

2003

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Recommended Citation

Wolfson AJ (2003) Student Learning in Biochemistry: Assessment of the Undergraduate Research Experience. Project Kaleidoscope Biochemistry Portfolio.

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Student Learning in Biochemistry: Assessment of the Undergraduate Research Experience

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An undergraduate research experience is widely regarded as a key element in science education. The recent report from the National Research Council recommends that, "All students be encouraged to pursue independent research as early as is practical in their education." (1)

The benefits of undergraduate research to the student have been variously described as: increased confidence and ability to "do science," gains in critical thinking, acquisition of specific technical and communication skills, clarification of major and career path, development of close relationships with faculty and increased understanding of the nature of scientific knowledge. Benefits are also expected to accrue for the mentor in terms of collegiality and productivity, for the institution as increases in students and visibility, and for industry as increased interest in and preparation for graduate education.

These hypothesized benefits have, for the most part, not been documented by well-designed assessment projects. Most reports have been descriptive and based on small samples of students at a single institution. As noted by Seymour *et al* (2), it is understandable that science faculty would argue the value of undergraduate research based on the direct personal experiences of their students and themselves. Those studies that achieve a broader relevance (examples such as (3) and (4)) have been designed by experts in assessment and sampled a larger group of students. Such studies can serve as models for future assessments. (see (2) for a comprehensive review of the literature).

Undergraduate research is supported by the National Science Foundation most specifically through its REU programs; the Howard Hughes Medical Institute also devotes a large portion of its funding for undergraduate education to opportunities for research, as do many other funding agencies and foundations. Program evaluation, as reported to funders, usually involves quantitative data on numbers of majors and students going on to graduate school in the sciences. However, no study has yet established the nature or extent of the contribution of undergraduate research experiences on these two outcomes.

Case Study

It is clear that in order to assess the benefits of undergraduate research, a collaborative effort, involving several institutions and several approaches to the problem is needed. Four liberal arts colleges (Grinnell, Harvey Mudd, Hope and Wellesley) with outstanding reputations for undergraduate research came together for the purpose of assessing their own programs and providing data for evaluation and design of programs at other sites.

The initial design of the research project was contributed by sociologist Elaine Seymour (University of Colorado, Boulder) and psychologist David Lopatto (Grinnell College). They designed the assessment with two complementary components: a qualitative component (in-depth interviews) and a quantitative component (comprehensive questionnaires). Student responses from interviews were incorporated into questionnaires which were administered to larger groups of students. Data from the questionnaires correlated well with the interview data and both methods support the findings.

The continued involvement of scientists and administrators at all of the colleges was also crucial. An important decision made by administrators was to limit the study to summer research experiences in order to control for program variables, as these are likely to affect outcomes.

Although this study is not specific to biochemistry programs, all of the participating schools have interdepartmental majors in biochemistry (also called biological chemistry, or molecular biology), and all have summer research programs that involve students from across the sciences.

The first data to emerge from this study demonstrate overwhelmingly positive experiences for students. (2) However, the benefits described were sometimes different from those expected. For example, very few students were influenced to attend graduate school on the basis of their summer research experience alone, and very few reported gains in their writing skills. On the other hand, personal-professional gains, such as growth in confidence to do research combined with the feeling of making authentic contributions to science, taking more responsibility for the direction of the research and for their own learning and learning to work together were reported by the majority of students.

The power of this research study is that it allows identification of benefits that do not necessarily emerge from looking at traditional measures of success in undergraduate research programs (such as the number going on to grad school). Further, new research questions arise from the data. Having documented the benefits of research for students, the researchers can now ask how these benefits are attained. To begin this analysis, they collected data as to the benefits and costs to faculty of mentoring students in research. Both the student and faculty costs and benefits will have important programmatic implications

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