AC 2007-857: IMPROVING LEADERSHIP AND COMMUNICATION SKILLS USING DEPARTMENT-CONSISTENT LABORATORY TEAM EXPERIENCE

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Improving Leadership and Communication Skills Using Department-Consistent Laboratory Team Experience

Abstract

The Department of Civil and Environmental Engineering at the University of Utah has implemented a coordinated team approach into the laboratory components of the required undergraduate Soil Mechanics, Hydraulics, and Materials courses to deliver team building experiences, develop accountability and leadership opportunities, and enhance written communication. The evolution of the approach required the initial cooperation and continued interaction of three faculty members. Preliminary assessment included comparison of pre- and post-implementation student laboratory reports, exit interviews, and post-semester surveys. Report comparison documented greater organization of technical content and fewer writing errors in reports produced after the approach was implemented. Student comments at exit interviews indicated the consistent report format guidelines enabled them to focus more effort on technical content and spend less time with tedious format requirements. The majority of students interviewed felt the report guidance and team leader activities were instrumental in their improved report writing and understanding of technical concepts. A majority (75% or more) of students responding to the post-semester surveys felt the team leadership activities made them more capable to delegate tasks, more confident in working with others, and more experienced managing team conflicts.

Introduction

"In today's global economy, technical competency is not enough; communication, project management, and leadership skills are becoming more important than ever"[1]. Not only would most engineering educators agree with this quote, but evidence points to strong student desire to learn communications, leadership, and management skills in addition to the technical competency they develop during their undergraduate education[2]. Because most undergraduate civil engineering curricula were developed with little consideration for incorporating communication, management, and leadership, addressing the emerging need has been accomplished with new courses[3,4], special programs[5], and creative teaching tactics. Many civil engineering departments do not have the luxury to introduce required courses into the curriculum; consequently, the importance of developing and implementing new teaching methods and educational activities into existing courses to address communications, teaming, management, and leadership is paramount[6]. Recent ideas include the use of role playing[7] and the enhancement of team design experiences[8]. In this paper we present the approach developed at the Department of Civil and Environmental Engineering at the University of Utah to introduce teaming and leadership activities into the laboratory components of the required undergraduate Soil Mechanics, Hydraulics, and Materials courses. Below we describe the approach, explain the faculty interaction required to implement the approach, and summarize preliminary assessment results.

Coordinated Laboratory Team Approach

Prior to the 2005-06 academic year the three faculty members responsible for the Hydraulics (Professor Burian), Materials (Professor Romero), and Soil Mechanics (Professor Bartlett) courses had different laboratory report formats and team member interaction requirements. Each in their own way was focused on addressing the ABET multi-disciplinary team requirements. However, lack of administrative coordination caused confusion as students dealt with differing format and group interaction requirements. Significant student time and effort was expended simply resolving format and reporting issues and less time was dedicated to fostering team building and leadership. It became clear that we needed to develop a closer working relationship to coordinate our efforts and provide a consistent, reinforcing laboratory experience for enrolled students. From the outset the objectives of our coordination were to:

- Optimize the use of laboratory facilities during a time of rapid departmental growth.
- Enhance students' data analysis abilities and reinforce technical concepts by reducing time spent learning course-specific laboratory formatting and procedural requirements.
- Improve the quality of technical writing and report organization by using team leader oversight, team participation and accountability, peer review, and direct instructor-to-student feedback.
- Develop interpersonal and leadership skills through team laboratory experience, resolving conflicts and barriers and exercising leadership.

The approach developed for implementation in the 2005-06 academic year included (1) the use of a department-consistent laboratory report format, (2) the introduction of additional teacher-student discussions on communications and leadership, and (3) the use of a designated team leader position to provide instructional and application opportunities. Introduction of the laboratory format and teaming procedures are done at the beginning of each course. Because the requirements are the same for all three courses, ideally this introduction could be done only in one course and not repeated; however many students in our program are out-of-sequence in their curriculum path and do not all take the same course first. Therefore, the introduction of the report format and teaming and leadership requirements is included in all three courses, with repetition serving to reinforce the concepts from semester to semester.

Laboratory Report Format

The laboratory report format evolved from the format requirements developed by Professor Romero for the Materials course. We took those requirements and modified them to accommodate the three courses. In the current format guidelines, the reports must contain the following: cover page, executive summary, purpose, procedures, results, discussion, and conclusions. A 3-page guidance document is provided to the students that explains each section. A template report with more details and examples accompanies the guidance document. These two documents are introduced in all labs and explained during the first lab session. The guidance document and the report template are also provided on the department web page (www.civil.utah.edu).

Although we have a consistent report format, each course has instructor-specific elements. For example in the Hydraulics Laboratory, a memo is required instead of a cover page to gain insight into team dynamics. Team leaders are required to compose a professional memo to accompany the report containing brief statements regarding the following:

- *Activity Report:* listing of tasks performed by each team member and his or her assessment of the quality of that task (including their own activities)
- *Time Report:* listing of time spent on experiment and report tasks (including their own)
- *Timing Report:* timelines of assigned deadlines and actual completion of tasks
- *Grading Report:* A summary table of ratings for each team member (not including team leader) in a defined set of grading categories

This information is used by the instructor to grade the team leader and to assess team dynamics (and to decide if intervention is necessary to resolve conflict, etc.). Feedback is provided to the team as necessary, especially in cases when conflicts are degrading the team productivity. Not only do the memos serve to inform the instructor, but they also reinforce time management, organization, and peer review concepts discussed in the laboratory session. Although the memo approach is not used in the Materials and Soil Mechanics courses, a grading sheet is used that collects similar information. The grading sheet is completed by the team leader and is used to assess each team member's participation. Used in this fashion, the grading sheet reinforces the responsibility that the team leader has in encouraging and overseeing participation.

Teaming and Leadership Exercises

As we worked to introduce a common laboratory format, we discussed the methods we each used to implement teaming and leadership activities. This led us to exchange ideas and implement a more coordinated team leader approach to the laboratory teams. At the beginning of the semester, a primer on team dynamics and leadership is provided to the students in a compilation of excerpts and summary of important points from team-building and leadership texts[9,10,11]. The primer defines a team, list advantages and disadvantages of working in a team, describes characteristics of an effective team, defines leadership, and discusses conflict types and conflict resolution. Additional short reading assignments are given at the beginning of selected lab sessions (about every other session in the Hydraulics course) to supplement the general overview of teaming and leadership with focused excerpts from texts and brief papers presenting qualities of effective leaders[12,13], stressing the importance of leadership and communications in the civil engineering profession[6,14,15], and describing the importance of civil engineers taking leadership positions in industry and government[16]. These "leadership" laboratory periods begin with students reading the assigned paper or excerpt. The instructor or teaching assistant then leads a short discussion, case study review, or role play to reinforce the concept. For discussion we invite teams to describe how their teams or leaders may be displaying attributes exemplified in the reading. For case studies we pull from our past experiences working in consulting practice or with research colleagues in academia. For role play we invite teams to offer problems or issues they may be experiencing. By creating a friendly atmosphere we often can get teams to offer relatively minor team conflicts (e.g., meeting conflicts due to work schedules, leader doing too much of the work, leader not taking responsibility) for role play reenactment. This has proven to be a fun exercise to bring potential conflicts to the forefront and to address them through

instructor-teaching assistant-student interaction. The entire activity requires approximately 15 minutes and the students then move directly into the technical laboratory activity.

A team leader can be selected by the team members, by the teaching assistant, or by the supervising professor. However, it is important that the team leader designation rotate frequently during the semester so that all team members have an equal opportunity to lead the group. Additional team leader information is provided to all class members in the form of a handout containing excerpts from standard leadership texts[11,17]. The team leader is responsible for the following activities:

- Managing the experiment by assigning duties for each team member and insuring all procedures are followed correctly.
- Assigning data analysis tasks and insuring they are performed correctly.
- Leading the discussions compiled in the report.
- Formulating and overseeing the writing of experimental conclusions and executive summary.
- Keeping the experiment and report preparation on time.
- Grading team member contributions. Ratings are known by the team members and instructions are given on how to deal with conflict, if it arises.
- Writing a professional memo or preparing a standard grading sheet to summarize team activities and effort.

The team leader is given a refresher on the attributes of a leader periodically by the instructor or teaching assistant and is then assigned full responsibility for the laboratory including directing preparations for the experiment (Fig. 1), designating experiment duties, and guiding the report through completion. The team leader rates the team members and the team members rate the team leader in specified categories. The team leader is also graded by the instructor based on the information contained in the memo or summary grade sheet (reflecting organization, efficient use of resources, leading by example) and quality of the laboratory report. Introspective team discussions are encouraged to self-analyze team dynamics and develop plan to improve.

In Hydraulics, the report format, team dynamics, and team leader issues are reinforced in a face-to-face session between the instructor and each student team after two reports have been graded. In these sessions the instructor reviews the first two reports and discusses areas of improvement in format, writing, technical methods, graphics and tables. In addition, characteristics of effective teams and team leaders are reviewed and compared with what is occurring in each team. Team interaction problems are identified and discussed. In Materials this is done during the down time in the lab while other groups are physically operating the equipment. In Soil Mechanics feedback and issues regarding formatting and team dynamics are discussed and resolved by the Teaching Assistant. The professor works with the TA weekly to aid his or her development of teaching methods and facilitation of team experiences. The professor does become involved directly with teams when issues affect the whole laboratory exercise or its administration.

Figure 1. Hydraulics lab team conducting an open channel flow experiment. Team leader (standing) is guiding the team members to perform experimental tasks while he records data and checks off procedures.

Assessment

We are continuing to assess the effectiveness of the consistent laboratory report format and teaming and leadership instruction. To date our assessment has included comparison of pre- and post-implementation reports, instructor-student meetings and exit interviews, and post-semester surveys. Each semester we modify the teaming and leadership content and change the delivery approach in an effort to revise the laboratory team experience in response to student feedback and our own self assessment. Our assessment also continues to change. The summary below mostly reflects the assessment of the Hydraulics course, additional assessment from the spring 2007 Materials and Soil Mechanics courses will be reported at the conference.

Report Comparison

In Hydraulics, comparison of the reports for the first lab submitted in fall 2004 and fall 2005 semesters provided an opportunity for pre- and post-implementation assessment. The report grade (on a scale of 10) is based on participation (1 pt.), appearance (1 pt.), format and organization (1 pt.), writing quality (1 pt.), results presentation (3 pts.), clarity and pertinence of discussion and conclusions (3 pts.). The format score increased (from 0.8 to 0.95) as expected because clear format guidance was provided and some students had been introduced to the format in the previous course. Student comments in interviews and on the post-semester survey supported this conclusion (see below). Interestingly, the writing score had the greatest magnitude of improvement (from 0.7 to 0.9). After considering student comments in the interviews and post-semester surveys we concluded the reason to be the team leader oversight. In general students indicated laboratory reports were previously compiled by combining separate sections

generated by team members without an overall integration and final proofread. Imparting responsibility for report cohesiveness and final proofread on the team leader as part of his or her grade is the probable cause of the improved integration and writing quality.

Instructor-Student Team Meetings

In Hydraulics, an approximately 15 minute meeting occurs during the laboratory session between the instructor and team after the second report has been graded and returned to the team. The purposes of these meetings are to (1) explain and discuss report grading and written comments, (2) discuss team dynamics and leader duties, and (3) solicit feedback on the report format requirements and teaming and leadership activities for assessment. Student feedback regarding the department-consistent report format has been both positive and negative. One important general comment from the students is the feeling that the requirements are too strict and do not allow flexibility and stifle creativity. Unfortunately, this is accurate for some of the teams that have the capacity to effectively organize a report and present their results using their own approach. However, some teams do not have this skill and the required format gives them a model to follow. This is a difficult trade-off, but we feel it is more important at the junior level to provide relatively detailed formatting requirements to aid the students without report writing ability. This also fosters consistency in report grading by the Teaching Assistants and instructors. Another important general comment from the Hydraulics students was from those that had the Materials and/or Soil Mechanics courses before taking the Hydraulics course. They overwhelming agreed the exposure to the format guidelines in a previous course made the report writing easier in the subsequent course by enabling them to focus on results, discussion, and conclusions.

The instructor-team meetings in Hydraulics also have the purpose of reinforcing the importance of report writing. It is interesting to see the improvement from the second to the third report after having their format, writing, and organizational issues discussed face-to-face. The overall report score decreases because of a more challenging laboratory topic and data analysis requirements, but the number of writing mistakes reduces (score increased from 0.76 to 0.83 in fall 2006 semester) and the format and organization are also improved (score increased from 0.82 to nearly 1.0 in fall 2006 semester). This is very interesting because the same comments and issues are identified and stressed in the grading of the first report, except the feedback is provided as written comments to the students. The face-to-face interaction and discussion has a greater effect than the written comments.

Surveys

In Hydraulics, a survey was given to the class after the final lab report was submitted (near the end of the semester). The survey was designed to assess how the student felt the team leader aspect of the class aided development of several teaming and leadership skills in themselves. Table 1 lists several of the questions and summarizes the responses. The majority of students found the activities to aid their development. Specifically, students felt strongly they could delegate tasks to peers and work with others. Moreover, they gained an appreciation of time required to complete technical tasks. Interestingly, we felt instituting the team leader into the courses would increase the frequency of team meetings and lead to greater interaction. Student

responses to question 4 suggest that they did not meet more often. However, considering the team dynamic information provided in the memo and from responses in the informal exit interviews the fewer meetings were characterized as productive and organized because of the team leader. Further, students identified the use of more communication by email and wireless phones, especially between team leader and individual team members. Therefore, this led us to conclude question 4 on the survey to be misstated because it implies face-to-face meetings.

Table 1. Post-semester survey questions and responses from fall 2006 Hydraulics course (59 completed survey forms).

Question	Yes	No
1. Do you feel more capable of delegating tasks to your peers?	53	6
2. Do you feel more confident working with others?	54	5
3. Do you have a better understanding of the time it takes to complete tasks?	54	5
4. Do you feel you met more as a team because of the team leader?	19	40
5. Do you feel higher quality reports were produced because of the team leader involvement?	37	22
6. Do you feel your leadership ability has improved?	44	15
7. Do you feel you have better understanding of conflicts that may occur in teams?	53	6

Faculty Interaction

One critical aspect to the success of the department-wide laboratory coordination is the interaction of the three faculty members responsible for the courses. Prior to our coordination we had our own methods for selecting teams, our own report format requirements, and only Professor Bartlett was using the rotating team leader concept, except the internal grading was secret. Professor Romero borrowed the concept from Professor Bartlett and put his own spin on it by making the internal grading open, trying to instill a professional world model along the lines of "The Apprentice" television show. The first coordinated effort of the three faculty members followed a CE Department discussion and establishment of consistent homework format guidelines and expectations. Professors Romero and Bartlett coordinated a report format requirement for the Soil Mechanics and Materials courses for the 2004-05 academic year. Following their coordination Professor Burian became involved prior to the fall 2005 offering of Hydraulics. We have had a coordinated report format in the three courses since the fall 2005 semester and we continue to make adjustment before the start of each semester.

During the summer of 2005 as the report format requirements were being finalized, the discussion of the team leader concept evolved. Professors Bartlett and Romero implemented the team leader concept in the 2004-05 academic year and they had discussed the successes and failures they had experienced. While discussing the report format requirements with Professor Burian the concept of the team leader was raised and a formal coordination was established for the 2005-2006 academic year.

Successful development and implementation of this cross-department initiative required instructor flexibility, openness, and compromise. Continued success requires an organized interaction to revise and maintain laboratory report format guidelines and learn from and improve teaming exercises and leadership activities. Our current interaction includes one formal

meeting each summer, exchange of ideas at the end of each semester, and numerous informal discussions throughout the academic year.

Summary

In this paper we presented the development and current state of our approach to providing a consistent laboratory experience in the Department of Civil and Environmental Engineering at the University of Utah. Through initially unplanned faculty interaction and coordination the three required laboratory courses in the department were modified to implement consistent report format requirements, a team leader concept, and team leadership and accountability opportunities. The effort has increased collegial interaction among the three faculty members and has evolved into a coordinated, planned activity. We have preliminary data assessing our effort indicating students are generally pleased with the coordination and benefit through increased technical focus on the reports, more confidence being a leader, improved writing, and a more professional experience. However further and more detailed assessment is required and will be conducted in future semesters (additional insight from assessment in the spring 2007 semester will be reported at the conference). Given our success from informal coordination we have acted recently to formalize our interaction by meeting once per year, writing this paper, and developing a more open interaction regarding our teaching methods. We hope our interaction will continue to benefit the students and develop into an effective model that can be adopted at other universities facing similar challenges of building stronger cooperation among faculty members and incorporating teaming and leadership opportunities into the undergraduate curriculum.

We are planning to expand our three-course coordination to a fourth course, the technical writing requirement offered in our department, and increase our coordination with the Center for Engineering Leadership (CLEAR) at the University of Utah (www.coe.utah.edu/clear/). We aim to provide the students a comprehensive report format that is flexible to encompass a range of report writing requirements in the professional world. Therefore, students can develop a firm understanding of report writing and apply that knowledge at the early stages of their careers. Having the report format requirements described in a technical writing course will strengthen our message and permit greater depth of the report elements to be discussed in the context of writing. We also continue to identify problems with using teams and team leaders in undergraduate courses. After identification we discuss at first through email and then in meetings ideas for solutions. Our recent consideration has been the encouragement of equitable participation, especially in out-of-class activities. In class, the TA or instructor is there to see that all are participating; but out-of-class issues in the past have shown that some groups become dysfunctional as tension develops or due to schedule conflicts. We have resolved some of these in the past by talking with those concerned and mediating the issues. We have also tried to allow team members the capability of giving poor participation grades; but this is negative reinforcement. We have decided to test the use of a formal list of expectations for team members and a commitment from the students to meet those expectations.

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