Experiences with Interdisciplinary Based Design Teams

Morris H. Morgan, III, Department of Chemical Engineering
Christopher Washington, Department of Electrical Engineering
Bradford Grant, Department of Architecture

The School of Engineering and Technology
Hampton University
Hampton, Virginia 23668

Abstract - *Within most academic settings design courses are taught in isolation. Typically each separate academic unit or department teaches its own version of design that is for the most part very narrow in scope and presentation. Such approaches overlook the interdisciplinary character of the design process and are not representative of the type of design experiences students will encounter in industry. In the latter setting a team will generally consist of individuals with very diverse backgrounds and experiences. The purpose of such an arrangement is to make the design process as inclusive as possible. In this paper, we describe the development of an interdisciplinary-based design approach that addresses the above concern.*

Introduction

In 1982, Hampton University started its engineering program in response to both local and national needs for more trained engineers. Hampton's entry into this academic area made it one of only a few Historically Black Colleges and Universities (HBCU's) that offer such degree programs. Hampton's engineering program began with two degree offerings (chemical and electrical). Since that inception, the engineering program has grown both in student enrollment and stature.

In 1995, the present School of Engineering and Technology (SE&T) was forged. It consisted of the two original engineering degree granting programs and two existing technology programs (aviation science and architecture) that were previously under the direction of the School of Pure and Applied Sciences. After a decade of sustained growth, under the old organizational structure these programs were primed for expansion and restructuring. At that time market surveys and feedback from our admission's office had indicated that the typical student demographic mix that we serve would be most attracted to a mechanical engineering degree option. In fact, the recently devised two-year core curriculum within the SE&T has been formulated with this long-term strategic interest in mind. With this strategic focus as a backdrop and a "core" group of faculty interest in adding realism to the undergraduate engineering experience, the concept of Interdisciplinary Based Design Teams was born. What we summarize in the subsequent discussion are our efforts toward integrating this concept around three courses currently offered within the SE&T.

The Course Philosophy

In the present context, we describe our efforts to develop an "analogous industrial design experience" for the students within the School of Engineering and Technology at Hampton University. In this case study/hands-on approach, students from three separate engineering and technology courses were grouped into design teams. They were charged with the task of developing a scaled prototype, evaluating the economic viability of their design and modeling the system control aspect of the heating and cooling characteristics of their proposed concept [1-3].

Specifically, the students in this restructured course were assigned with the task of designing a new structure for a newly envisioned mechanical engineering program. The resulting unit would be an add-on to the existing structure. Students from three courses were split into heterogeneous groups. Each group developed its own design concept, built a scaled model of its structure and displayed their work at mid-semester which happens to coincide with the National Engineers Week (1998). Instructors who taught this course were drawn from the architecture, chemical, and electrical engineering departments within the SE&T. Students enrolled in the course, "Environmental Systems II", served as technical building consultants to the various lead engineering economics teams and aided in developing initial design concepts (see Figure 1). Groups from the electrical engineering course, "Control Systems", formulated controller designs for the heating and cooling systems and planned electrical cable layouts. At the end of the term, final designs were displayed in the lobby of the engineering building and critiqued by a select group of faculty.

The engineering economics course (EGR 315) which is the main focus of revision here has traditionally been delivered to its student constituency via the standard lecture mode format. This involved two formal lectures per week (75 minutes in duration) for a full academic semester. A series of quizzes (4) would normally be given during the semester followed by an end of the term final examination. The intent of this course is to expose junior level electrical engineering majors to basic principles of economic analysis and to provide them some insight into the managerial decision making process. In an attempt to broaden the student's educational experience, we (a "core" group of renegade faculty) decided to restructure the current course and deliver it in a more interactive fashion. What resulted from this restructuring is a new course packaging that we believe disseminates the material in a more engaging manner and is more representative of the type of experiences young engineers will encounter in industry [4-6].

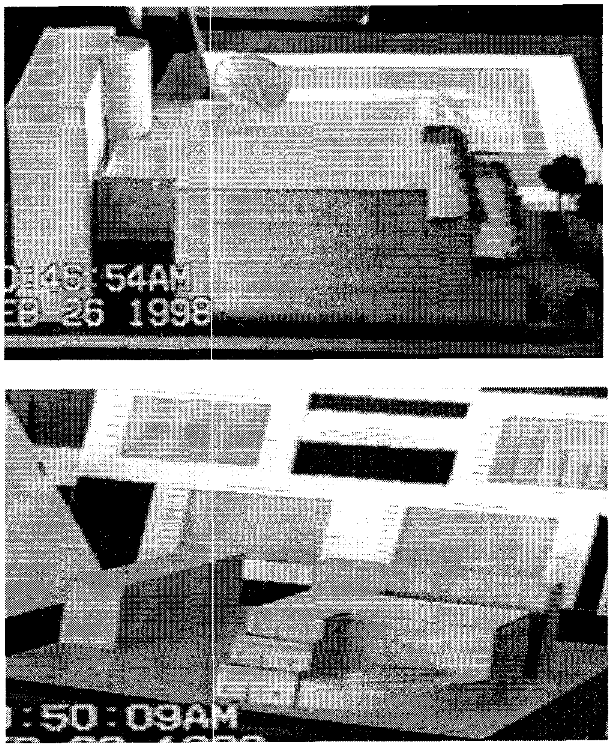

Figure 1. Two envisioned add-on designs.

Course(s) Structure and Dynamics

Within each course, students were charged with the task of devising a rationale for team or group member selection. Group size was limited to between three and five students and only four groups were allowed per class. The lead groups from the engineering economics course were responsible for identifying their affiliate consulting teams (2), coordinating inter-group meetings with individual consulting teams, monitoring overall programmatic progress and providing timely reports (memos) to upper management (EGR-faculty). The type of group dynamics fostered by the interdisciplinary-based design concept is summarized in Figure 2. The histogram shown in Figure 3 indicates how the level of individual group participation varied throughout different phases of the overall design process.

This activity also posed several problems for the faculty involved:

- The scope of the project had to be targeted for junior/senior level engineering and architecture students.
- The project scope had to be broad enough to hold the interest of a very diverse student mix.
- Guidelines had to be devised for assigning weights to various project tasks.

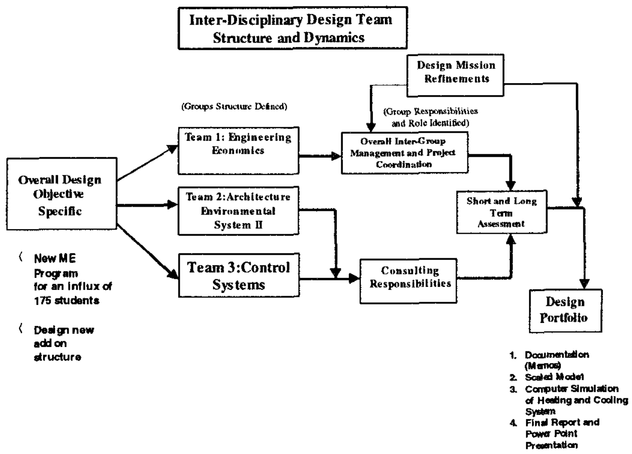

Figure 2. Basic Interdisciplinary Design Course Structure and Flow.

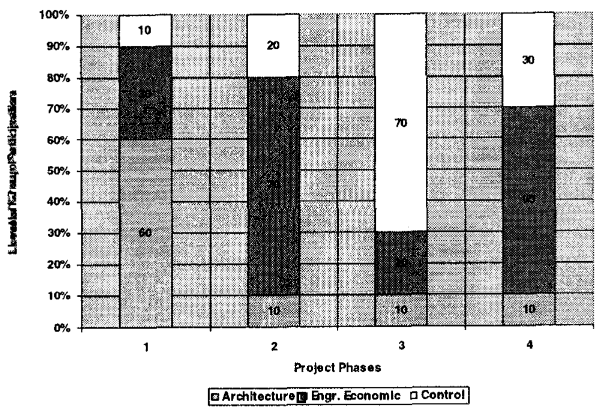

Figure 3. Level of Group Participation at Various Design Stages.

Faculty and Student Observations

From the faculty perspective, the following outcomes were apparent from this case study/hands-on approach:

- It provided an opportunity for students to enhance their computer skills.
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- It fostered an understanding of basic economic concepts, and tied these considerations to the overall engineering design process.
- It linked theory to real world applications, and provided a hands-on-experience for the students.
- It forced students to write about and articulate their concerns about technical issues.

Within the SE&T this experience set precedence and established a new paradigm for teaching this course where heretofore only a theoretical presentation devoid of a connection to the design process was given. This activity also forced us to address issues of assessment and outcome measurements raised in ABET 2000 [7].

From the student perspective as assessed from course exit surveys (Figures 4-6) this experience was successful on several fronts.

- It exceeded their initial expectations about the course.

  "I expected to do supply demand curves, banking statements and then depreciation. I didnt feel it would have a correlation to engineering."

  "I thought this course would be like my other courses."

  "I thought it would be boring."

- It proved to be an excellent way to deliver engineering and economic concepts.

  "Yes, because we were able to relate the cost analysis to a project."

  "I enjoyed this and think that projects such as this one should be implemented in other classes."

Obviously, the students enjoyed the project. It helped them to visualize concepts and aided comprehension. More importantly, this approach emphasized the integration of economic, design and engineering principles.

"This project is going to demand dedication and consistency throughout the entire semester. I feel the material in this control systems course and laboratory have become a real world project and I have to produce some deliverables throughout the semester."

"I can see how to design control systems because of this project."

"The project made the course and laboratory very interesting."

Engineering Economics Survey

This is an informal assessment of this new format for teaching engineering economics. Please answer the question below honestly.

1. Rate this course on a scale of 0 to 10 with 10 being the highest. ________
2. Comment on your initial expectations about this course.

   ____

   ____

   ____
3. List what you like most about the course format.

   ________ ________ ________

   ________ ________
4. List what you liked least about the course format.

   ________ ________ ________

   ________ ________
5. Was the level of participation by the various consulting group distributed appropriately?
6. Would you like more test given in this course?
7. Were the various phases of the project weighed appropriately?
8. Did you feel that you learned a lot about the role of engineering economics?
9. Rate the course's level of difficulty on a scale of 0 to 10 with 10 being the highest. ______
10. What grade do you expect to receive in this course?

Figure 4. Student exit survey form.

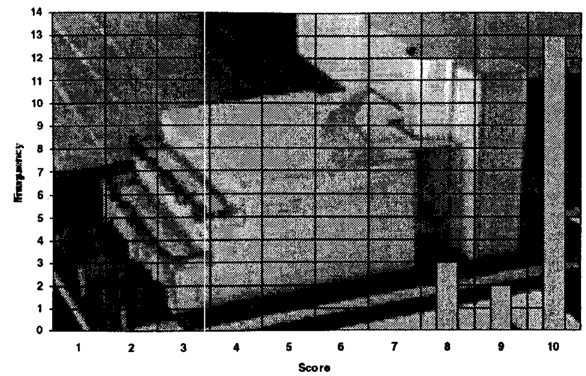

Figure 5. Results for question 1 of the student survey.

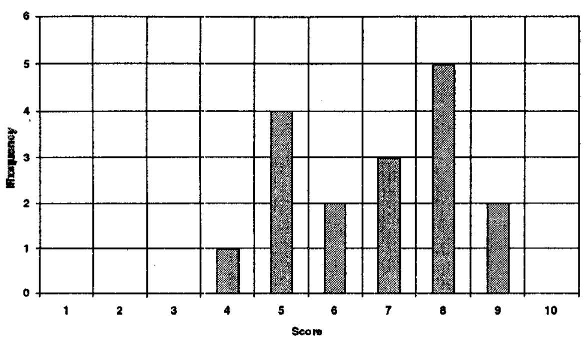

Figure 6. Results for question 9 of the student survey.

Student Portfolio

A typical student team generated portfolio is highlighted in Figures 7-10. In particular, Figures 7 and 8 are representative technical outputs from the control groups. Each student team generated control scheme and controller design was simulated on the computer and verified in a follow-up laboratory session. In the remaining Figures, non-technical outputs such as the overall economic analysis, scaled prototype designs, and sample PowerPoint presentations are displayed.

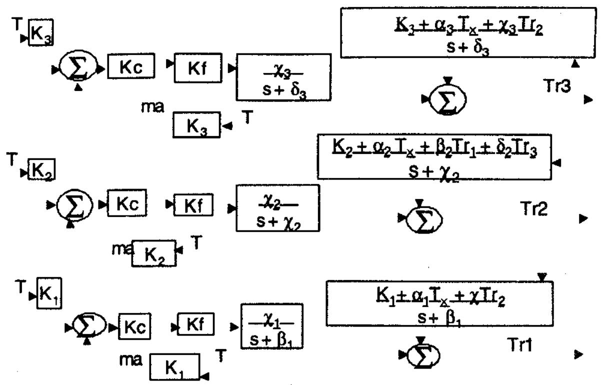

Figure 7. Derived control scheme for the add-on design.

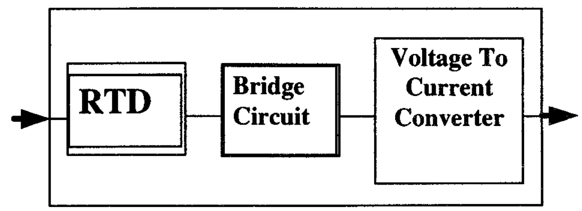

Figure 8. Block diagram for the feedback element (sensor).

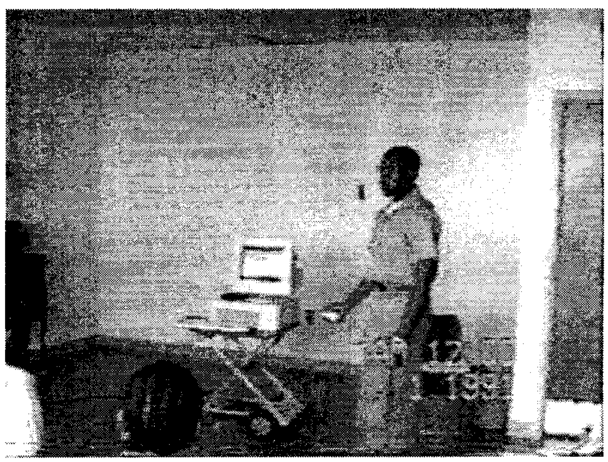

Figure 9. Student team presentation at end of semester.

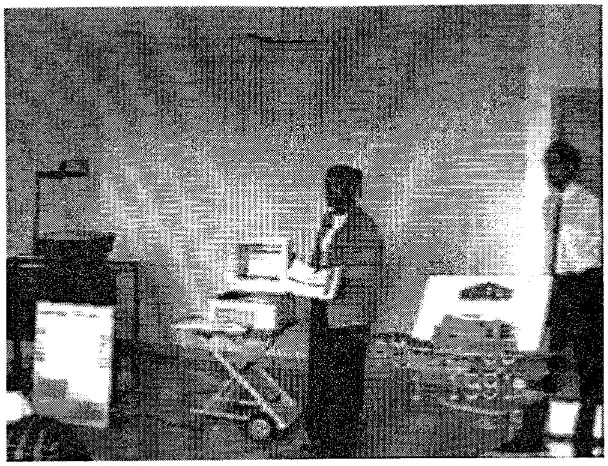

Figure 10. Student overview of project economic feasibility.

The grading guidelines for the participating courses are listed below:

Engineering Economics

Tests:	30%
* Mid-Semester Project:	20% *
* Final Semester Project:	45% *
Final Examination:	5%

Control Systems

Homework:	10%
*Design Projects and follow-up laboratory session:	25% *
Tests:	30%
Final Exam:	35%

Environmental Systems II

Reading and Research	10%
Field and Site visits:	15%
* Design and Graphic Depiction of Principles:	20% *
Quizzes and Exams:	30%
Classroom Discussion:	5%
Written and Graphic Reports:	20%

The interdisciplinary design project accounted for 20-65% of the total grade for the respective courses. We believe that such a large weighting of the design project (note items with asterisk in the above grading guideline syllabi) would indicate to the students our seriousness about this activity. Each final exam also included questions about various aspects of the design project. In the control systems course, the simulation and verification of the design was 50% of the total grade for the laboratory.

Conclusion

Given that this was a first attempt at integrating the design experience across disciplinary boundaries, we are happy with our initial parlay. During the upcoming year, both internal and external funds will be sought to strengthen and expand this activity. Clearly, the success of such an experience hinged on the willingness of faculty members to expand their horizon beyond their normal comfort zone.

References

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