ASSESSMENT RESULTS FOR A RECENTLY INTRODUCED INTERDISCIPLINARY LABORATORY SEQUENCE IN ELECTRICAL ENGINEERING

T. Roppel and A. S. Hodel
Electrical Engineering Department, Auburn University

Abstract

In the fall of 1997, the Auburn University Electrical Engineering Department implemented a new, interdisciplinary core laboratory sequence. This new laboratory sequence was one outcome of a complete curriculum revision based on four years of work by the departmental Curriculum Study Committee. This paper will present the results of a multi-part assessment conducted during the spring, summer and fall quarters of 1998. The purpose of the assessment is to measure the effectiveness of the new lab format against the goals established by the Department, which include providing a high level of motivation for the students, avoidance of "cookbook" laboratories, substantially involving the entire faculty in laboratory design, teaching, and assessment, and helping students perform better in lecture courses by having prior hands-on experience with components, formulae, and computer simulation software.

It has been found that many students are initially surprised by the level of challenge provided in the first laboratory course, but readily accommodate as they progress through the sequence. The overall result of the new laboratory experience is that students have a more integrated approach to design and a much better understanding of the hardware, software, and instrumentation used in electrical engineering practice.

I. Structure of the laboratory sequence

An overview of the curriculum revision and the details of the new laboratory sequence have been presented previously[1]. In brief, the Electrical Engineering undergraduate core curriculum model includes a total of six 1-quarter hour (3 contact hours/week) laboratory courses during the sophomore and junior years. These courses are designated Lab I (1st quarter sophomore) through Lab VI (3rd quarter junior). The laboratory courses are not tied to a specific lecture course; rather they incorporate material from several topic areas within electrical engineering, build upon previous laboratories, and are supplemented from outside sources including guest lectures. Students encounter a significant number of concepts for the first time in the laboratory courses. The first course consists of experiments that are largely prescriptive, but as the laboratory sequence progresses through the sophomore and junior years, students are increasingly challenged to think creatively in design projects and to write technical reports in a variety of formats.

II. Assessment Based On Student Feedback

Students in the Electrical Engineering Department are asked to fill out evaluation forms at the end of each quarter for every course they take, including the laboratory courses discussed herein. There are eight standard multiple choice questions, and room for written comments. In addition, there is a common one-hour written final exam for all sections of Lab I and a similarly structured common final for all sections of Lab II. At the end of each exam for Fall Quarter 1998 for Lab I and Lab II we included several additional questions and a request for comments. Evaluation results derived from these metric tools for the first two laboratories in the six-laboratory sequence are summarized below. The Lab I and Lab II students were asked to rank from 1 (strongly agree) to 5 (strongly disagree) how each of the following words or phrases applied to their laboratory experience: "challenging," "stimulated my thinking," "frustrating," "interesting," and "boring." The Lab I student responses are shown in Table 1 and in Figure 1.

Table 1. Lab I (First Quarter Sophomore) student responses. Table cell values are the percentage of total respondents circling each response (1-5).

	challenging	stimulated my thinking	frustrating	interesting	boring
1 strongly disagree	3 %	3 %	3 %	0 %	21 %
2 disagree	9	6	18	12	30
3 neutral	6	21	27	15	33
4 agree	55	48	18	45	6
5 strongly agree	27	21	33	27	9

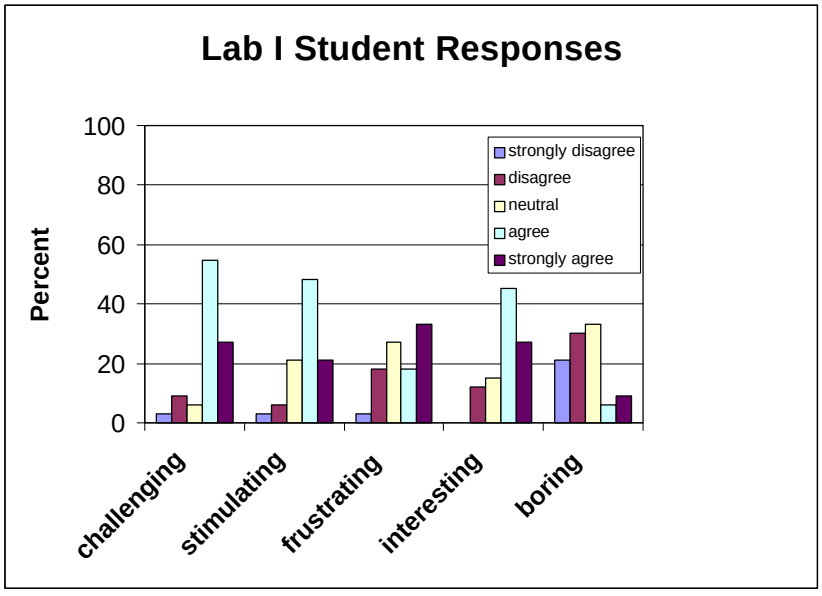

Figure 1. Histogram representation of Lab I student responses.

We observe that students overwhelmingly rate their first Electrical Engineering Laboratory experience as "challenging," but the second largest responses are "stimulating" and "interesting." As discussed in the next section, students report that the source of most of their frustration is the novel experience of learning some of the required background material "just in time." In order to confirm this and to address whether some frustration was potentially generated by experiments that were too difficult, students were asked to evaluate the difficulty of the laboratory experiments (including prelab work). The laboratory experiments fell into two categories, four introductory experiments requiring no digital logic knowledge, and four experiments which introduced and built up experience with digital logic. Although not a prerequisite for Lab I, some students already had a lecture course in digital logic. Two questions were asked:

Question 1: *"Considering my level of preparation, the non-digital experiments 1-4 were (a) Too difficult, (b) About right, (c) Too easy.*
Question 2: *" Considering my level of preparation, the digital experiments (5-8) were (a) Too difficult, (b) About right, (c) Too easy."*

The results, shown in Table 2, clearly indicate that most of the students found the required work to be at a reasonable level of difficulty regardless of the type of experiment.

Table 2. Lab I Student assessment of the difficulty of the required laboratory work.

	Non-Digital Experiments	**Digital Experiments**
Too difficult	18 %	15 %
About right	82	85
Too easy	0	0

The students were also asked to express their opinion regarding the type of laboratory course that they believed was best. Specifically, they were asked to compare a "traditional" laboratory course which is linked to a specific lecture, with the non-traditional type of course they had just completed. The question was:

Overall, which type of lab class do you think is better:
(a) A lab that is tied directly to a specific lecture course, where the experiments each week correspond to the lecture material.
(b) A lab which integrates ideas from several lecture courses and presents new concepts, but is not tied to a specific lecture course.

In Lab I, 61% of the students chose (a), representing the more traditional type of laboratory course.

A similar set of questions were posed to the Lab II students. These results are shown in Table 3 and in Figure 2.

Table 3. Lab II (Second Quarter Sophomore) student responses. Table cell values are the percentage of total respondents circling each response (1-5).

	challenging	stimulated my thinking	frustrating	interesting	boring
1 strongly disagree	0 %	0 %	7 %	4 %	29 %
2 disagree	10	7	29	7	50
3 neutral	17	11	21	14	11
4 agree	45	43	32	32	7
5 strongly agree	28	39	11	43	4

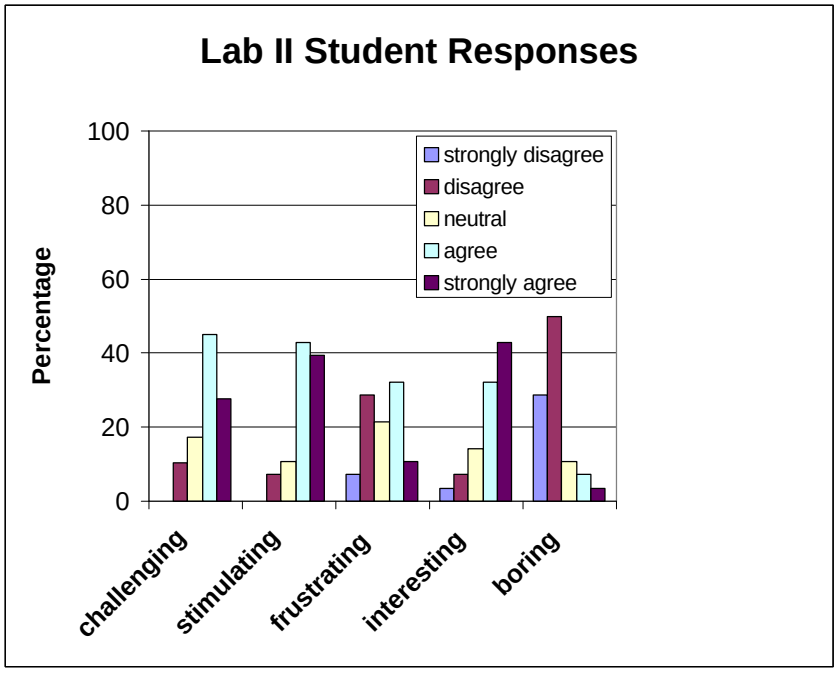

Figure 2. Histogram representation of Lab II student responses.

We can observe that the Lab II students also rate their course as challenging, although to a slightly lesser degree than the Lab I students. Also, 79% of Lab II students disagree or strongly disagree that the course is boring, compared with 51% for Lab I. Based on student interviews, this seems to be more related to the more mature students' greater understanding of and appreciation for the usefulness of the material, rather than anything specific to the course content.

Lab II students were also asked to express their opinion regarding a traditional laboratory vs. the multidisciplinary laboratory that they had experienced for two quarters. Their responses were significantly different than the Lab I students; 66% expressed a *preference* for the multidisciplinary laboratory.

Oral interviews were conducted with students in each of the six laboratory courses. The students were asked a few specific questions, but mainly just asked to provide feedback as they felt appropriate. From these responses, we learned that the primary sources of excitement in the laboratories were the design projects. Students are required to purchase their own parts, and to replace any parts that are damaged. They reported that this gives them a feeling of owning not just the parts, but the entire problem as well. They also reported positively on the writing requirements, including laboratory reports, design reports, and technical memos. Although they were initially fearful and often did not trust their own ability to meet the requirements, they found out through practice and feedback that it became easier and eventually, for some, even enjoyable. In the earlier laboratories we tried to develop a set of videotapes to introduce complex equipment such as the oscilloscope and analog trainers. We found out that in order to be effective and relevant, the videotapes need to be presented in blocks, rather than in one continuous segment, so that students can follow along at their workstation. Another valuable lesson we learned was that laboratory finals must be designed with care to focus on in-lab work, since students will often have a limited amount of retention of the pre-lab material, especially if they are seeing it for the first time. After the first quarter of the new laboratory program, the average score on the one-hour laboratory final (worth 10% of the course grade) for Lab I and Lab II was about 50%. This has since improved to the neighborhood of 70%, although many students state that they simply choose not to study hard for the laboratory final since the laboratory is only worth one credit, and their laboratory grades are high enough to guarantee an A or B. We are continuing to address the testing issue, and are looking for a more representative way of evaluating the knowledge the students actually gain in the course.

III. Assessment Based On Faculty Interviews

A number of faculty members with an active role in the laboratory development and teaching process were interviewed for their observations. A common response is that they are very pleased with the students' newfound ability and willingness to integrate ideas from different courses, and there is a noticeable improvement in student writing quality. Some faculty have borne the brunt of complaints from beginning students who feel somewhat overwhelmed by the non-traditional format of the early laboratories. For the most part, though, the frequency of complaints decreases to near zero by the time students are in Lab III. The overall faculty assessment after 18 months of implementation is that this has been a very positive transition for the Department; and it has played a significant role in our increased undergraduate enrollment.

IV. Conclusions

This assessment study has shown that students quite readily accommodated to a non-traditional, multidisciplinary laboratory program. Most students in the early labs express roughly equal measures of challenge, stimulation, and frustration, but rarely do they express boredom or disinterest. Students find the later labs, involving a greater proportion of design work, to be very

exciting. This excitement spills over into their lecture classes, where they ask more questions, demand more "real-world" explanations and examples, and show improved writing ability.

References

1. J. Hung and S. Wentworth, "An Integrated Approach for Electrical Engineering Laboratories," presented at the *ASEE Frontiers in Education Conference*, Nov 98, Tempe, AZ.

THADDEUS ROPPEL

Thaddeus Roppel is an Associate Professor of Electrical Engineering at Auburn University. He teaches undergraduate courses in circuits, electronics, and solid state, and graduate courses in plasmas and microsensors. He conducts research in the areas of neural networks and chemical microsensors. He has been a member of the Electrical Engineering Department Curriculum Study Committee since 1993.

SCOTTE HODEL

A. Scottedward Hodel is an Associate Professor of Electrical Engineering at Auburn University. He teaches undergraduate courses in systems and control theory, and graduate courses in linear algebra. He conducts research in non-linear control theory applied to flight dynamics. He has been a member of the Electrical Engineering Department Curriculum Study Committee since 1993.