

The Status of Laboratory Instruction for Introductory Biology in U.S. Universities

Marshall D. Sundberg Joseph E. Armstrong

BIOLGY teachers already know that our budgets are too low, our classes are too large, space is limited and traditional laboratory instruction is often unproductive. Furthermore, there is continued pressure to cut back on undergraduate science laboratories from many administrators who see the laboratory as an inefficient and ineffective method of instruction. Given the current budget crisis in education, a primary rationale for this study is to provide documentary evidence of the current status of laboratory instruction at major colleges and universities in the United States, those institutions that provide a biology experience to the majority of undergraduates in the U.S. This could be either an introductory course for majors or a terminal course for nonmajors. Our goal was to identify current national norms and any trends that may be resulting from the renewed concern for science education in this country. In particular, we were interested in how successfully investigative laboratory instruction has been implemented in large, multi-section courses. We hope that this information will be used to argue for protecting funding and improving laboratory instruction on individual campuses.

This report is based upon responses to a questionnaire distributed during the fall of 1991 to 118 public and private universities throughout the U.S. These included the top 50 institutions, ranked on their acquisition of federal grant monies, and 68 additional regional state universities. We received 73 responses. Questions addressed several variables that contribute to the quality of laboratory instruction including course organization, instructors and resources available to support laboratory instruction. The survey results are summarized below in three broad categories: course organization, instructors and resources.

Course Organization

Laboratory instruction is part of introductory biology at almost all responding institutions (70 out of

Marshall D. Sundberg is biology coordinator at Louisiana State University, Baton Rouge, LA 70803. **Joseph E. Armstrong** is a biology professor in the department of biology at Illinois State University, Normal, IL 61761.

73). The majority, 62 percent, of institutions providing laboratory instruction offer separate biology courses for majors and nonmajors. Only three institutions have no laboratory instruction at this level.

One respondent commented: "Our introductory biology lab is not general biology but a biochemistry and cell biology lab for second semester sophomores and first semester juniors, a full year. Most of our students have taken the equivalent of general biology in high school."

Several responses suggest a disturbing trend, and we quote,

"We are now considering a proposal to drop the laboratory component from our large intro courses. This has evolved as a result of increasing enrollments, insufficient number of teaching assistants and the enormous time burden on all staff. We expect to place greater emphasis on upper level laboratory courses taken by the biology majors. The laboratory component in the intro-level courses will likely be replaced with discussion/problem-solving sessions and some demonstrations."

There is renewed interest in investigative types of laboratories as a method to teach students science by allowing them to do science. This approach was highly recommended in the 1970s by the Commission on Undergraduate Education in the Biological Sciences (Thornton 1971) and has been especially successful at small liberal arts colleges. Investigative laboratories have been less widely employed at larger institutions. Only three of the responding institutions, Arizona State University, University of Missouri-St. Louis and Stanford University, are fully committed to investigative laboratories. At half of the responding institutions, the investigative approach is used in at least some of their laboratory exercises. As might be expected, given the move toward investigative laboratories, most of the respondents (89 percent) rely heavily on laboratory exercises developed "in house" to provide these experiences.

At most institutions, laboratory instruction involves a combination of modified versions of commercial laboratory manual exercises, exercises obtained at workshops or conferences, and exercises developed internally. Only two schools rely exclusively on commercially available laboratory manuals. One respondent's comment, "Most of the laboratory

exercises published in lab guides are simply awful!" apparently reflects a generally held low opinion of these publications.

Student enrollment in introductory biology is high at most of the universities surveyed, requiring multiple laboratory sections per course. Fifty-nine percent of the schools report enrollments of more than 500 students in their introductory biology courses, and more than a third, 34 percent, offer more than 30 lab sections per week. Laboratory sections usually meet once per week, but at 10 percent of the institutions, laboratory sections meet twice per week. Most laboratory sections (55 percent) last for three hours, 30 percent last for less than 3 hours and 14 percent have longer laboratory periods.

Instructors at 68 (93 percent) of the responding institutions said laboratory instruction is done primarily by graduate teaching assistants, however other personnel frequently are involved as well. At least some tenure-track faculty teach in the laboratory at 30 percent (22 out of 73) of the institutions surveyed. Although this is more common at private and regional universities, faculty also teach in the laboratories at some of the larger comprehensive universities such as Clemson University, Indiana University, Kansas State University, University of Minnesota and Purdue University. Many of the larger institutions (27 percent of respondents) employ career instructors. Undergraduates assist in laboratory instruction at 29 percent of the responding institutions including: Case Western University, University of California at Berkeley, Columbia University, Emory University, Stanford University, Vanderbilt University, Kansas State University, Michigan State University, Pennsylvania State University, Purdue University and State University of New York at Binghamton. At nearly half of the institutions using undergraduates, the undergraduate assistant is the only instructor in the laboratory! In one instance, individual undergraduate assistants are responsible for teaching laboratory sections of more than 30 students. Fifty-five percent of laboratory sections have a student:faculty ratio of 10-20:1; an additional 41 percent have a ratio of 20-30:1. Stanford University and Columbia University report fewer than 10 students per instructor in the laboratory.

We asked respondents to indicate how instructors are prepared for teaching in the laboratory. For example, are there weekly pre-lab meetings, an independent one-to-several-day training session, or a formal training course? Four respondents indicate that they have no training for their laboratory instructors, including one of the institutions where undergraduate assistants have full responsibility for laboratory sections! Weekly training sessions are held at 88 percent of the institutions. A formal course in

laboratory instruction is offered at 10 institutions, including nine of those with weekly meetings.

Resources

One respondent seemed to be speaking for most when he wrote: "Right now our funds are in terrible shape . . . we are barely alive." Half of those responding report a laboratory budget of less than \$10 per student to purchase all the equipment, materials and supplies required to teach their laboratories. Curiously, in spite of this, only 21 schools charge their students a laboratory fee. At three of the institutions charging a laboratory fee, the fees provide the only support for the laboratory as they receive no money for supplies or equipment in their regular budget. On the other hand, 15 of the schools charging a laboratory fee receive more than \$10 per student of regular support. A typical laboratory fee is about \$15, but the fees range generally from \$5 to \$45. Two of the private institutions charge students \$100 or more.

Space is another limiting resource at many institutions. Of the 44 institutions where more than 500 laboratory students are taught, only 25 have four or more teaching laboratories at their disposal. At four of these large enrollment universities, all of the introductory laboratory sections are scheduled into a single laboratory classroom.

In addition to the physical laboratory space required to teach laboratory exercises, support facilities may be needed for preparation of materials, storage of supplies and the growth of experimental and study organisms. Although nearly three-fourths of the institutions polled have a greenhouse or growth chamber to grow and maintain plant materials for classroom use, only half report facilities for maintaining cultures, and just 42 percent have access to an animal room to maintain living animals. Yet only half of the greenhouses, one in five of the culture rooms and two of the animal rooms at these institutions have any space available for student projects. Nearly half of the schools supplement their facilities by using nearby natural areas for field work; in one case the natural area was the only local resource for obtaining living organisms for study. The situation was summarized by one respondent who stated, "Materials brought in as needed; no space." Indeed, six of the schools surveyed reported no support facilities available and no ready access to a natural area.

Summary & Discussion

The laboratory is recognized as a critical component of biology instruction (NSF 1990), yet in the face of shrinking real budgets, universities continue to de-emphasize the laboratory as an effective means of

teaching science. In the majority of responding institutions at least one of the four critical components—personnel, space, budget and support facilities—is inadequate. In large measure we biologists may have brought this problem on ourselves. As enrollments increased and budgets shrank, we tended to “make do” by allowing increased class size or fewer instructors per class, which resulted in the high student/faculty ratios observed in this survey. Alternatively, some have succumbed to the pressure and dropped laboratory instruction in favor of more passive modes of teaching. Overcrowded facilities contribute to this problem and reduce the amount of space dedicated to large enrollment laboratory instruction in favor of research laboratories. Despite these negative trends, there appears to be a movement toward using more open-ended, investigative laboratory exercises in introductory courses. Intuitively this seems to be counter productive. The generally held dogma is that larger class sizes require more structure for students to learn effectively. Furthermore, moving large numbers of students through standardized exercises provides an economy of scale that is desirable. Yet, in the early 1970s biologists claimed that investigative laboratories can be more cost efficient than traditional laboratories (Thornton 1971). This claim seems to be born out at Arizona State University where more than 500 students, at a student:teacher ratio of nearly 30:1, are enrolled in a laboratory program that is totally investigative and is supported by a budget of less than \$5 per student. The investigative approach only works, however, because of a correspondingly larger time investment on the part of the laboratory instructors, the graduate teaching assistants and the laboratory coordinator. At Arizona State University, in addition to attending regular weekly pre-lab meetings, teaching assistants are required to enroll in a formal training course and participate in an intensive one-to-three day training session prior to the start of the semester.

For a number of years the authors have struggled, mostly independently, to develop quality laboratory activities for our students in large enrollment, multiple-section courses, within the constraints of limited resources. This has been a very time consuming process and generally has not been well rewarded by university administrators. The survey summarized above was done, in part, to document the current state of university biology laboratory instruction in an effort to establish the need for a nationally supported effort to improve laboratory instruction. We thank the many colleagues who took time to respond and provide us with these data. Copies of the survey and complete tabular data are available from the first author upon request.

Specifically, as part of a grant proposal, we wanted to document the need and interest in intensive week-long workshops where groups of like-minded biologists could develop a number of investigative-type laboratory activities appropriate for large, multi-sectioned laboratory courses. We are pleased that this proposal has been funded by the National Science Foundation. We invite interested individuals to contact either one of us for information about participating in the first such workshop to be held at Illinois State University the week of June 13, 1993. Enrollment will be limited and participant support funds are available. Marshall Sundberg, (504) 388-8563; E-mail: BTMARSH @ LSUVM or SUNDBERG @ LIFE.JSC.NASA.GOV; Joseph Armstrong, (309) 438-2601; E-mail: JEARMSTR @ ILSTU or JEARMSTR @ LIFE.JSC.NASA.GOV.

References

- National Science Foundation. (1990). *Report of the National Science Foundation workshop on undergraduate laboratory development*. Washington, DC: Author.
- Thornton, J.W. (1971). *The laboratory: A place to investigate*. Washington, DC: American Institute of Biological Sciences.

**Teach your students
about career opportunities
in biology research,
technology & education with...**

CAREERS IN BIOLOGY: AN INTRODUCTION

Your first copy is FREE!
Additional copies are \$6 (set of 25)

Order your copies today! Call (703) 471-1134

National Association of Biology Teachers (NABT)
11250 Roger Bacon Drive, #19, Reston, VA 22090