Chapter 5

Using Online Data for Student Investigations in Biology and Ecology

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ABSTRACT

Undergraduate research experiences are difficult to provide in large classes, institutions with no lab or field facilities, and distance-learning courses. This chapter illustrates how to overcome such obstacles and engage undergraduates in environmental and life science investigations using large and rapidly growing online databases including ecological data derived through citizen science and behavioral data available through Cornell University’s archive of sound and video. Examples are provided of driving questions and curricular support of undergraduate investigations focusing on two themes central to undergraduate biology: 1) ecology and conservation, and 2) organismal biology and behavior. These database investigations serve one or more of three pedagogical goals: 1) to enable undergraduates to conduct ecological and biological research in any setting, even where fieldwork is impossible, 2) to set the scene for student fieldwork, or 3) to make it possible for students to view their field data within the context of broader temporal and geographic trends.

INTRODUCTION

Large datasets are becoming an increasingly critical component of biological and ecological research, and the resulting web-based tools and resources provide unprecedented opportunities for students to work with data, develop analytical skills, and compare their results with those of peers and professionals across the globe (National Science Foundation Task Force on Cyberlearning, 2008; Porter, 2004). In fields in which professional research relies on use of web-based datasets, cur-
ricular resources have been developed to scaffold classroom use of these data resources. Examples include the BioQUEST curriculum for use in molecular biology and On the Cutting Edge for use in geosciences (for more information, see Edelson, 1998; Lombardi, 2007a; Manduca et al., 2010). Organismal biology and ecology have gotten off to a slower start in realizing the classroom potential of online data, but this will likely change rapidly as the field of ecoinformatics gains definition. Automated sensors are assembling a wealth of environmental data (e.g., Lehning et al., 2009), and growing numbers of students and members of the public are collecting and submitting “citizen science” data about organisms they have observed or environmental parameters they have measured. Collectively, these data sources present unprecedented opportunities for research by both professionals and students (e.g., Kelling, Fink, et al., 2009; Kelling, Hochachka, et al., 2009; Lowman, D’Avanzo, & Brewer, 2009; Trautmann, Shirk, Fee, & Krasny, in press).

Engaging students in research promotes deep learning, motivation, career awareness, and recognition of the practice of science (Brewer, 2003; Edelson, 1998; Lombardi, 2007a). Due to rapid advances in cyberinfrastructure, “today’s students are entering a scientific workforce in which they are expected to have skills in areas such as data mining, modelling, visualization, and annotation,” yet most undergraduate science educators “have limited experience in working with modern e-science resources” (Donovan, 2008, p. 461). Through exploration of data, scenarios, and case studies, even non-science majors can develop the critical-thinking, group work, and problem-solving skills that are highly sought by future employers (Lombardi, 2008). Designing classroom activities that make effective use of online databases and visualization tools to scaffold productive student inquiry is an important challenge for educational designers. Such designs should aim to provide faculty with meaningful examples and rubrics (e.g., Underwood, Smith, Luckin, & Fitzpatrick, 2008), assisting them in addressing 21st century environmental and conservation challenges in their teaching (Brewer, 2003; National Science Foundation Task Force on Cyberlearning, 2008).

Engaging students in research using current scientific data poses a number of challenges, including potentially unwieldy datasets and need for structure to ensure student learning. Such challenges can be overcome using carefully scaffolded educational technologies such as online databases and user-friendly tools for data analysis and visualization. Assessing student learning also can be challenging because intended outcomes typically extend beyond recall of content knowledge to also include development of understandings and skills related to conducting scientific research.

Using examples from our work with faculty teaching environmental and life science courses in diverse settings across the United States, in this chapter we present:

- reasons for engaging undergraduates in investigations using online data,
- several vast and rapidly growing databases of high value in student research related to ecology and animal behavior,
- the learning theory underlying our curriculum development efforts,
- a framework for assessing relevant student learning outcomes, and
- recommendations for future work in this field.

**BACKGROUND**

Growing efforts to reform undergraduate science education call for engagement of students in scientific processes, including designing investigations and analyzing data. The aim is for students to achieve understanding of how scientific investigations are conducted, how knowledge is tested and advanced, and what types of questions can be