

Science 101: Building the Foundations for Real Understanding

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Two online projects offer one-stop shopping for teaching evolution, as well as the nature and process of science

It's not just about evolution anymore. Growing antiscience sentiment in the United States now infuses public discourse on conservation, vaccination, distribution of research funds, and notably, climate change (1), much to scientists' and educators' chagrin. Low rates of scientific literacy (2) exacerbate the problem. Although the public recognizes its indebtedness to the products of scientific knowledge, few understand much about the nature of that knowledge or the processes that generated it (3). Without a basic understanding of how science works, the public is vulnerable to antiscience propaganda, which engenders distrust of science when it comes to social issues, consumer choices, and policy decisions.

The University of California Museum of Paleontology's interest in this issue stemmed from a project on evolution education, which expanded into an effort to support more effective teaching of the nature and process of science (see the first figure). In 2000, we hosted a conference on evolution instruction that brought together stakeholders from education, academia, and the media (4). Participants identified a critical need for a resource that would provide vetted tools for teaching evolutionary biology. Understanding Evolution (www.understandingevolution.org) was built, in collaboration with the National Center for Science Education, to meet this need and to provide a clear and comprehensive reference for the general public.

Understanding Evolution brought together scientists, Web designers, authors, and master teachers, not just in name, but face to face. Over the course of multiple meetings, these advisors worked together to create a vision for the project. Key aspects of the development process included teacher guidance on content types, Web features, and pedagogical style, review and editing by scientific experts, field testing through teacher advisors and formative assessment, revision of materials with additional expert review, and summative

evaluation performed by the educational evaluation firm Rockman *et al.* (5).

The result of this process was a Web site that provides educational materials targeting students, teachers of kindergarten through fourth year after high school, and the general public (see the second figure). Teacher advisors on the project requested resources that directly engage students with data, that explore scientific reasoning and science as a human endeavor, and that demonstrate the relevance of evolution to biological research and to students' everyday lives. Site resources that respond to this need include (i) "Evo in the News," a monthly feature that reveals the evolutionary science behind a current news story and integrates data from the primary literature with discussion questions and background reading; (ii) research profiles and case studies, which follow a particular scientist or investigation and step students through the logic of testing evolutionary hypotheses; and (iii) interactive investigations (e.g., visualizing life on Earth, http://evolution.berkeley.edu/evolibrary/article/ldg_01) that ask students to put scientific reasoning into practice. Many such resources will be housed in our undergraduate library, an area devoted to college-level evolution instruction with an anticipated opening of January 2011.

Since its launch in 2004, Understanding Evolution's impact has continued to grow. The site now averages more than a million page accesses per month during the academic year. Through translations by international educational organizations, the site is now available in Spanish (www.sesbe.org/evosite/evohome.html) and Turkish (www.evrinianlamak.org/e/Ana_Sayfa) and has been distributed in Tibetan to Buddhist monks as part of the Dalai Lama's Emory-Tibet Science Initiative. Additionally, site resources have been shown to improve teachers' and students' understandings of evolution and to increase instructors' confidence in their ability to teach this challenging, and sometimes charged, material (5).

As we developed Understanding Evolution and noticed similar tensions and misinformation arising around topics like

climate change, we came to the realization that much of the public's mistrust of evolution stems from more basic and even more important issues: poor understanding of how science works to build reliable knowledge and confusion about the strengths and limitations of this process. Hence, we envisioned a Web site that would leverage the format and style of Understanding Evolution toward the goal of helping teachers reinforce the true nature and process of science throughout their teaching by providing a clear, approachable reference on how science really works for students and the general public.

The Understanding Science Web site (www.understandingscience.org) was launched in January 2009. Its development process closely followed that for Understanding Evolution, bringing together distinguished scientists, cognitive scientists, philosophers of science, teachers, writers, and Web designers to conceive the site and to develop and vet content. The site is unique in its straightforward presentation of science, not as an esoteric topic that is packed with vocabulary and facts, but as an intensely human endeavor—a multifaceted process that students and scientists alike can use to better understand the natural world. Instead of oversimplifying the process of science into a five-step recipe, the Web site emphasizes the flexible, dynamic, and iterative nature of the process, as well as the role of creativity and community in scientific progress. Understanding Science is designed to give students and the general public the tools they need to recognize the relevance of science to their everyday lives and to keep pace with the ways in which science informs personal and societal decision-making. These ideas are communicated through a friendly primer on the nature and process of science, as well as “Science in Action” features, which use stories from the history of science to reinforce basic scientific concepts, teach what science is, and show how science works through animations and graphics.

By providing a comprehensive, practical resource for teaching the nature and process of science, Understanding Science also fills a major gap in the landscape of science education materials. Teaching resources on the site (second figure) are informed by educational research showing that instruction in this area is most effective when it is explicit, reflective, and reinforced in multiple contexts (6). Three tools from Understanding Science 101 are designed to help teachers put these guidelines into practice and can be incorporated into many different instructional settings. The Science Checklist helps students identify the key characteristics of science in different investigations and endeavors. The Science Flowchart provides a more accurate and appealing representation of the scientific process than the

rigid Scientific Method (first figure). The Science Toolkit helps students analyze science-related policies and media messages to get to the science behind the spin.

Although less than 2 years old, Understanding Science has had far-reaching impacts and currently averages more than 60,000 page accesses per month during the school year. The project has been endorsed by organizations such as the American Institute of Biological Sciences and the California Science Teachers Association, and materials from the site have been incorporated into middle- and high-school textbooks from major publishers. Most encouragingly, an evaluation of a year-long in-service training program indicates that site materials generate a high level of teacher buy-in, meaningful increases in student understanding, and teacher reports of increases in student engagement and motivation (7).

In the current climate of both funding constraints and concern for the future of science education in the United States, we see opportunities for additional contributions from these projects, such as new resources and collaborations with scientists, as well as challenges, such as maintaining vibrant and freely accessible teaching materials while seeking a sustainable funding model. Fortunately, many other initiatives have also set their sights on improving science literacy in the United States (8), and this complements a growing movement within the scientific community itself to reach out to students and the broader public (9). We are proud to be a part of this movement and are committed to working with scientists, scientific agencies, the media, and educators to build a more scientifically literate society.

References and Notes

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Fig. 1. Teaching the process of science. Mark Stefanski, an Understanding Science teacher advisor, uses the Science Flowchart with high-school biology students at Marin Academy, where the entire science faculty employs the flowchart to help students focus on the process of science embedded in their laboratory activities. [Credit: Liz Gottlieb]



Fig. 2. Educational resources. The Understanding Evolution and Understanding Science Web sites offer a wealth of resources for teaching and learning evolutionary biology and the nature and process of science. K–12, kindergarten to high school.

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EDUCATIONAL RESOURCES AVAILABLE THROUGH UNDERSTANDING EVOLUTION AND UNDERSTANDING SCIENCE

Resource	Target Audience			
	Students	K-12 Teachers	Undergraduate Instructors	General Public
Understanding Evolution				
Searchable lesson database		●	●	
Tips, strategies, and teaching help		●	●	
Common misconceptions and explanations		●	●	
Conceptual framework		●	●	
Image library		●	●	
Evolution 101 and basic content	●	●	●	●
Advanced tutorials	●	●	●	●
Interactive online labs	●	●	●	
Research profiles and case studies	●	●	●	●
Evo in the News articles	●	●	●	●
Understanding Science				
Individual lessons and activities		●	●	
Searchable lesson database		●	●	
Tips, strategies, and teaching help		●	●	
Guidelines for modifying lessons		●	●	
Tips from the education research literature		●	●	
Common misconceptions and explanations		●	●	
Conceptual framework		●	●	
First-hand instructor reports			●	
Understanding Science 101 and basic content	●	●	●	●
Advanced supplementary content	●	●	●	●
Science in Action stories	●	●	●	●
 Currently available  Launching this academic year				

