

ESTABLISHING EFFECTIVE MULTI-UNIVERSITY STUDENT TEAMS FOR ADDRESSING INTERDISCIPLINARY DESIGN PROJECTS

*Marvin W. Dixon, P.E.
Alumni Distinguished Professor of Mechanical Engineering
Clemson University*

INTRODUCTION

Universities have the task of educating student engineers such that they can provide effective and responsible solutions, both as an individual and as a member of a team, to human-social-environmental needs. For years capstone design courses have been used in single engineering disciplines and at single universities to foster the understanding of the design process and teamwork. The Department of Mechanical Engineering at Clemson University has had such an industrially sponsored capstone design course since 1970. During this time at Clemson, over 2500 mechanical engineering students have addressed more than 180 industrial projects proffered by 76 different industries and agencies.

However, more is required to prepare engineering students to interact in teams with members of different backgrounds and to meet the challenges that they will encounter in their careers. Universities and industry must work together to identify and eliminate those barriers to effective teaming and communication. This paper addresses a modification of the aforementioned capstone design activity to include multi-university student teams addressing interdisciplinary problems.

Since August 1994 some mechanical engineering students in the capstone design class at Clemson have teamed with students from other universities and other disciplines to address interdisciplinary projects. To date a total of 61 multi-university, interdisciplinary student teams have addressed twenty-one different problems sponsored by Westinghouse. During the school years 1994-96, students and faculty in chemical and mechanical engineering at Clemson University and the University of South Carolina, and students and faculty in mechanical engineering technology at South Carolina State University participated in collaborative design efforts addressing environmental restoration and waste management needs of the Westinghouse Savannah River Company. Mechanical and nuclear engineering students and faculty from Georgia Tech were also included in the project during the school years of 1996-1998. This project has received the major portion of its funding from the South Carolina University Research and Education Foundation (SCUREF) with additional support coming from the Southeastern University and College Coalition for Engineering Education (SUCCEED) and from Westinghouse.

OBJECTIVE

The specific objective of this program is to establish effective procedures for addressing interdisciplinary design problems with multi-university student teams. Even though this need has been discussed in various engineering educational groups, there are no other formal efforts known that address this need. Therefore this effort serves as a model to illustrate how interdisciplinary, multi-university teaming may be accomplished and has been the subject of three newspaper articles, an article in the Westinghouse newsletter, four conference presentations, an article in an university alumni journal, and was discussed in an article in the July 1996 issue of Mechanical Engineering. The specific goals of this program are to identify and implement techniques which:

- (1) prepare the student to function in interdisciplinary design groups composed of members with diverse thinking styles [Teaming],
- (2) enhance effective communication using conventional methods and modern technology (Computer Conferencing, Video

Conferencing, Phone Conferencing, Web Pages, FAX, E-Mail, etc.) [Communication], and

(3) eliminate boundaries that prevent students from integrating course material and its application into real projects from engineering and engineering technology [Innovative Design]. The first two of the stated objectives were identified as the two most important elements that an emerging engineer needs to know in the NSF sponsored - American Society of Mechanical Engineers report, "Integrating the Product Realization Process into the Undergraduate Curriculum."

METHODOLOGY

In coordination with the faculty involved, personnel with the Westinghouse Savannah River Company established broad statements of need for several of their specific problems, which address issues of environmental restoration and waste management. The faculty from the various universities then selected those problems, which could be addressed most effectively by student teams in the allocated time. At the beginning of the semester the students from the universities were divided into multi-university, interdisciplinary teams. These students and their faculty advisors then traveled to the Westinghouse Savannah River Site where the student teams were assembled and the problems were presented by Westinghouse personnel. After the presentation of the problems, the student teams selected team leaders, developed specific objective statements for their problem, confirmed with their Westinghouse liaison that their objective was appropriate, developed time-task charts, assigned specific tasks to team members, and selected times for their scheduled electronic communications during the remainder of the semester. The student team members then returned to their universities where each student addressed their team's problem.

The faculty, representing the involved disciplines at each university, participated in this program to facilitate the work done by the students. Also these faculty insured that the electronic communication systems were accessible for the students and served as technical resources for the students.

Each week, each member of the student teams conferenced with their team members in an hour-long telephone conference and in an hour-long computer conference using ISDN lines. In addition twice each semester all teams had one-half hour television conferences. Each team practiced for their final oral presentation to Westinghouse personnel by using two-way television conferencing. The students transferred files, auto-cad drawing, etc. from one university to another using computer conferencing , e-mail, and fax.

At the end of the semester, the students traveled back to the Westinghouse SRS site where solutions for their problem were presented by each team in both written and oral format with appropriate proof-of-concept models. The solutions and reports were judged by Westinghouse and the faculty members. After the presentation of the final report, the students were asked to submit a written critique of the techniques and communication procedures used in addressing their problem, to offer suggestions as to how their experience could have been improved, and to evaluate the contributions of each team member.

There was some concern by the faculty at the beginning of this project in 1994 that communication problems and other difficulties might make achieving the objectives of this project difficult if not impossible. Therefore during the Summer of 1994 one faculty each from Clemson, South Carolina State, and the University of South Carolina met with employees of Westinghouse Savannah River Company and selected only three problems for use in the Fall of 1994. At this time these faculty also established procedures for student interaction and selected communications links and procedures to be used between the three universities. Each of the three problems selected was addressed by one team composed of five students and one faculty member from each university. Hence only fifteen students and three faculty were involved during the first semester of this project. During this first semester the faculty, in addition to addressing the objective listed above and developing a solution for the problem, sought to identify and eliminate difficulties associated with the operating procedure and the communication links used by the students.

The program grew under constant evaluation and modification by the faculty such that by the beginning of the Fall 1996 semester six faculty and 155 students had been involved in the program. During the Spring 1996 two faculty from Georgia Tech. (one in mechanical engineering and one in nuclear engineering) expressed an interest in working on this project with the faculty and students from the South Carolina universities.

The two Georgia Tech. faculty observed the project during the Fall 1996, and these faculty and their students became actively involved in the project in the Spring 1997. The project continues during the Fall 1997 with eight teams of students, but Georgia Tech is not involved because of the scheduling difference between Georgia Tech's quarter system and the semester schedule of the other schools. However Georgia Tech will be involved in this program with the other universities during the Spring 1998.

DISCUSSION

A total of eight faculty at four different universities and in four different academic disciplines have participated in this project. A total of 298 students have worked on teams which have addressed twenty-one different projects of environmental restoration and waste management.

Westinghouse, the students and the faculty all feel that they have benefited from the program. A typical student comment is "My experience with the Westinghouse Senior Project has been extremely beneficial to me in gaining a complete education. I can clearly see the relevance of an innovative team of different engineering disciplines working together on a project that has many different parameters." A professor involved in the project stated, " I think that the program was extremely beneficial for the students. The projects showed the students how they can work with other disciplines to get things done. Also the students had their confidence boosted by seeing students from other schools and seeing that they can hold their own." In a letter to the author of this paper, the manager of the process chemistry and control section at the Westinghouse Savannah River Company stated, " During this time we have realized benefits from the student designs in several areas. Last semester their contributions to the Counter Current Decantation project for sludge processing and the designs for the remote placement of the canister weld plug were particularly helpful.

It appears that the senior projects program is very beneficial to the students. If you agree and would like to continue the program next fall, we would welcome the opportunity to work with you again."

LESSONS LEARNED

This project has been highly successful and has been the subject of much interest and discussion. It has grown from the involvement of three universities in South Carolina to regional involvement. An additional year of funding (1997-1998) has been provided by SCUREF, SUCCEED, and Westinghouse which will allow the effort to grow: (1) to include students and faculty in additional disciplines, (2) to develop a more mature understanding of the interdisciplinary design process implemented across great geographic distances, and (3) to assist Westinghouse and additional industries in obtaining workable solutions for some of their real problems.

To insure the quality and consistency of the student's reports and work, a document was written and distributed to the students which defined what should be contained in the team's interim written report, the individual final written report, the team's final written report, the log book, etc. This document helped insure that the quality assurance goals were met, and that the students operated in a professional manner. Also the students were provided written information on and discussed issues of teaming (how teams should work, problems typically encountered, etc.).

In the Spring 1996 Westinghouse limited the number of teams per problem to four. Even though the number of viable

solutions increased as the number of teams increased, it seemed that the optimum number of teams with which a Westinghouse liaison could effectively interact reached an effective limit at about four teams. Hence from the Spring 1996 the maximum number of teams per problem was limited to four. Also it appeared at the beginning of this project that Westinghouse was involved to foster public relations and to assist the education objectives of the university. However, when they became aware of the quality of the work done by the students, Westinghouse saw this project as a source of technical assistance. Even though only four problems can be addressed during a semester, the number of problems which were submitted to the faculty for the students to address has grown from 4 during the Fall 1994 semester to 13 for the Fall 1997. Now in addition to their original two, Westinghouse has another objective in participating in this project. This is to have their problems solved.

It was observed that the multi-university teams tended to make uniform and consistent progress toward a solution whereas the single university teams did not. Upon checking it was found that members of multi-university teams seldom allowed other activities to take priority over their conference meeting. When a computer conference or phone conference was scheduled, they were there with their assigned tasks completed. However single university teams did not always meet at their scheduled times and on occasion meetings were called off so that members could attend social activities.

Technology such as video conferencing, phone conferencing, and electronic mail can be difficult to use when crossing institutional boundaries. These difficulties are a result of differences in systems at the various institutions or some institutions not having some capabilities at all. However with institutional support these problems can be overcome.

CLOSURE

This project is meeting its objective of developing the student' skills in teaming, communication, and integrating the application of hard engineering science with safe, ethical and innovative design. Procedures have been established which will lead to achieving greater success in meeting this objective. These procedures will be implemented in the extension of this project. The enthusiastic response to this project by all who hear of it encourages the project faculty to believe that they are at the leading edge in developing techniques for teaching tomorrow's engineers.

The faculty involved in this project in addition to the author are listed below:

Said I. Abdel-Khalik Professor of Mech. & Nuclear Engr. Georgia Institute of Technology
Charles Barron Prof. of Chemical Engineering Clemson University
Francis Galada-Maria Assoc. Prof. of Chemical Engr. University of South Carolina
Stanley Ihekweazu Assoc. Prof. of Mechanical Engr. Tech. South Carolina State University
Sheldon Jeter Assoc. Prof. of Mech. Engr. Georgia Institute of Technology
Jamil A. Khan Assoc. Prof. of Mechanical Engr University of South Carolina
Steve McNeill Assoc. Prof. of Mechanical Engr University of South Carolina

The person responsible for coordinating this project at Westinghouse is:

Chris Randall
Manager, Process Chemistry & Control Group
Westinghouse Savannah River Company