Students Designing, Mentoring, and Learning in a Laboratory Environment

Arnold F. Johnson

University of North Dakota

Abstract

An innovative approach for conducting laboratory courses in an electronics sequence is presented. This approach, which relies heavily on student involvement, is not only interesting, current, and meaningful to the students, but also efficient and effective from an instructional viewpoint. Students take a very proactive part in this laboratory experience, which provides them with many opportunities for leadership, design, communication, teamwork, planning, and originality. The methodology used also provides an educational depth not normally experienced in traditional laboratory assignments.

In this approach, the entire class is divided into groups of three or four students (known as lead-groups) who are each responsible for preparing two laboratory experiments during the semester. Instead of the students performing laboratory experiments that are pre-defined by the instructor, they develop their own new experiments under the instructor's guidance. The lead-group meets with the instructor to select a topic that is pertinent to the material being covered in the concurrent lecture class. A rough methodology is laid out for the lead-group students to design, test, and refine their experiment in a laboratory environment. The students prepare both prelab and lab assignments which are distributed to the remainder of the class prior to the scheduled lab session. Since the lead-group has become very familiar with the laboratory exercise, they are assigned the responsibility of administering the labs (acting as mentors) as their classmates perform the lab exercises.

Not only are the laboratory exercises current and relevant to what is being covered in the classroom, but they also provide an interesting open-ended laboratory design experience to the lead-group and an opportunity for these students to share their knowledge and experience with their peers. As active learners of technology, their communication and leadership skills are enhanced, along with their self-confidence. The author has been conducting his laboratories in this manner for the past three years, and the students respond very positively to this intensive involvement and experience.

Motivation for Change

There were a number of underlying motivational factors that provided the impetus for a structural change in the electronics laboratory sequence in the electrical engineering department at the University of North Dakota (UND):

- The current laboratory experiments had been used for a number of years and needed revision.
- A different text was being used in the sequence and experiments needed updating.

- A large number of students could be accommodated in an efficient and effective manner.
- Students could enhance their learning by mentoring one another.
- Students would be more motivated by being involved in the laboratory to a greater extent.
- Students are likely to learn more if they are forced to organize material.

Structure of the Laboratory

During the last three years at the UND, the Electronics I and Electronics II Laboratory sequence has been conducted in a rather nontraditional fashion. The entire class is broken into clusters of three or four students known as lead-groups. Each lead-group is then responsible for designing and administering a new laboratory experiment. The scheduled lead-group meets with the instructor during the week prior to the laboratory. Possible alternatives, issues, and viable options for the laboratory exercises are discussed with the students, and then they select their topic and main emphasis for the experiment. They work in the lab on their own, with minimal instructor assistance, until they formulate a suitable laboratory exercise. Students in the lead-group then prepare assignments that are used by the remainder of the class during the regular laboratory time. Lab instructions, prelab assignments, and handouts are then distributed in the lecture class several days prior to the laboratory. The remaining students in the class perform the laboratory experiments. During the following week, they write up lab reports and turn them in at the beginning of the next laboratory class. Lead-groups are also responsible for correcting lab reports and making chalkboard presentations of the prelabs and experiments. Group members report the grading results to the instructor. The cycle then starts over with a new lead-group for the next experiment.

Students Are Deeply Involved

One of the primary purposes of structuring this laboratory in this manner is to allow students to become active learners by involving them in the various aspects of the laboratory course. For each laboratory exercise, one lead-group has total responsibility. The lead-group chooses the topic, conducts the necessary experimental work, designs the laboratory experiment, works with the instructor and GTA, writes up the exercise, and mentors other students while they conduct the experiment. The lead-group may also introduce the laboratory activity to the other students during the lecture class or at the beginning of the lab period, if supplemental information is necessary. In addition, the lead-group is responsible for grading the lab. At the conclusion of the lead-groups' activities, they present their experiences during a debriefing session with the instructor. The latter activity enhances the degree to which students reflect on learning, another mechanism whereby learning becomes active via deeper cognitive processing.

Rotation of Lab Partners

Another variation in the format of this course is that lab partners are exchanged; each person has a different partner for each experiment. That is, no one has the same lab partner during the semester. Lead-groups do not include students that have been their lab partners during the semester. This offers a number of advantages. First, students get to know one another better. Second, students have an opportunity to work with a variety of partners, thus enhancing their teamwork skills. Third, there is a chance for mentoring to occur between partners. Fourth, one cannot select the same lab partner all through college and thus limit diversity opportunities.

Fifth, students play different roles and learn through this process. Finally, a dominant leader will circulate through the class sharing his/her skills and expertise.

There are also several disadvantages associated with the rotation of partners. One is that not all lab partners carry their own weight. Some students may resent this, but on the other hand, the students that traditionally do not work as hard may be forced to produce more with this format. Overall, the rotation of partners provides a balancing effect. However, a more important factor is that schedules do not always mesh for all partners to work together on their lab reports or for working together in the lead-groups.

Advantages Are Numerous

Conducting laboratories in this fashion provides numerous benefits. First of all, the experiments are current and relevant to what is being done in the concurrent lecture class. This is not always the case with other laboratories. Many times, older experiments may not be currently relevant. When laboratory exercises are constructed in this new manner they are always current with lecture material, because they are generated by the students using material covered in the lecture. Lecture material is thus reinforced by laboratory exercises. Laboratories become experimental design exercises as opposed to being cookbook affairs; thus, areas of special interest to the students get emphasized.

Lead-group students become mentors by helping, assisting, trouble shooting, and answering questions. Students obtain experience in leadership and communication skills and feel more involved in the class. Students, especially in the current lead-group, actually get involved in experimentation and in the design of experiments that enhance their creativity.

From an instructor’s standpoint there are also distinct advantages. The biggest advantage is that during the actual laboratory there is a large cadre of assistants to help the students, specifically the instructor, the GTA, and the members of the lead-group. In addition, the laboratory becomes much more exciting and relevant. Special effort to update lab exercises from one year to the next is not required, as this is a natural consequence of utilizing the lead-groups.

Disadvantages Are Few

One disadvantage is that laboratory experiments will be untested by the instructor and GTA, often requiring additional effort. There is an additional lead-in effort, making sure that the lead-groups are organized and on track. Also, one does not have a pre-packaged set of experiments available at the start of a semester. Each instructor needs to weigh these disadvantages against the many advantages of this format. Students sometimes have schedule conflicts in meeting as a group with the instructor. Students in the lead-group carry many more responsibilities on their shoulders to prepare the laboratory exercise and distribute them promptly. There is also some variability in the depth of coverage from one lead-group to the next.

Additions and Modifications

During the last three years, several changes have been incorporated in an attempt to improve the process. For instance the rotation of partners, having students do the grading, having two different lead-groups prepare separate experiments each week, and the debriefing sessions were added. I plan to have a second preparation meeting with the lead-groups prior to the lab. The basic underlying theory of the lab will be reviewed to make sure that they have a solid understanding of the material prior to formulating the lab exercise. In addition to discussing the theory, I plan to have them present an outline of the prelab and the lab.

An Improved Learning Pedagogy

With the change in the laboratory structure comes a greater and deeper involvement by the students in their learning experience. Their learning experiences are more active and collaborative because of their involvement and responsibility. They are required to synthesize experiments during the construction of the laboratory exercises. By their deep involvement in the development of the laboratories, they obtain an improved understanding of the theory. Also, the students know the areas where they need to receive the most help in understanding a concept, and thus they can mold the experiments accordingly. In addition, UND's Center for Teaching and Learning has recently been consulted to better understand the pedagogical aspects of the lab.

Student Perceptions and Comments

When students were asked in a survey if they perceived this lab as being similar to or different than other science and engineering labs, the students responded**:**

Very different	48%
Different	52%
Similar	0%
Very similar	0%

Of the fifteen activities presented in this survey, the top five areas having the greatest difference from traditional labs are reported. This was measured using a 4 point Likert scale (with 4.00 representing the highest level of difference from the traditional labs and 1.00 the least amount of difference):

Participated in the grading of other students	3.82
Taking the role of teacher as part of the lab	3.72
Amount you learned as a result of being part of the lead-team	3.66
Debriefing session after the lab	3.45
Meeting with the instructor prior to the development of lab activities	3.41

When rating the effectiveness of how the fifteen different dimensions of the lab course helped in meeting the needs of the student as a learner, the students rated the following as the top five items on a 4 point Likert scale (4 most effective, 1 least effective):

Amount you learned as a result of being part of the lead-team	3.79
Opportunity to engage in teamwork	3.45
Taking on the role of teacher as part of the lab	3.41
Currency (being up-to-date) of the lab exercises	3.34
Meeting with the instructor prior to the development of lab activities	3.31

Comments from several student surveys are listed as follows:

- "I really liked the idea of having the lead-groups that designed the lab."
- "I think having the students design the labs definitely forces the labs to be relevant to lecture material."

- "It followed the material probably closer than many of my other lecture/lab classes that I have had."
- "You learned so much more by teaching the lab. Your understanding of a subject is greatly enhanced when you have to know it well enough to teach other students.
- "It gave me more confidence."
- "The designing of the labs really helped you understand the material better."
- "I thought the best part of the course was being in the lead-group. You are able to learn the material so much better when you design the lab!"
- "I thought the way the lab was run was great."

Reflections and Conclusions

After conducting the course and experimenting with the format for six semesters, I believe that the course has proven successful. There are a number of additional enhancements and improvements that can still be made based on suggestions from recent student surveys. The students who have taken the laboratory courses under this format have reacted very positively. Students liked participating as a part of the lead-group, even though it involved a lot of work. The students really enjoyed the lead-group activities and thought it was an excellent learning experience.

This format provides more open-endedness than normal labs and furnishes additional design experience that is beneficial for the student. In addition, the labs are current, relevant, and interesting. Because of their heavy involvement, the students feel an ownership to the laboratory and their motivation for learning is enhanced. I plan to continue offering the laboratory courses in this manner, but will experiment further with the format, with the objective of strengthening the learning experience.

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References

Johnson, Arnold F.; *Laboratory Lead-Groups, an Open-ended Lab Experience with Mentoring*; Proceedings of the 58th Annual ASEE North Midwest Section Meeting, Fargo, ND; Oct. 3-5, 1996.

Biography

ARNOLD F. JOHNSON has been an Assistant Professor of Electrical Engineering at the University of North Dakota since 1988. He earned his B.S.E.E. at the University of North Dakota in 1959 and his M.S.E.E. at Iowa State University in 1962. He spent 15 years in industry. For 13 years he farmed and taught for UND in an MBA program at Grand Forks Air Force Base prior to his current position.