Under the Microscope: Review of the Research on Biological Lab Experiences 1987-2007: A Research White Paper

Brian Drayton, **Gilly Puttick**, **and Meaghan Donovan**

Cambridge, MA: (2013) TERC, Inc.

Summary

A sound education in the fundamentals of biology is increasingly important for all citizens of the 21st century (Kress and Barrett 2001). Issues ranging from environmental change to medical genetics require a populace that understands not just "biology facts," but also the nature of biological investigation and evidence, and the evolutionary basis that underlies the entire field. Many crucial developments in our world cannot be well understood without some facility with the kind of reasoning about complex, variable, and hierarchical systems that are typical of biology. Biology education also plays an important "gatekeeper" role for the sciences. After "general science" (which often includes a life science component), biology is the discipline that the highest proportion of 17-year-olds have taken, and thus may be the final science many students encounter (NAEP 1999).

Practical engagement with problems that possess these living characteristics is an indispensable ingredient in the development of this kind of reasoning and understanding. Laboratory experiences have been seen as essential parts of high-quality biology education since the 19th century (Lurie, 1988; Deboer, 1991; Janovy, 2003), as a way to convey biology content, and to help students understand how biology is done. However, the actual contribution of laboratories to student learning remains actively open to question (NRC, 2006). A recent groundbreaking study, America's Lab Report (National Research Council [NRC] 2006), has identified significant "frontiers of ignorance" awaiting attention; their findings echo those of an earlier survey of the role of laboratory experiences in science by Lazarowitz and Tamir (1994). For example, at the outset of the review, America's Lab Report listed several learning goals which high school laboratory experiences are assumed to further. However, the NRC survey of the US research literature left the authors asking such basic questions as "What are the specific learning outcomes of laboratory experiences? What are the teaching and learning processes by which laboratory experiences contribute to particular learning outcomes for diverse learners and different populations of students? What kinds of curriculum can support teachers and students in progress toward these learning outcomes?" (p. 10). Furthermore, the NRC study limited its research to high school, expressly leaving aside the question of earlier grade levels, and the progression from elementary school to college.

Finally, and most important for our purposes, the NRC study does not explore any of these questions from the point of view of particular disciplinary content. While some studies of high school biology lab experiences are referenced in their work, the authors did not, even within the chosen limitations of their study, set out to systematically review the literature on the life sciences. Thus, some of the unique characteristics of the biological sciences have not been used in a consideration of the goals, value, and growth of understanding in biology during students' biology education careers.

This paper reports results from a study, funded by the National Science Foundation , which examined the nature of published research on life-science laboratory experiences in the English-language, peer-reviewed research literature. The study sought to understand the extent to which the research literature addressed i) student learning about the characteristics of living systems, ii) the growth of students' biological reasoning with respect to "biological distinctives" (evolution, complexity, dual causation, populational thinking, and variability) (Mayr 1982, 2004; Sterelnyi and Griffiths, 1999), and iii) novel or standard lab activities.

We examined research methodology, biological subject matter addressed, and materials and methods used in the lab. We sought to establish some estimate of the degree of student inquiry that the lab allowed. This paper will focus on our findings on: i) the size and basic characteristics of the corpus, ii) the biological domain addressed, iii) the degree of inquiry, pedagogical design and activity structure of the lab experiences studied, and, iv) student outcomes measured in the studies reported.

Download Paper »