Development of Instructional Optics Laboratories

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ABSTRACT

A survey was conducted to provide current information about the instructional optics laboratory courses at North American institutions offering bachelors and masters level optics programs. This paper gives the results of the survey and provides examples of instructional optics lab development activity. Problems facing the development of new instructional optics lab courses and refinement of existing instructional optics lab courses are discussed.

1. INTRODUCTION

Because of the growth of the optical industry over the past several years, we have seen an increasing demand for persons educated in optics. This demand has caused an increase in the number of B.S. and M.S. level optics educational programs offered and an increase in the numbers of students pursuing careers in optics. However, the resulting larger class sizes are at cross purposes with a typical instructional laboratory environment. Ideally, lab courses should have a small number of students thus providing each student with as much hands-on experience as possible. The labs can be run with larger numbers of students and still maintain the desired hands-on experience if sufficient equipment is available but then faculty/teaching assistant time becomes an important consideration. Every institution must come to grips with these practical problems in designing curricula which meets the needs of the students and the industry who will ultimately hire these students.

Two common questions facing science and engineering educators in designing optics curricula are:

** How do we increase a student's hands-on experience?
** How do we enhance a student's communication skills?

One way to simultaneously answer both of these questions is to incorporate laboratory activity into the curriculum, either through formal classes or through project work.

2. SURVEY ABOUT INSTRUCTIONAL OPTICS LAB COURSES

In order to assess the breadth of instructional optics laboratory activity and determine how the development of the lab courses was accomplished, a short questionnaire was sent to institutions in North America having some type of B.S. and/or M.S. optics educational program. Fifty-four institutions listed in the 1987-88 edition of Optics in Education[1] were surveyed with 37 responses received.

2.1. ARE LAB COURSES NECESSARY?

The first question on the survey asked: "Is a lab component necessary for a successful program?" The respondents were given three choices: absolutely necessary, maybe and bad idea. The overwhelming response was that a lab is absolutely necessary with only two respondents stating that maybe it is necessary for a successful program. Noone responded that it was a bad idea.

2.2. INSTRUCTIONAL OPTICS LAB EQUIPMENT

Survey question number two attempted to ascertain how instructional optics lab equipment was acquired at each institution. The respondents were asked to indicate the approximate percentage of their optics instructional equipment that was acquired through several listed categories. The average percentage of all responses for each category is shown in Fig. 1. The category labeled, "Other", includes equipment that is homemade, purchased through a student lab fee, government surplus and/or history/museum pieces.

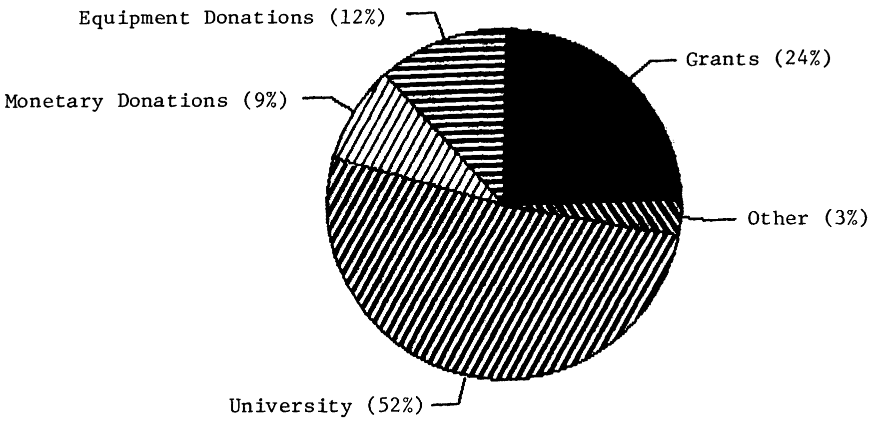

Figure 1. Average of all institutions acquisition of instructional optics lab equipment.

2.3. INSTRUCTIONAL OPTICS LAB COURSES

The next six questions on the survey dealt with the number, type, size and length of typical optics lab courses. Table 1 shows the results.

Table 1. Survey of Instructional Optics Lab Courses in North America

	Average	High
Number of B.S. optics lab-oriented courses	2.3	7
Number of M.S. optics lab-oriented courses	2.3	7
Number of students per optics lab section	13.0	40
Number of contact hours per week per course	4.0	10
Number of experiments performed per lab course	7.7	20

Note that not all of the surveyed institutions have both a B.S. and an M.S. program. Thus all averages include only those institutions which responded with a nonzero answer to the survey questions.

In general, there are two schemes used by educators when designing a lab course; either incorporate a lab component with a lecture or have a lab-only course. Each scheme has advantages and disadvantages but generally the scheme that is adopted by an institution is chosen because of internal institution requirements or specific program considerations. At Rose-Hulman Institute of Technology (R-HIT) we generally incorporate a lab component with a lecture, however we have used both schemes depending on particular program requirements. Our area minor in applied optics program is an example of the first scheme in that three out of the five required courses -- Laser Physics and Applications, Fiber Optics and Applications and Optical Instrumentation -- have a laboratory component associated with the courses. We think that this is advantageous to the students in this program since they will have an optics lab scheduled at least once each week for an entire academic year thus spreading out the students exposure to the lab. The required optics courses in the B.S.(Applied Optics) degree program at R-HIT are a combination of both schemes. Of the nine required optics courses, five of the courses have a lab incorporated with a lecture component. The sixth lab-oriented course is a lab-only course and is the final course taken by senior students. This course is intended to be a capstone course and have experiments which bring together optics concepts from several areas.

As mentioned earlier, an added benefit of having a lab course in the curriculum is to help enhance a student's communication skills. Not only do the students in the R-HIT instructional optics lab courses keep an up-to-date lab notebook but each labgroup collaborates in writing a formal lab report. The formal lab reports written by the students in these courses generally conform to the guidelines specified by the AIP Style Manual for submitting a paper to be published. Requiring formal laboratory reports allows us to test the students on their communication skills as well as the technical quality of their work.

Undergraduate research projects are a vital part of many of the optics programs surveyed. These projects provide many of the same benefits that a formal lab course provides. At R-HIT we offer directed research courses with topics such as: fiber optic acoustic sensor, wavelength multiplexing in fiber optic communication systems, character recognition using matched spatial filters and surface roughness determinations using laser speckle.

2.4. DEVELOPMENT OF INSTRUCTIONAL OPTICS LAB COURSES

Questions 9 and 10 asked about the development of optics lab courses and experiments performed in these courses. Most respondents indicated that the faculty designed and wrote the experimental procedures themselves. Usually they had help from students (both undergraduate and graduate students) either testing the experiments or by having the students do a design project which led to an experiment. Only three respondents commented that their course development was externally funded. Lack of funding sources for this type of development does not seem to have stopped the development of instructional optics lab courses but it may be the reason why some of the survey respondents commented that faculty were reluctant to develop instructional labs. Ideas for the types of experiments performed in the optics labs are classical optics experiments, standard measurement techniques and test procedures, individual research, student design projects and industrial interests.

The development of the Laser Physics and Applications instructional lab course at R-HIT is a good example of a typical development activity. We were fortunate to have received a course development grant from Lilly Endowment, Inc. which allowed us to develop this course. We hired undergraduate students to work during the summer before the course was to be taught and had these students perform the experiments using procedures that we wrote. The students helped to refine the experimental procedures and made sure that the experiments would work with the available equipment. The experiments were designed to include not only some basic laser principles but also incorporate some application such as the use of lasers for performing length measurement, etc. Examples of the type of experiments performed in this course are: laser beam properties (HeNe and diode lasers), laser modes, temporal and spatial coherence measurements, laser speckle and applications, organic dye laser with applications to pulsed optical ranging and a holography experiment.

Other instructional optics lab courses at R-HIT were developed in a similar manner. The development of the four masters level instructional lab courses at R-HIT were aided through a grant from Indiana's Corporation for Science and Technology. In addition, the curriculum for these programs was enhanced through our Visiting Lilly Fellows Program which brings in representatives from the optics industry and other optics educators to critique our programs.

Another notable optics lab course development was undertaken by workers at Texas Tech University through grants from the National Science Foundation. Laser experiments,[2-3] optical information processing experiments[4] and fiber optic experiments[5] were developed and are an excellent source of information and ideas on these instructional optics labs.

Even if an external funding source for lab course development is not available there are some sources of assistance to optics educators for developing instructional lab courses. For example, both SPIE and OSA have educational development grant programs that may be useful for developing lab courses. Also, an example of a good source to use for ideas for fiber optics experiments is the applications handbook compiled by the staff at Newport Corporation.[6] The optics industry could provide some assistance here by making similar handbooks available to educators as is done by many electronics firms.

2.5. PROBLEMS FACING THE DEVELOPMENT OF INSTRUCTIONAL OPTICS LABS

The final question was: "What do you see as the major problem facing the development of instructional optics labs?" All but six respondents stated that their major problem was lack of funds to purchase equipment for the optics labs or the cost of the necessary equipment. Other responses included lack of faculty, lack of faculty time, lack of lab space dedicated to teaching and maintenance of existing equipment.

3. SUMMARY

From the results of a survey of educational institutions offering B.S. and M.S. degree optics programs, instructional optics labs are absolutely necessary to have a successful optics program. There has been some industry assistance to educators for developing instructional labs but generally the development of the current optics instructional labs has been done with little external support. Equipment donations are helpful but in many cases the equipment is out of date when it is donated. Most of the instructional optics lab equipment in typical institutions was obtained mainly through the institution's own resources. Monetary donations are of course also helpful but are usually obtained sporadically and can never be counted on. One thing that would help most optics educational programs would be to have monetary donations each year so that development could be spread out over a longer period of time and allow the institution to gradually build the instructional labs. This, coupled with equipment discounts for instructional laboratories, would be a tremendous help to instructional optics lab development.

From an educator's point of view nothing can compare to the students' excitement when they make their first hologram or couple light into an optical fiber for the first time. These are things that the students can never learn in a lecture and are why instructional lab development is vital to a student's education. That is why the development and teaching instructional optics labs is such a rewarding experience.

4. ACKNOWLEDGMENTS

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