Capstone Design via Distance Education
A *DESIGN* Partnership Including Industry and Higher Education

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Abstract
A unique capstone design course was offered by the University of North Dakota (UND) to distance education students at their industry work sites using company based projects and industry mentors for the first time in the fall of 1996; the course was offered again in the fall of 1997. The structure of the capstone design course, the university-industry partnership, the selection and utilization of industry mentors, and experiences in the first two years of the capstone offering are presented. Differences and similarities between the on-campus and off-campus students are characterized, as well as how these differences and similarities are addressed in the course.

The capstone design experience is being developed for industrial students enrolled in UND's Corporate Engineering Degree Program (CEDP) under a grant entitled "A *DESIGN* (*D*istance *E*ducation involving *S*tudents and *I*ndustry in a *G*rowing *N*etwork) Partnership" funded by the United States Department of Education's *F*und for the *I*mprovement of *P*ost *S*econdary *E*ducation (*FIPSE*). A primary goal of this grant is to work with industry partners to formulate the mechanics and philosophy for an ABET-acceptable capstone design experience that is implemented at the student's work site.

A Higher Education/Industry Partnership
In response to a need from industry, UND started working with 3M of St. Paul, Minnesota, on a distance education program[1] in engineering in 1988. As a result of this effort, the Corporate Engineering Degree Program (CEDP) evolved offering undergraduate distance education degrees in chemical, electrical, and mechanical engineering. The delivery method consists of taping lectures, duplicating the video tapes, and distributing them to the students. Students watch the same lectures, complete the same homework, and take the same exams as the on-campus students. Laboratories are offered in a compressed format (time but not material) during the summer on campus.

The program allows students who are currently working full time in industry to complete their engineering degree. Many of them have work and family obligations which leave them with no other option for completing their college degrees. This distance education program allows the student flexibility for shift work, travel, family, and other responsibilities that would normally not be possible with on-campus classes.

The CEDP presently includes 24 companies. A few of the companies represented include 3M, GE Plastics, Lucent Technologies, Hewlett Packard, Hutchinson Technology Inc., Conoco, Raychem, Whirlpool, and ALCOA. The CEDP allows students to earn a bachelors degree in chemical, electrical, or mechanical engineering while continuing to work full-time in industry. Experiential knowledge and previous technician education are assessed in a special course[2] to eliminate unnecessary duplication.

UND is working with its industry partners to develop the capstone design course that is being delivered through CEDP. In the summer of 1997, three faculty members visited several industry sites to review the capstone design process with industry managers, engineers, education coordinators, and students. Discussions at these meetings helped formulate the capstone design policies and procedures used in the

information packet. In addition, UND is working with the students, mentors, and faculty to provide additional structure to the course as a second series of students take the capstone design course during the 1997-98 school year via CEDP.

Challenge of Delivering Capstone Design via Distance Education

Even though all of the ingredients are present to deliver a successful capstone design course via distance education, there is the challenge of the student being located remotely from the faculty member. Even though students are prepared for the capstone design course, the challenge of its practical implementation still exists. In addition, there is the concern of monitoring and guiding the students who are located at a distance from the university, but the idea of an industry mentor seems to cover that need. The primary objective remains of providing a meaningful design experience that is acceptable to ABET. In an effort to satisfy these challenges, UND submitted a proposal entitled "A DESIGN Partnership" which was funded in 1996 by FIPSE under grant[3] P116B60229. This grant provides funding to assist in the implementation of the capstone design course in the Corporate Engineering Degree Program (CEDP) at UND.

Methodology for Delivery

When students enrolled in the CEDP reach the point in their engineering education where they are ready for capstone design, they request an information packet[4] describing the capstone design process. Topics covered in the capstone design information packet include the following:

- Purpose of capstone design
- Objectives of capstone design
- Frequently asked questions (with answers):
  - When can I take the course?
  - What is an acceptable project topic?
  - How do I get an industry mentor assigned?
  - How does the course work?
- Checklists for:
  - Students
  - Mentors
  - Site supervisors
  - Faculty advisor (technical)
  - Faculty coordinator (course administrator)
- Mentor guidelines
- Mentor agreement
- Expected outcomes

The faculty technical advisor identifies the deliverables along with the time lines for the student. The faculty provide the guidance necessary for the students to successfully complete the course. Students communicate with the faculty member via telephone or e-mail and send in their interim progress reports via fax. Other than the separation between the faculty and the student and the means of communication between them, the course and its outcomes are very similar to capstone design courses populated by on-campus students. The use of mentors to mitigate the effect of the faculty's remote location is covered in the following section.

The Use of Industry Mentors

Mentors are selected by the industry students and are required to meet the following *qualifications* as described in the information packet:

- A mentor should hold an engineering degree in the student's discipline from an ABET-accredited

school;

- A mentor should be an experienced design engineer, and she/he should be familiar with company-specific design practices and procedures;
- A mentor should be respected as an excellent designer within the company;
- A mentor should be a people-oriented person with good communications skills; and
- A mentor should have a good pedagogic perspective.

In addition, the information packet specifies the following as *responsibilities* of the mentors:

- Review the student's proposed design project and assist in defining a project scope which is of appropriate magnitude and difficulty.
- Review the student's proposed project team and offer advice based on experience with the company's internal structure and procedures.
- Provide encouragement, suggestions, and moral support as the project progresses.
- Periodically review the student's progress and offer constructive criticism aimed at guiding the student through the design process. The mentor should permit the student to discover and learn from his or her own mistakes, but she/he should also intervene if the student is perceived to have made a serious error which will jeopardize success of the project. In this respect, the mentor is acting as a faculty member by proxy.
- Periodically discuss progress with the student's faculty advisor.
- Upon completion of the project, review performance with both the student and the student's faculty advisor.

It is felt that the use of mentors supplies an additional communication channel between the student, the faculty, and the mentor, which provides additional support for the student.

On-campus/Off-campus Student Differences[5]

Slotnick, Pelton, et al.[6] have documented the attributes of adult learners on campus. However, there are a number of differences in the backgrounds of the on- and off-campus students taking the capstone design course. The following are general observations through our nine years of experience with the CEDP. First, the off-campus students have spent a number of years in industry and already have been exposed to more design experiences than their on-campus counterparts. In addition, some industry students have completed a number of design projects on their own as a part of their work assignments. Secondly, the on-campus students are trying to simulate a design experience of what occurs in industry, while the off-campus students are presented with many actual real-world opportunities. Third, the on-campus students have faculty monitoring their activities, while the off-campus students are supervised by their engineering managers and colleagues. Fourth, the on-campus students are usually more aware of the theoretical aspects of design, while the off-campus students have a better grasp on the practical aspects of design. Fifth, on-campus students work in groups on capstone projects to learn teamwork, while most off-campus students have already experienced teamwork during their involvement on various projects. Sixth, in general the off-campus students are usually older and have different interests than the on-campus students. Seventh, the off-campus students who have reached the capstone design course near the end of their educational experience are a highly motivated, self-achieving students who have attained an extensive industrial background at this point in life compared to their on-campus counterparts.

In addition, there are several other differences that come into play when offering the capstone design course via distance education. First, the faculty is not available on site to monitor the project. Secondly, the student will usually not be working on the project with other students who are taking the capstone design course. In addition, the off-campus student will most likely write the entire final report by himself/herself, whereas the on-campus student will write the report with other members of the team.

Finally, the time line for the off-campus project is dictated by industry, while the time line for the on-campus student is determined by the school term.

No matter how and where the differences occur, adjustments need to be made. UND's first experience with the off-campus capstone design class provided considerable insight, and as the second round of capstone design projects is being implemented, the course methodology is continually under review.

Benefits of Implementing Capstone Design via Distance Education

From an academic viewpoint, one of the largest benefits is that of academia interacting with industry at the design level. This is mutually beneficial. Academia provides assistance in solving industry problems, and industry keeps academia up-to-date on their latest technologies. In addition, a number of engineering faculty are exposed to numerous industrial work sites and technologies. The faculty are challenged by current industrial problems, and this is very helpful in keeping the faculty abreast of new developments. Industry also becomes acquainted with a group of academicians that can potentially serve as industrial consultants.

From a student standpoint, he/she may be able to use a project or a portion of a project that he/she is already working on for a capstone design. This reduces the amount of student effort outside the workplace to complete the requirements for this course. Also, not having to travel to campus for the capstone design during the summer is financially beneficial to both the student and the employer.

Indirectly, students on campus benefit as they see examples of capstone design projects over a wider range of technologies. The faculty are also presenting material to the students from a broader perspective because of their additional exposure. In addition, the potential exists for on-campus and off-campus students to work on the same capstone design project; with modern communication technologies, such as teleconferencing on the desktop, this is now possible.

Concerns Associated with Implementing Capstone Design via Distance Education

From an industrial viewpoint there are several concerns. One concern is that the confidentiality of a proprietary project may be sacrificed. If this cannot be prevented through nondisclosure agreements, then maybe the project or that portion of the project should be avoided as a capstone design project. Another industrial concern is that of the project time line. Projects may be too involved or not be synchronized with the university's time frame. These problems can be solved by the student carving out a subproject that meets the time frame, or by the university being willing to work with the student (let him/her start early or extend the completion date beyond the term end dates).

There may be a concern by the faculty that since they are not at the site with the student, they do not have a good feel for the activity on the project because of the lack of face-to-face contact. Even though this is a possible concern, the faculty are confident that with constant communication with industry mentors, and the students, the capstone experience will be a worthwhile design experience. Since the student is sending regular progress reports, the faculty have direct contact with the student. Furthermore, the faculty have regular discussions with the mentor and the student's supervisor at the work site, so in depth monitoring by everyone involved is achieved.

There may also be a concern by ABET that the capstone design is being offered off-campus. However, measures are being taken to assure that the faculty are completely aware of the student's work and the project status at the student's work site through the use of progress reports and the faculty's ability to communicate with the student, the mentor, and the student's supervisor.

Conclusions

Offering the capstone design to distance education students at their work site appears to be very implementable. Two students in mechanical engineering completed a pilot program in 1996-97. Their feedback was incorporated into the second phase of the pilot program starting in the fall of 1997, in which three students (one mechanical and two electrical engineers) participated in capstone design. Engineering faculty have met to discuss capstone design with representatives of two large corporations who currently have a number of students enrolled in the CEDP. Industry has been very cooperative and supportive of the program.

A survey of both faculty and students is planned to get their input and perceptions regarding the distance education implementation of capstone design. Results of this survey will be used to modify the course further and to provide faculty development in areas where needed.

To date, the capstone design experience has been a very positive one. The end result is a situation where everyone comes out a winner: the student, the corporation, the faculty, and the university.

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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 also took both undergraduate and graduate courses in Business Administration at the University of Minnesota and spent 15 years in industry as an engineer. For 13 years, Professor Johnson operated a farm and taught for UND in an MBA program at the Grand Forks Air Force Base.