Organizing Effective Laboratory Work In Teams

LTC Andre H. Sayles, CPT James H. Wise
United States Military Academy

Abstract

Although the engineering design group notion sounds simple, it can be a complex process for undergraduate engineering students as well as for professors. Some of the concerns are: the basis for placing students in a particular group, evaluation of both group and individual efforts, interpretation and implementation of ABET criteria, and the effectiveness of the learning experience within the design team process. At the US Military Academy, electrical engineering students start the program with a group design experience in the introductory digital logic course taught to sophomores. They complete the program with a similar group design effort in the senior design project course. This paper is an opportunity to discuss these two experiences and measure the growth of the students' ability to interact with peers in an engineering design environment.

Introduction

Job transitions for engineers are often partially due to social incompetence [1] or an inability to stimulate and maintain effective interactions with fellow workers [2]. With the backing of the Accreditation Board for Engineering and Technology, Inc. (ABET), industrial managers are encouraging more design team experience in undergraduate engineering programs. Many engineering programs across the country are looking for better ways to prepare engineering undergraduates for group or design team experiences after graduation. A common approach is to include a one or two semester group design project at the end of the academic program. At the US Military Academy, the group design experience is being evaluated based on the first and last courses in the electrical engineering program. The first course is an introductory digital logic course taught at the sophomore level. The final course administers the senior-level capstone design project. The two courses have several similarities; however, they are also dissimilar in areas such as course objectives and levels of personal and academic maturity among the students. Prior to the 1994–95 academic year, neither course had included the team approach to engineering design. The program has generally been successful, although many improvements are planned for the future. As a whole, the students believe the experience to be a positive one and have provided several recommendations to make it even stronger. This paper includes a preliminary assessment of the two group design experiences, student recommendations, and selected post survey data.

Sophomore Design Teams

Implementing design team work in the first course in the electrical engineering program presented some interesting challenges to the instructor. Because design teams had not been used previously, there was no historical reference for implementation of current ideas. Secondly, since this is the first course that students take in the electrical engineering program, they were not familiar with other students in the classroom when the semester began. Previously, all laboratory work was on an individual basis, with laboratory availability being limited to two-hour supervised sessions.

At the beginning of the semester, the instructor decided to divide the students into randomly assigned two-person teams for each of eight laboratory exercises. Repeat partners were permitted for subsequent exercises. The design teams were given unlimited access to the laboratory equipment through the use of a keypad combination lock on the laboratory door. Each team then had to schedule a mandatory ten-minute demonstration of their working laboratory solution with their instructor. During this demonstration, the instructor conducted a question and answer session with the design team. This demonstration was a graded event that comprised forty percent (40%) of the laboratory grade for each exercise. The instructor's questions were targeted to ensure the key learning points of the exercise were understood by both members of the design team. Some questions were posed to both students while other questions were posed to an individual team member, especially those who appeared to have contributed little to the overall effort. Some of the questions were intended to make the team

0-7803-3022-6

aware of other design solution methodologies. The written laboratory report made up the other sixty percent (60%) of the exercise grade. Each team received a single grade for the demonstration and the laboratory report.

From the instructor's point of view, the experience was resoundingly positive. The purpose of instructor assigned teams was to overcome unfamiliarity between students and build camaraderie among the electrical engineering majors. Additionally, it was believed that grouping students with various skill levels and personalities would also enhance interpersonal skills as each team member learned to cope with the strengths and weaknesses of others in order to accomplish the task at hand. The team size was generally kept at two because of the limited content in each laboratory exercise. The key to the success of the program was the decision to remove the artificial time constraint by making the laboratory equipment available on a full-time basis and the notion of having the students present a mandatory, graded demonstration of their solution. Removing the time constraint allowed those students who needed or desired extra time to work until the exercise was completed to the collective standards of team members. This greatly enhanced pride and self-esteem while providing an opportunity for each group to overcome inefficiencies caused by personality or scheduling conflicts.

In previous years, students had been required to complete similar exercises on an individual basis. Many of them spent considerable time on the design exercises, but walked away from the experience dejected because they needed more time or perhaps a second perspective. The current group approach appears to improve student time management skills because they now have to determine the required time themselves and fit it in with competing requirements. So far, nearly all of the students found the time to accomplish the tasks. The graded demonstration and question session requires the instructor to devote considerable time to the students outside of the normal classroom lecture. However, the feedback from the professor is extremely important to the student and well worth the time. It is also important because the instructor very quickly determines the extent to which the objectives have been met by the students while completing their work. Many misconceptions can be corrected on the spot. The students quickly learned that they had to prepare for these sessions as their lack of understanding proved embarrassing for both team members. The quality of the demonstration and their ability to field questions improved very quickly after the first few sessions. This oral session would be very effective in other disciplines as well. It is particularly well suited for computer science work as students could demonstrate their working code. The weakness of the group process perhaps was in giving a team grade instead of individual grades. However, with the "snapshot" of individual performance being limited to ten minutes, the sense of fairness in an individual grade was elusive and therefore not assigned. The absence of an individual grade was partially offset by the requirement that concepts demonstrated in laboratory exercises be a component of normal course examinations. Students who performed poorly on the examinations were likely the same ones who contributed little to their team's effort in the laboratory exercises.

Student reaction to the team approach to laboratory design exercises was encouraging. A survey was administered to give students a chance to comment. Students were asked what the basis should be for assigning individuals to teams. The choices were to make random assignments, allow the students to pick, create teams based on course average (high paired with low), or make assignments to ensure distribution of gender/race. Fifty eight percent (58%) preferred random selection, thirty nine percent (39%) wanted to pick their own partners, three percent (3%) by average, and no student preferred team selection by race/gender.

The students' comments indicated that they liked the random assignment of partners because it was fair to all and forced them to get to know at least one other student in the program. Generally, the students who wanted to pick their own partners disliked having to align schedules in order to make time to work on the projects. Overall, the students felt that working in a team was very beneficial. The students' comments speak for themselves:

regarding basis of team assignment—

> "I met other students whom I had not known very well before."
> "Normally, at least one of the two [team members] would have a clue."
> "I disliked having to meet my partner's schedule."

regarding the oral presentation—

> "It forced both partners to be prepared and understand the material."
> "I really liked this portion because it let you shine in front of your instructor."
> "I liked it because we were able to get feedback directly which helped a great deal on the lab write up."
> "I liked briefing the project because it gave us practice at briefing material ... the questions usually made me think more about the project."

Senior Design Teams

Students in the senior design course did not have an opportunity to work in teams in the digital logic course when they were sophomores. Most of them had brief group experiences in several other courses, but not for the purpose of

engineering design. The new senior design course implemented for academic year 1994–95 covers the final semester of the electrical engineering program. Lecture material in the 47 lesson design course is limited to topics related to design methodology and professional practice. Material covered in the course is reinforced by guest lecturers in the co-requisite seminar course, with both courses being supervised by the same faculty member. All grades in the combined courses are derived from milestone requirements related to the design project. Available projects were identified and advertised during the previous semester; however, design teams were not formed until the beginning of the final semester. In the future, team and project assignments will be completed in the semester prior to the project semester.

Team assignments were based on a combination of student preferences for team members, student preferences for projects, and instructor selections. The target group size for each of the eight design teams was four electrical engineering majors plus students from other disciplines as needed. Students were asked to provide three prioritized project choices from the list provided at the end of the previous semester. They were also permitted to nominate up to two other students for their design team for each project selected. Thus, students were given an opportunity to suggest team members but under the two person constraint could not put together a complete team during the sign-up process. Many of the students did not list the same team members for all three project choices, which was perhaps an indication that they were taking skills and background into consideration instead of choosing partners based on outside relationships. Upon completion of the sign-up process, all available information was used to select a team leader for each project and make an initial assignment of one or two additional team members. All but one team leader volunteered for that additional responsibility. It appeared that the students had discussed team leadership before the sign-up process began. The most difficult part of the assignment process was to complete the design teams with the pool of unassigned students based on a variety of considerations such as past academic performance, individual skills, choice of project, team leader personality, and advisor opinion or preference. Ultimately, the eight teams were established by the instructor with sizes ranging from three to six students, including members from other disciplines.

Project grades were assigned based on individual and group performance throughout the semester. Approximately 35% of the student grade was based on assessment of individual performance. Assessment tools included five peer ratings, five individual reports, and a discretionary grade from the primary advisor. Early in the semester, students typically divided the peer rating points equally among all team members. However, by the second rating cycle, which covered the second three weeks of the semester, students were beginning to place actual contributions to the project above friendships or the peer pressure to rate everyone the same. Peer ratings were submitted confidentially via electronic mail. An individual technical report was required at the same time as each peer rating. In this report, students were required to describe their individual contributions to the project in several different categories and report the total time spent making that contribution. The remaining 65% of the overall grade was a measure of team performance based on written and oral proposals, two in-progress reviews, a critical design review, a hardware demonstration, final oral and written reports, and the advisor discretionary evaluation. Theoretically, the system allows grades within a single design team to range all the way from A through F, but the differential is not likely to exceed two full letter grades.

Assessment of design team performance and group dynamics will be an ongoing process throughout the next academic year. Some groups have worked exceptionally well, to include the integration of management and computer science majors. However, in one group a disproportionate amount of work was done by the group leader. He finally reached the point where he was willing to sacrifice his own grade for the sake of group productivity and, in an effort to get his peers to carry their share of the load, required them to put together the hardware demonstration and accompanying oral presentation without his help. Another group appeared to work well together, but after two-thirds of the semester had passed, they were reporting their fourth proposed solution to the engineering problem. They spent most of the early part of the semester looking for an existing solution instead of working through the engineering design process. The other seven groups had settled on a design concept by the third week of the course. In addition to group dynamics, other aspects of the team design concept are being studied. Topics of interest include the grading process, correlation between peer ratings and individual technical reports, procedures for assigning team members, and the extent to which computer science, physics, engineering management, and other majors have been successfully integrated into the teams.

Conclusion

This paper describes two examples of implementation of the engineering design team concept at the undergraduate level. Both implementations are new to the electrical engineering program and will be the subject of extensive study in the future. Ultimately, some comparisons between the sophomore level groups and the senior level groups will be made and appropriate conclusions drawn. The same pro-

fessors will supervise the subject courses for at least one more year to ensure continuity.

References

[1] Martin, J. Campbell, *The Successful Engineer: Personal and Professional Skills—A Sourcebook*, McGraw-Hill, 1993.

[2] McGinnis, A.L., *The Friendship Factor*, Augsburg, 1979.