Chapter 74
Opening Both Eyes:
Gaining an Integrated Perspective of Geology and Biology

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ABSTRACT

The focus of this chapter is an exploration of integrated geology and biology learning—from past to present. The chapter explains why active and integrated geological and biological learning became the lodestar of the authors' decade-long EarthScholars Research Group's research program. The authors argue that using an active and integrated geobiological pedagogical approach when teaching geology or biology provides natural opportunities for students to learn and do authentic scientific inquiry in a manner similar to how contemporary scientists conduct their work. The authors further review research that concerns the active, integrated geobiological science learning approach—in middle school, secondary, and college classrooms, laboratories, and field studies. The authors favor a gradual course transition to this pedagogy, while highlighting the advantages of adopting such an approach—both for teachers and students. Finally, the authors conclude the chapter with challenges and future directions in the design of active, integrated geobiological science learning environments.

INTRODUCTION

During the 2010 holiday season, a former student approached us in a crowded sporting goods store. It was practically a decade since she was registered in one of our large introductory geology courses, and yet she favorably recalled the experience, and sought us out to tell us so. When we asked what she remembered most about the course—and what she liked the most—she replied she enjoyed the petrified wood in the classroom (Clary & Wandersee, 2007). She also pleasingly volunteered the statement that our planet was 4.6 billion years old.

When we reflected back on that introductory geology course for non-science majors, we realized that this former student targeted not only what was successful with our class, but also the successful underpinnings of our entire research program.

DOI: 10.4018/978-1-4666-7363-2.ch074

For ten years, our EarthScholars Research Group has advocated "opening both eyes" in every science class and informal learning experience, and immersing learners in the integrated and interdisciplinary nature of the sciences. Through state, national, and international field-based, image-based, and archival research, we seek to integrate geological and biological learning with the ultimate goal of improving public understanding of these sciences. EarthScholars' research has focused on traditional classrooms at the middle, high school, and college level, as well as non-traditional online and distance classroom settings, and informal educational environments.

In our research program, we stress that most biological and geological learning, and informal and formal science educational programs, are separated for artificial reasons. This separation is to the detriment of meaningful science learning. We seek to bridge informal and formal learning, and improve the articulation of the sciences, for a more scientifically literate population.

INTEGRATED GEOLOGICAL-BIOLOGICAL LEARNING: A HISTORICAL REFERENCE

Even within elementary grades, students often have definitive periods or days specifically dedicated to different subjects. By the time students reach middle school settings (US grades 6-8), their classes consist of separate courses within "life science" or "physical science" or "Earth science," with scientific content presented independently from mathematics instruction. However, the compartmentalization of scientific sub-disciplines in *educational settings* does not have a history that parallels that of *scientific investigations*.

The earliest analyses of our natural world were grouped under the general heading of "natural philosophy." Natural philosophy's encompassing nature resulted in an integrated approach to observed problems arising from nature, with mathematical expressions used as needed to explain and clarify the collected and recorded data. Chemistry, physics, and much of geosciences content can be subsumed under natural philosophy's earlier organization.

As scientific methodologies developed, the modern scientific approaches differed from natural philosophical ones in systematic observation and research. However, even with modern scientific approaches in the 1800s, scientific sub-disciplines were not separated in instruction, nor taught independently in schools. Before 1900, students in US classrooms generally studied an integrated science approach with chemistry, physics, and geosciences, with mathematics routinely included in the investigation and study of natural phenomena.

BENEFITS OF INTEGRATED SCIENTIFIC LEARNING: THE HUMAN CONSTRUCTIVIST VIEW

As firm supporters of the inclusion of the history and philosophy of science in science teaching (Matthews, 2003), we recognize that the most effective methods for science instruction do not necessarily involve new approaches or the latest technology. In our research and historical investigations, we concluded that the re-appropriation of some historical techniques can add value in modern science classrooms. For example, our research demonstrated that several historical visualization methods—including aquarium view graphics or scientific caricatures—can be used for effective teaching and assessment (Clary & Wandersee, 2005, 2010a). We further recognize that the older, more integrated approach in science classrooms more authentically represents the interdisciplinary nature in which contemporary scientists conduct research. We propose a return to the "natural philosophy" by which science instruction was historically conducted.

In 2002, we founded EarthScholars Research Group with the mission to promote interdisci-