What happened to the Advanced Lab?

With all the attention that the physics community has paid to Physics Education Research in introductory courses, to K-12 teacher training, to class demonstrations, to hands-on learning, and to various other areas, I am troubled by the fact that our profession has neglected the development of advanced experimental physics education. Yes, undergraduate research participation has become a popular program at many colleges and universities, but I am concerned that these research experiences are practical only for a small fraction of physics majors and usually only for those in their senior year. It is difficult to design a research experience that is appropriate for an undergraduate physics major. The successful few are given high-profile publicity, as if they were the norm. Too often colleges and universities use these research experiences in part to replace the advanced lab because they require less time, effort, and breadth of experience on the part of the faculty, and not because they optimize the learning experience. Even seemingly successful programs frequently amount to "narrow band" idiosyncratic tasks that keep the students busy without giving them sufficient experimental experience.

Advanced junior and senior level labs are an essential component of the undergraduate curriculum. They offer a range of experimental physics experience that few, if any, research experiences can provide. Here, students can perform experiments in nuclear physics, optics, condensed matter physics, x-ray crystallography, gaseous electronics, high vacuum, magnetic resonance, optical spectroscopy, and the list goes on. A department could hardly imagine an undergraduate curriculum without advanced theoretical courses that examine these areas of physics, yet many of these departments deprive their students of the opportunity to do experiments that are seminal in these areas of study. We owe it to our students to find a way to enhance existing upper division laboratory programs and to support the development of new ones.

There are many reasons for the decline of advanced laboratory instruction. These labs are expensive, both in money and faculty time. Pressure on young faculty to obtain research grants and publish papers is much greater than when I entered academia in the mid-1960s. There is little academic reward for developing an advanced laboratory program. It may even be held against an untenured faculty member-"Why weren't you using your time to do research?" The most important reason for the decline is what I would call the isolation of faculty who have both the talent and inclination to create these laboratory experiences. These faculty are isolated from each other, isolated from substantial and long term funding, isolated from professional recognition, and isolated from up-to-date sources of vital information. A change in this culture is long overdue. It is time to put the advanced lab "on the radar screen." I have some suggestions.

We need to bring together faculty who have already developed excellent advanced labs and those who would like to accept this challenge. With the focused efforts of the APS and AAPT, there might be a series of Gordon Conferences, special sessions associated with regular meetings or some special conferences, supported by the NSF, where plans and strategies can be developed. These faculty need to be brought together, both to learn from one another and to plan the resurgence of advanced labs across the nation.

As you might expect, I have my own ideas of how to facilitate this resurgence. One serious problem is the lack of a central source of information about advanced lab experiments. Suppose there was a mechanism established for vetting actual lab experiments at various schools and creating a digital library of these refereed labs. Faculty using this peer-reviewed resource could be confident that the experiments would actually work. Wouldn't that be nice!

Along with directions for building the experiments themselves, "user friendly" information could be included. So many seemingly simple things can make a crucial difference, such as where to buy parts, how to fabricate components, and what types of cheaper components might be substituted. It would also be important to include some of the small but essential tricks of experimental design and development that are often omitted from the literature.

For this effort to be sustained, it is essential that a place be developed for people to present their ideas, to have creative intellectual discussions and debates, and to interact with peers who share a commitment to advanced laboratory instruction. I do not mean a physical space, but rather a place in our professional agenda for this type of effort. This means predictable sessions at major meetings and on-line forums that create and sustain efficient lines of professional communication among those involved in the advanced lab. And to promote individual commitment, the AAPT and APS should develop mechanisms through which excellence in advanced laboratory instruction will be recognized and rewarded. This should certainly include special invited talks, where, when possible, actual apparatus is demonstrated.

I propose a dedicated professional association, created under the joint umbrella of APS and AAPT and supported by the NSF, that would put the advanced lab back on the map of the physics profession. Let's not forget that physics is an experimental science. This time there are no congressional representatives to write. It is up to each of us to encourage and support new initiatives of the AAPT, APS, and NSF.[1]

[1]This editorial is based in part on my talk, "Advanced laboratory consortium 'conspiracy'," given at the March 2006 APS meeting.

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Bunsen-type Spectrometer. The present-day spectrometer employs a diffraction grating; if the grating spacing is known with precision the wavelengths may be obtained directly from the angle at which the particular lines appear. For most of the nineteenth century the typical spectroscope used a prism to separate the spectral lines. Calibration was obtained by projecting the lines of a known spectral source onto the same plane as the unknown lines. Light from the reference source is sent down the collimator using a small prism located by the lower half of the entrance slit. To use interpolation to find the unknown wavelengths, a scale etched on a glass reticule is reflected from the surface of the prism and projected on the images of the known and unknown sources. A divided circle is not necessary for finding wavelengths. This spectrometer, probably by Queen of Philadelphia, cost $35 at the end of the 19th century. It is in the Greenslade Collection. (Photograph and Notes by Thomas B. Greenslade, Jr., Kenyon College)