie Hoskins, CHANCE 2005.
>
> I am a high school Biology and AP Environmental Science teacher. The CHANCE program was the BEST professional development program that I have participated in, in over 20 years of teaching. The interactive approach to Conservation Biology, integrating research was invaluable. I learned the importance of providing my high school students with this skill, and the modules make this task truly possible. In addition, seeing, feeling, touching, participating in programs in Costa Rica was absolutely a life changing experience that I bring to my classroom every day. Paula Wang, CHANCE 2007.
>
> First, the experience of field work in Costa Rica has helped invigorate me in the classroom; second, the wealth of experiences, pictures, knowledge and research picked up during the trip (and in the accompanying assignments) has provided me with tons of new material for my classroom; and third, the available modules are helping me integrate interactive technology into my classes as well as being valuable curricular material in their own right. Rick Bloom, CHANCE 2007.

Free response comments by Pennsylvania high school teachers collected after participation in a CHANCE "research module" workshop included the following:

> The modules really are engaging. I felt an adrenaline rush as a teacher as I worked through the module. All I could think of was that my students will love this and actually learn something meaningful about the environment as they use it.
>
> Liked the animations, pictures, activities, and research scenarios. I can't wait to try the other modules.

Author Notes:

- The CHANCE modules are freely accessible at https://teamworks.campuses.psu.edu/psu/lv/chance
- To apply to participate in the 2008 field course in Costa Rica or to participate in an upcoming workshop on CHANCE module training, see www.lv.psu.edu/jxm57/explore/costarica2008 or e-mail Jacqueline McLaughlin, Founding Director, at Shea@psu.edu.
- CHANCE is the winner of the 2005 "Bringing the World to Pennsylvania" Award from the Pennsylvania Council on International Education.

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