Web-Based, Active Learning Experiences for Biology Students

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ABSTRACT: Educational research shows that learning is enhanced by experiences that help students challenge preconceptions and connect new concepts to prior knowledge. While it is often difficult to provide “hands-on” learning experiences in large classes, the Internet offers the opportunity to create classroom and laboratory lessons that are engaging, self-paced, and encourage critical thinking. Although a growing number of online exercises exist, broken links and labor-intensive assessment preclude their easy adoption. We have developed a website that avoids these problems and teaches students about exotic species, their introductions, and their potential impacts. Students are provided with background information, a glossary, and online quizzes that allow self-paced, investigative learning that builds on prior knowledge and challenges misconceptions. Our website addresses concepts that form a foundation for understanding ecology, pest management, and environmental ethics. These concepts are relevant to multiple biology classes, including introductory biology, ecology, biogeography, and human ecology. Key features of the website are (1) its self-contained, non-linear design; (2) a learning environment that allows students to test ideas without penalty; (3) real-world examples; and (4) built-in assessment tools that evaluate both background knowledge and student learning. We believe this website provides an excellent model for designing and implementing active learning exercises using the Internet, and that other biology educators can enhance their courses by developing similar websites to teach other concepts.

KEYWORDS: Online exercise, active learning, exotic species, website design, preconceptions

INTRODUCTION
Science works because those conducting science search for answers to unknown questions through the scientific method. The scientific method combines the investigator’s prior knowledge and experience with observation and experimentation to falsify incorrect hypotheses. Laboratory exercises and other “hands-on” lessons allow students in college and university science courses to experience the process of science first-hand. These experiences allow students to actively participate in their own learning, an important condition for the act of constructing meaning (APA, 1992). However, in many lower division classes, large class size and constraints on time and resources limit the implementation of such exercises. Professors and instructors often fall back on lecture-style delivery of information, perhaps augmenting lectures with multimedia aids. While this approach is an efficient way to deliver content, traditional lectures may not effectively challenge the preconceptions that students bring to class. Unless the students’ existing understandings are explicitly drawn out, misconceptions will persist (Bransford et al., 2000). In addition, students learn faster and retain information longer when new concepts are connected to their prior knowledge and experience (Caine and Caine, 1994). These connections can be achieved by engaging the student’s curiosity, challenging his or her misconceptions, and providing opportunities to explore ideas and construct new meaning (Carin and Bass, 2001).

While technology may not necessarily provide a panacea for the challenges of teaching large classes, educators have increasingly turned to Internet-based exercises to improve interaction and enhance learning. Moreover, as universities, colleges, and private companies launch more and more websites, students are able to use search engines to quickly reach sites where the webpage creator has provided a concise summary of the concept under study. Many of these
activities. Exotic species pose direct threats to reduction in habitat quality for wildlife and recreational disturbance (such as increased frequency of fires), and extinctions), alterations in the natural patterns of exclusion of native species (sometimes leading to environment. These threats include competitive exert a multitude of significant effects on the threat to ecosystem health because they potentially spread of invasive species pose a tremendous risk to environmental health, directly costing the U.S. economy over $130 billion per year. This is a remarkable figure and it accounts for only a small proportion of the materials arriving on our shores. Therefore, it is likely that as more people and goods are moved across continents, we will see a rising number of initial infestations resulting in greater chances that new invasive species will become permanently established. As these exotic invaders become entrenched, both the costs associated with eradication, control, and management and the impact on threatened native species rise dramatically (U.S. Congress, 1993).

Efforts to contend with the impacts of invasive species in North America were strengthened in 1999 when President Clinton signed Executive Order 13112 (Anonymous, 1999). This order mandates that federal agencies take action to address the problem of exotic species that become invasive. Government agencies were directed to pursue programs that prevent new introductions, expand and improve detection and monitoring, provide resources to ensure compliance with laws and regulations, and promote the use of native species for ornamental purposes. A key step in achieving these goals is public education and the development of environmental ethics in the general public. The ESCAPE website furthers these goals through exploration of case studies.

Key features
The ESCAPE website was designed to contain all of the information necessary to complete the exercise. Unlike Web Quests that direct students to gather information from other web sources, this site provides a wealth of content for students to explore. External links are used only to facilitate extended investigation. Missing or broken links are minimized and do not affect the user’s ability to meet the learning goals. The site’s non-linear navigational layout allows users to access information in any sequence desired, so students
can actively choose to view first the subjects they find most interesting. Questions, which they glean from a series of quizzes that are structured to give positive feedback for both correct and incorrect responses. These quizzes ask students questions about selected native and exotic species and test their knowledge of the species origin, importance, management, etc. Correct answers lead to either another question about the same species or a list of links to further information. Incorrect answers reveal the reason the selection was not the correct response and supply hints that lead the user toward the correct choice. This design allows students to test their knowledge without penalty for guessing or choosing incorrect responses. The pre-test and post-test are authentic assessments in that they present students with the same task as the quizzes, to select the correct response from a list of choices. The pre-test assesses the students’ pre-conceptions, engages their initial understanding, and assists them in assimilating the new information by activating the framework of knowledge they already possess. The post-test assesses the students’ learning gained from exploring the ESCAPE site materials.

The quizzes use information on real examples of exotic species introductions, as well as a few native species that might be mistaken for exotic. These examples cover a broad range of taxa (insects, vertebrate animals, and plants) and include both familiar species like dandelion and more obscure examples, such as the Jerusalem cricket (Figure 1). The quizzes present a variety of scenarios, so students hopefully learn that species introductions can result in very different outcomes. Some species are clearly beneficial, such as wheat and corn, while others are major pests, like leafy spurge. In some cases, the problems and benefits of introduction are not so clear-cut.

For example, one quiz focuses on the mosquitofish, Gambusia affinis. Students are asked about the distribution of the fish (native to the southern U.S., but widely introduced outside of its original range), which allows them to address whether a species native to one region of a continent is considered exotic when introduced to other parts of that continent. The students are also asked to hypothesize about the reasons for mosquitofish introduction (biological control of mosquitoes) and its impacts on target and non-target organisms (mosquitofish are generalist predators which often cause more problems than good outside of their native range).

As another example, students explore information about purple loosestrife (Lythrum salicaria). Purple loosestrife is native to Europe. The reasons for its introduction are unclear but most likely it became established as a contaminant of ballast soil. Students are asked how they think that early scientists

The post-test encourages students to find the correct answers to a set of multiple choice questions, which they glean from a series of quizzes that include both correct and incorrect responses. The quizzes ask students questions about selected native and exotic species and test their knowledge of the species origin, importance, management, etc. Correct answers lead to either another question about the same species or a list of links to further information. Incorrect answers reveal the reason the selection was not the correct response and supply hints that lead the user toward the correct choice. This design allows students to test their knowledge without penalty for guessing or choosing incorrect responses. The pre-test and post-test are authentic assessments in that they present students with the same task as the quizzes, to select the correct response from a list of choices. The pre-test assesses the students’ pre-conceptions, engages their initial understanding, and assists them in assimilating the new information by activating the framework of knowledge they already possess. The post-test assesses the students’ learning gained from exploring the ESCAPE site materials.

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Exotic Species Quiz

Test your knowledge about non-native species in North America. Each answer will link to a new page containing more information. Links at the bottom of the page will allow you to return here. Good luck! For a challenge, you can keep track of how many you got right on the first try.

Exotic species quizzes feature a diversity of taxa and include species that are native, that are exotic but beneficial, that are exotic and harmful, and which have mixed positive and negative impacts.

Figure 1. Exotic species quizzes feature a diversity of taxa and include species that are native, that are exotic but beneficial, that are exotic and harmful, and which have mixed positive and negative impacts.
LESSON PLAN FOR USING ESCAPE IN THE CLASSROOM

Audience: This activity is designed for use with undergraduate college students. The topics covered are relevant to a number of courses, including general biology, ecology, pest management, and geography. This exercise could also be adapted for a high school biology class or a graduate course in environmental studies, ecology, or biogeography.

Previous Knowledge Needed: Background knowledge in biology and ecology is helpful but not necessary. The web site provides a brief introduction to the topic, necessary background information, and a glossary.

Objectives: After completing this exercise, students will be able to:
   1) Distinguish between exotic and native species.
   2) List reasons for the introduction of exotic species.
   3) Explain why some exotic species are beneficial, some are neutral, and others are harmful.

Time Requirements: This activity can be completed in a 75-minute class period or assigned as a take-home project.

Materials: Students will require individual computers with access to the Internet and a web browser, such as Internet Explorer or Netscape. Additional resources for enrichment might include newspaper articles on exotic and/or invasive species, pictures, readings from the bibliography, etc.

Procedure:
1. Direct students to the ESCAPE website at http://www.unk.edu/ESCAPE.
2. Click on the “Quizzes” button on the left of the screen and select the “pre-test” link.
3. The pre-test will ask students twenty multiple-choice questions about plant and animal species found in North America.
   A. Direct students to choose the best answer for each question.
   B. At the end of the test, students enter their name and the instructor’s email address. Upon submission, the quiz is corrected and emailed to the instructor. Students will then be directed back to the ESCAPE site via a link.
4. Students explore the ESCAPE web site to learn about the species featured in the quizzes.
   A. The “Introduction” page contains information about exotic species and their ecological and financial impacts in North America.
   B. The “Ecology” page provides information about the role an organism plays in an environment, where it occurs, and what limits its population size.
   C. The “Quizzes” page contains links to a series of self-tests over 12 species. Students can explore the quizzes in any order they choose and may follow external links for further information on species of interest.
   D. The “About ESCAPE” page provides information about the project and the authors, as well as email addresses for the authors.
   E. The “Glossary” page provides definitions for terms that are used throughout the site.
5. After exploring the site, students return to the “Quizzes” page and take the “post-test”. Again, students should enter their name and instructor’s email at the bottom of the test page to submit their scores.

Follow-Up and Discussion Suggestions:
• For species featured on the exotic species quiz, classify the effect of introduction on U.S. economy as positive, negative, or undetermined.
• What ecological and life-history features of the problem exotic species make them so detrimental?
• Are humans an exotic species in North America? Why or why not?
• What procedures might be used to prevent the introduction of invasive species to new areas?
• How does knowledge of exotic species biology help us to design means of controlling those species?
• As an extra challenge, ask students to research and write a quiz for a species not covered on the ESCAPE web site.

Additional Resources:
GENERAL DESIGN CONSIDERATIONS

We believe that the design features of the ESCAPE website allow users to explore ideas, test hypotheses, and learn efficiently. Websites of similar design could be created to deliver many types of biology concepts. Should a professor decide to enhance his or her course with web-based, active learning exercise, there are a few important points to consider.

Choosing a theme

The first step in creating an online learning module is to choose a theme. A theme or central question provides the framework for developing the rest of the site. The theme should be broad enough to present unresolved biological questions and multiple examples with contradictory answers. Because of the interdisciplinary nature of biology, the theme of the site can cut across sub-disciplines and include social and ethical components as well as basic biology. Moreover, by using multiple examples that provide different answers, students can better understand the reason hypotheses are not proven, studies are repeated, and scientific debates are often fierce.

Specific Learning Goals

Whereas the theme of a website can be very broad, open-ended, and imaginative, the learning goals and assessment must be specific to avoid overwhelming or confusing students. Both the information presented and the assessment tools should be closely linked to the selected learning goals. The website should provide enough background material for users to understand the concepts, regardless of their prior experience, but should be succinct and understandable by the intended audience.

Assessment

Online quizzing and student feedback require either expertise in programming languages or the use of freely available Internet resources. For this website, the Discover Center’s quiz-making program was used. This program is user-friendly and the resulting quiz is hosted free of charge from the Discovery channel website (http://school.discovery.com). This allowed construction of a multiple-choice quiz, with multiple options for correction and reporting. On this website, student answers and resulting scores for both the pre- and post-tests are reported via email to the instructor and to the student.

Copyrights and page elements

Enhancements to the site such as pictures of a specific organism or habitat greatly improve student comprehension and enjoyment. While traditional Web Quests do not require attention to copyright law, developers of self-contained Internet sites must either use public-domain materials, obtain permission to use copyrighted images, or generate their own pictures. For his site, copyright-free materials from the United States Department of Agriculture were used and pictures were created using a digital camera. Additional enhancement to the site can be the inclusion of external links. However, the key elements of the site should be self-contained, providing users with all the information necessary to discover the answers to the post-test. This is an important feature because it avoids the problems of broken links that result from changing servers, changing web addresses, and removal of information from the World Wide Web.

User-friendly style

A user-friendly website is easy to navigate, avoids excessive jargon, and defines terms that are unfamiliar to users. Sites that are visually pleasing and provide an appropriate amount of graphics invite exploration. In developing a new website, one may wish to obtain style and layout ideas from other sites or consult a good reference book, such as Lynch and Horton, 1999. Site designers must also ensure that their code is compatible with at least the two major browsers, Netscape and Internet Explorer (Niederst, 1999).

CONCLUSION

The Internet offers the opportunity to create classroom and laboratory experiences that encourage students to think critically, and enjoy self-paced exploratory learning. Although a growing number of online exercises exist, design limitations constrain their easy adoption across a broad curriculum. Among these limits are differences in site design that prevent ready integration with existing course materials, difficulty in assessment, and lack of clear educational goals. As such, these limits often result in a view that online exercises or educational websites offer little for most biology classrooms. This website involves the students in a learning atmosphere where they are the investigators. In addition to the results of the pre- and post-tests, students were asked about their experience. Use of this website resulted in high student enthusiasm, an almost doubling of knowledge from pre- to post-tests, and a desire from students to have more exercises of this type.

This approach to web-based exercises encourages critical thinking and provides a mechanism for students to experience the multi-disciplinary nature of biology. Moreover, by allowing students to explore the topic, they learn to think like scientists and experience the joys of intellectual inquiry.

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