AC 2011-280: A MODEL FOR INITIATING ABET-ACCREDITED ENGINEERING DEGREE PROGRAMS USING DISTANCE EDUCATION

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A Model for Initiating ABET-Accredited Engineering Degree Programs using Distance Education

Abstract

This paper presents a model that uses distance education to establish rapidly and economically engineering programs at four-year institutions that would otherwise not have the resources to do so. With modest costs and little risk, this flexible model can be replicated at many of the 83% of U.S. colleges that do not now offer engineering degrees. Benedictine College (BC) is serving as the proving ground for the model's full implementation and evaluation. After implementing the BC Engineering Model in Fall 2009, the new BC Engineering Department has established five-year dual-degree programs in each of the four major engineering disciplines (chemical, civil, electrical, and mechanical engineering) through a partnership with the University of North Dakota's Distance Engineering Degree Program (UND DEDP). Over the past 1.5 years, the BC Engineering Department has grown rapidly to 45 students ranging from freshman to juniors in the program. The key element to the rapid growth of the BC Engineering Department is its ability to offer students the opportunity to pursue ABET-accredited degrees immediately through its partnership with UND DEDP. This paper presents the detailed model as well as some of the initial lessons learned during its implementation at Benedictine College.

Introduction

The BC Engineering Model uses distance education as a means to establish rapidly and economically, engineering programs at four-year institutions that do not currently have the resources to offer an engineering degree or are concerned about the risks involved in starting new engineering programs. According to the National Center for Education Statistics[1], only 17% of the 2582 U.S. institutions granting four-year degrees (in 2006) award bachelor's degrees in engineering. For the remaining 83% of the nation's colleges, this model provides an economical pathway to initiate engineering programs by using efficiently the nation's existing faculty and facilities. The presence of attractive engineering alternatives at these colleges will provide students across the U.S. with previously unavailable options and will attract additional students to engineering careers.

The benefits of utilizing distance education in engineering are substantial and well established. Fisher and coworkers[2] investigated the development, implementation, and evaluation of a fully accredited undergraduate distance engineering program. They indicate that such a program, "…will enable access to superior engineering education by under-represented populations, students in remote locations, and students who are otherwise constrained…such a program could become a model for other undergraduate science and engineering curricula and programs offered online." The BC Engineering Model embraces and expands this vision. Fisher et al.[2] continue, "As current literature supports, online learning is now recognized as an equally effective instructional mode as the face-to-face classroom and one that can even surpass face-to-face in academic quality, rigor and outcomes." The advantages of online learning that these authors describe include the increased flexibility of asynchronous learning. Moreover, the authors draw on the research of Kassop et al.[3] which determined that online instruction stimulated interactivity of students beyond that of face-to-face instruction.

Overall, a significant body of research, summarized by Bourne et al.[4] shows that distance engineering education, when done properly, is at least equivalent to on-campus instruction. These authors make reference to "overwhelming evidence" in support of their claim that no significant differences exist in learning outcomes achieved by online students as compared traditional students. They stress the need for social connections between students, report that both faculty and students are satisfied with their online education experiences, and that constructivists approaches to education are effective online.

This new model will be a major step toward using distance engineering education to achieve the vision of Bourne et al.[4], "…many of the issues raised because of tradition can be solved through collaboration among institutions to create a strong national shared engineering curriculum enabled by online methods…(online education) may well play a remarkable role in bringing together the work of colleges and universities across the United States (and eventually across the world). Such collaboration will ultimately provide more choice and diversity of opportunity to learners with lower costs. For these reasons, online education will ultimately play a much greater role in changing higher education in the world than simply providing education at a distance. Collaboration, partnerships, and lowered costs for higher-quality educational products with higher learner satisfaction will become commonplace as a result of providing engineering education with quality, scale, and breadth."

The BC Engineering Model will encourage universities to provide distance undergraduate engineering education by expanding the undergraduate distance engineering education market to include traditional college students. This will mitigate some of the barriers that currently limit the number of undergraduate distance engineering degree programs. These barriers include the cost of implementing and running programs,[5,6] creating a faculty culture that accepts distance education and is willing to adopt teaching methods that will be successful for both on-campus and distance-education students,[7] accreditation,[2,8] advising students,[2,9,10] and other logistical considerations[11]. Note that although these considerations are important for the widespread adoption of the proposed model, the model can be implemented at some schools immediately by utilizing the University of North Dakota's Distance Engineering Degree Program (UND DEDP, hereafter referred to simply as DEDP), which has worked through these challenges to produce a thriving undergraduate engineering distance program. The educational challenges of undergraduate distance education, however, will be addressed below.

The term "distance engineering education" is applied to a wide variety of educational experiences and delivery methods. Thus, it is important to describe exactly how the proposed model uses distance engineering education to initiate new engineering degree programs.

BC Engineering Model implementation

The model will mitigate substantially the barriers of implementing an engineering program, which are primarily the cost and financial risk. Benedictine College (BC) in Atchison, KS was one such college that could not overcome the financial barriers that previously prevented it from initiating an engineering program. Like many liberal arts colleges with strong science and math programs, BC has had some form of "3:2" transfer programs in engineering for decades that involved few students. In 1983, BC commissioned a feasibility study to establish an in-house engineering program. The results of this indicated that establishing an engineering program would be one of the most expensive academic programs it could undertake. Because of the opportunity provided by DEDP, however, this initiative was reexamined and arrangements with DEDP provided the means to move forward with an engineering program of considerably greater scope with much less cost and risk.

BC is the first college to develop and implement this model for expanding student access to engineering careers and UND is the only U.S. institution that offers *ABET-accredited* B.S. degrees in chemical, civil, electrical, and mechanical engineering through distance learning. Through this partnership, BC engineering students can pursue these degrees without transferring. Currently, BC professors teach general education, math, science, and freshman, sophomore, and some junior-level engineering courses, while DEDP teaches upper-level engineering courses. Upon completion of the program, students earn a BC liberal arts or general engineering degree and an ABET-accredited B.S. degree in chemical, civil, electrical, or mechanical engineering from UND.

The BC Engineering Model combines the strengths of distance engineering education, the resources of an established undergraduate engineering program, and the benefits of a small liberal arts college that promotes student success. Because of the large number of supporting courses in the curricula, only one-fourth of the courses required for the dual-degree programs will be distance courses. The remaining 75% of the courses in the engineering curricula include a full liberal arts general education, which emphasizes group dynamics and exposes students to a variety of disciplines. This produces well-rounded graduates with excellent writing, reading, and interpersonal communication skills. As discussed below, this model goes well beyond the recommendation of Skurla et al.[12] whose experience with distance education underlined the necessity of a strong on-site mentor to make personal connections with the students as well as the importance of interaction between the instructor and students.

The BC Engineering Model combines the strengths of attending a small liberal arts college with those of a large engineering university; some of these advantages are listed below.

Small liberal arts college
- Broad education in liberal arts
- Small college community
- Personal attention
- Access to professors
- Focus on undergraduate education
- Small class size
- Opportunities for leadership

Large engineering university
- More degree options
- Wide range of electives
- Frequency of course offerings
- Career services
- Network of engineering alumni
- Opportunities for summer research
- Graduate school

The model builds on UND's established leadership in undergraduate distance engineering education. A 2007 study[2] from Stevens Institute of Technology states, "only UND offers *ABET accredited* degrees in the traditional disciplines of chemical, civil, electrical and mechanical engineering." Because UND has been delivering distance engineering courses for 20 years, it has solved or mitigated many of the distance engineering concerns discussed in the literature. The current delivery method has been described by others at UND[13], "DEDP delivery format includes streamed on-line lectures (with download or play options) available two-hours after each class is taught on campus, periodic video conferencing, e-mail- and phone-based office hours, and on-campus concentrated summer laboratory experiences. This delivery format ensures that each distance program has essentially the same content as the on-campus program…" Thus, all class lectures are captured electronically and posted on a Blackboard® site for each course, to which BC students and faculty will have access. The Blackboard® sites include integrated video and audio of class lectures, lecture notes, homework assignments and solutions, interactive chat sessions for student help, student study group areas, and individual and private student grading.

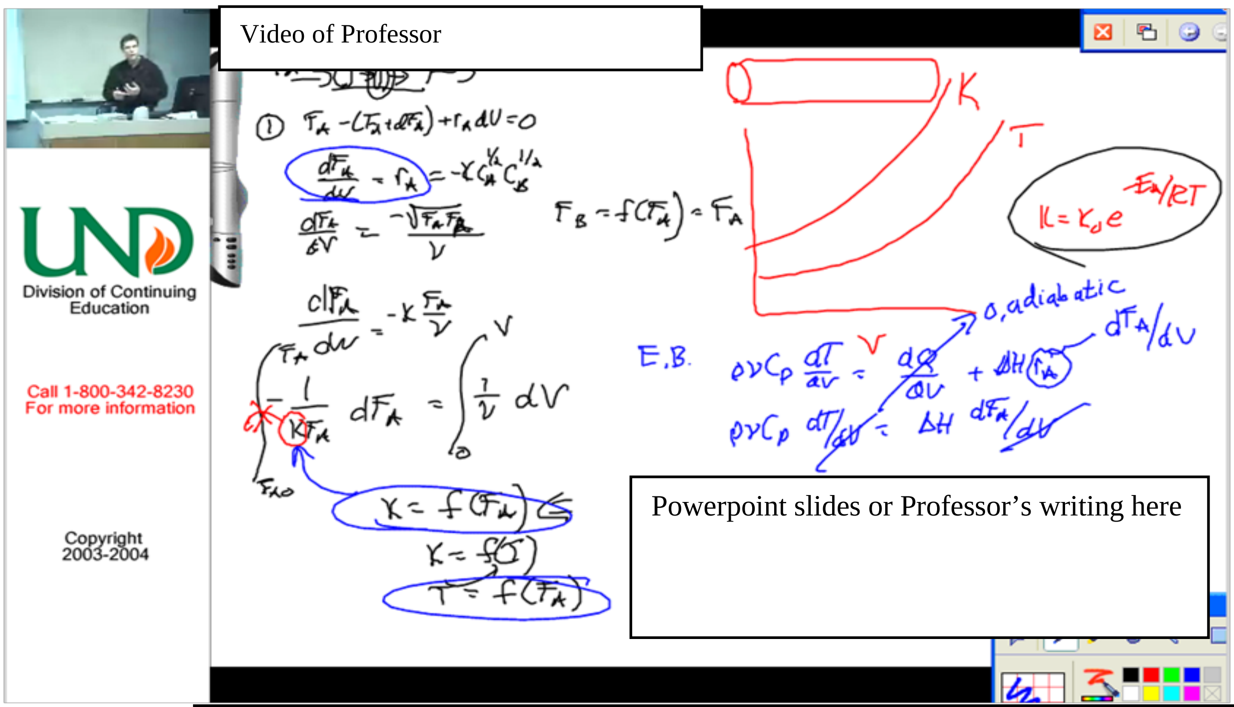

Figure 1: DEDP screen shot

Figure 1 is a screen shot of a typical DEDP course. Students see video and hear the audio of the professor's lecture as he or she displays the presentation slides (or writing on the board) during the on-campus lecture. The presentation slides comprise most of the screen. In addition, professors use tablet monitors to 'write' electronically on the presentation slides to highlight important information, all of which is captured digitally. Thus, distance-education students will view exactly the same lectures that were delivered to the students on UND's campus. The distance-education students can access all of the same course material as the on-campus students. Moreover, students will have access to the UND professor through telephone, e-mail, and scheduled online help sessions using collaboration tools such as Wimba®.

BC Engineering Model Overview

The BC Engineering Model provides a means to establish engineering programs across the U.S. at colleges that would otherwise be unable to undertake such an endeavor. Since the start-up cost for these programs can be extremely small, colleges incur almost no financial risk. The flexibility of the model allows growth of the program to occur as warranted by its success and the availability of resources. The model will enhance greatly student recruitment in these start-up programs because they can offer ABET-accredited degrees immediately upon inception of the program. The BC Engineering Model is flexible in that it has three distinct phases (Figures 2 and 3), each of which can become the final phase depending on the resources and goals of those institutions that adopt it. Each of these phases will be discussed below.

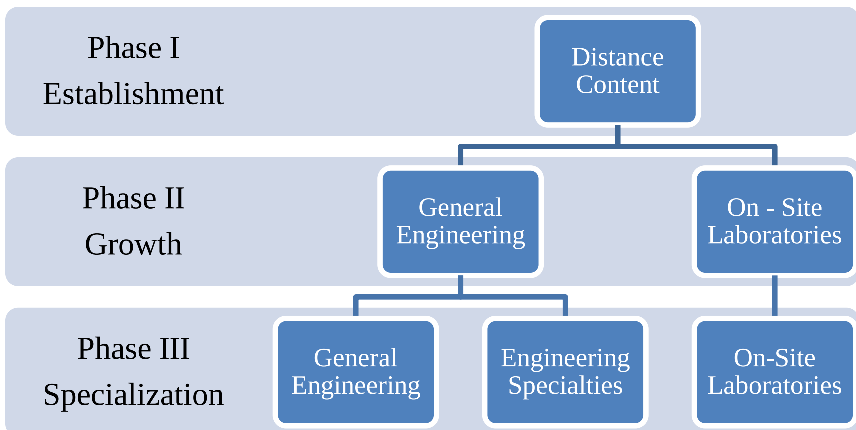

Figure 2: Overview of BC Engineering Model implementation

Phase I

Phase I involves initiating an extremely low-cost engineering program in the four major disciplines, using DEDP (or another distance education provider) to teach nearly all of the required engineering courses. Institutions in Phase I will most likely offer five-year, dual-degree programs in which students concurrently pursue an ABET-accredited engineering degree via DEDP with a complementary on-site degree in mathematics or science. Phase I can be implemented within a few months of establishing articulation agreements. An on-site program director administers the program, advises students, communicates with UND, and may teach entry-level engineering courses. Thus, Phase I allows colleges with limited resources to provide their students with the opportunity to pursue *ABET-accredited* engineering degrees while remaining on campus for their entire college career.

In Phase I, using distance education for program initiation provides substantial flexibility. Expensive on-site laboratories do not need to be established as students can complete summer laboratories at UND (2 to 3 sessions, each lasting two weeks). Colleges do not have to invest in a critical mass of engineering faculty until the student population justifies such an investment, and these colleges can attract more students initially by offering *ABET-accredited* degrees immediately. Moreover, the model is flexible enough to accommodate colleges that may wish to remain at Phase I, with an extremely low-cost engineering program that uses distance education long-term.

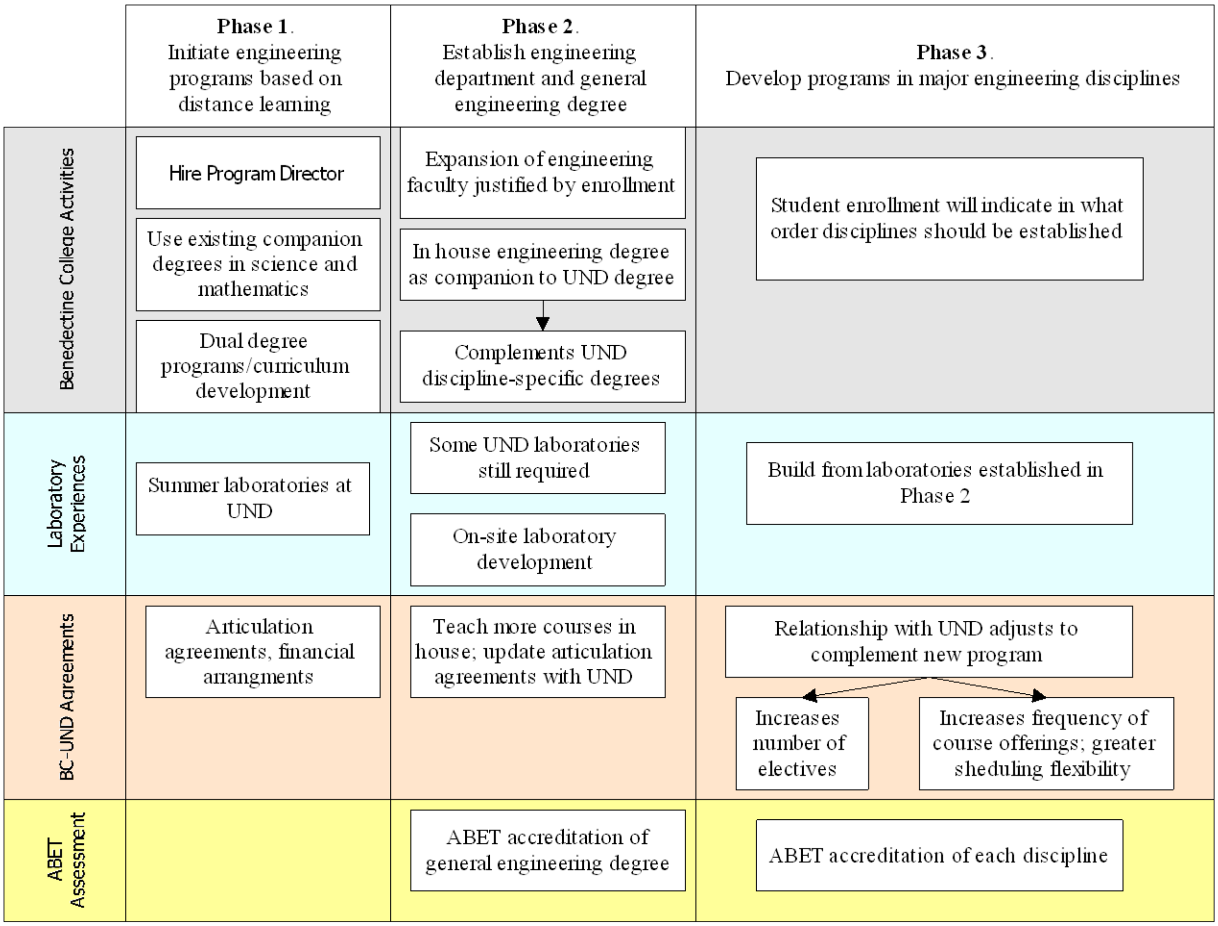

Figure 3: Proposed model to initiate engineering programs using distance education

Phase II

After completion of Phase I, some colleges may elect to expand their program by implementing Phase II of the model. Here, an on-site engineering department is established with the addition of faculty, whose hiring can be justified by the student enrollment realized in Phase I. These faculty members teach more engineering courses on site and thus fewer courses are taught via DEDP. The new department will offer a degree, such as general engineering, as the on-site companion degree to one of the four UND discipline-specific degrees; students still earn an ABET-accredited engineering degree from UND in Phase II. After the on-site engineering department graduates students with a general engineering degree, it can apply for ABET accreditation of its own general engineering program.

Although one substantial financial hurdle to achieving the goal of establishing an ABET-accredited engineering program in Phase II is the development of engineering laboratories, they are vital to a high-quality engineering program. This conclusion was also reached by Fisher et al.[3], who emphasized the need for a strong laboratory sequence that incorporates hands-on learning in programs that involve distance learning. These laboratories will be developed efficiently by establishing those experiments that fulfill simultaneously UND laboratory requirements and also may be used in one or more of the discipline-specific engineering programs in Phase III. This can be accomplished by selecting key laboratories offered by UND and reproducing them identically on site.

In Phase II on-site engineering laboratories are commissioned that will fulfill simultaneously requirements of the on-site general engineering degree as well as those for a discipline-specific degree from UND. This increases the appeal of the program to prospective students because it reduces the number of summer laboratory sessions at UND in Phase II. For these laboratories, students will remain at BC and perform the same experiments as those performed at UND. The deliverables, course instruction, schedule, and grading will be identical at the two campuses. For oral presentations, funds have been obtained to establish a video-conferencing classroom at BC so that students can give oral presentations to a live audience of BC students and faculty, with UND faculty and students watching them in real time. The UND faculty will have the means to interact with questions through conferencing software, which has been shown to be effective for distance laboratory presentations.[14]

This method of laboratory implementation will alleviate one hurdle in distance engineering education, which is the logistics of requiring students to travel to UND for the summer laboratories. In addition, it will also increase students' ability to pursue summer internships. Because these laboratories can serve as the beginning of the laboratory sequence for BC in Phase III, this overcomes a tremendous barrier to starting a new engineering program – laboratories do not need to be implemented all at once, they can be put in place as resources are secured.

Phase III

In Phase III, the on-site engineering department grows to offer its own ABET-accredited degrees in the major disciplines. On-site institutions simply monitor student enrollment to determine which engineering discipline warrants further investment of resources. That is, resources need only be committed to the disciplines that have proven to be viable at that institution in Phases 1 and 2. The college would add the required faculty to establish its own degree in one of the four major engineering disciplines (or others) and apply for ABET accreditation. This procedure could then be repeated sequentially for the remaining engineering disciplines that warrant further commitment of resources. In Phase III, the relationship with DEDP can be maintained to augment the on-site engineering program by enhancing course offerings and electives. For example, to establish a B.S. in Mechanical Engineering (ME), the on-site ME faculty will decide which courses in its curriculum are equivalent to those taught by DEDP. For this set of courses, DEDP can be utilized to reduce the teaching load of on-site faculty, allowing the start-up ME program to be implemented and accredited by ABET even before it has been staffed with enough ME faculty to teach all courses in the curriculum. Moreover, the partnership with UND will help provide the substantial stability that ABET requires in new programs as the new program develops. As the ME program grows, it can decide which DEDP courses to maintain, which to remove, and which to offer as electives to increase student course choices. The laboratories required in Phase III can be established by using the experiments already developed in Phase II.

Results of the BC Engineering Model implementation

After only one and a half years, BC has made significant progress in the implementation of Phase I (Figure 2) of the proposed model, which indicates that it can be readily implemented even at a small liberal arts college (total enrollment of approximately 1400 undergraduates). BC has hired an engineering program director, a second tenure-track engineering professor, a full-time adjunct professor, and a lab technician. Some of these hires were justified by the strong engineering student enrollment numbers, produced by the existence of ABET-accredited degrees in the four major disciplines. Benedictine College has entered a memorandum of understanding with UND, has established articulation agreements with each of the four UND engineering departments, and has completed three semesters of offering both on-site engineering and DEDP courses to BC students. Moreover, dual-degree programs have been published in the BC Course Catalog for each of the four major engineering disciplines. After its first year of the agreement with DEDP, the Fall 2010 BC engineering program enrollment consisted of ~20 sophomores and juniors and ~25 freshmen.

Five-Year, Dual-Degree Program

The plan for the BC-UND partnership is that students will pursue degrees from both institutions through five-year, dual-degree programs. In Phase I, students receive an ABET-accredited engineering degree from UND complemented by a theoretically oriented liberal arts companion degree in chemistry, physics, biology, computer science, or mathematics from BC. Students complete the entire BC liberal arts general education requirements and these courses fulfill simultaneously all of the general education requirements for the UND degree. All programs make reasonable demands on students due to significant overlap between the degree pairs. For example, the chemical engineering/chemistry program averages 15 credits/semester (plus 7 credits of summer laboratories). Government-sponsored financial aid is available to students for all five of the years that they are enrolled in the program.

Academic advising

Academic advising is particularly important for distance learning.[2,9] One consideration in advising traditional distance-education students is the increased student discipline that is required to complete their degrees in a timely fashion.[10] Currently, DEDP addresses advising by requiring all distance-education students (including those who also will be served by the proposed program) to receive the support of a dedicated UND faculty advisor (one faculty advisor in each engineering discipline). Every semester, over the telephone, each student reviews his or her progress in the program with a UND faculty advisor. Students have holds placed on their registrations until they agree on course selection with their advisor. In addition to UND faculty advisors, students in the proposed program benefit from BC faculty advisors who are familiar with UND’s requirements as well as their own. Thus, the proposed program is unique in that it provides distance-education students with the essential benefits of face-to-face faculty advising.

To provide enhanced advising services to students, faculty at both campuses work together to ensure that they are familiar with all curricula and graduation requirements. The authors have developed flow sheets that show clearly the critical path through each engineering discipline and map the prerequisites for each course. They also have listed the BC courses that fulfill the general education requirements at both institutions and have produced forms to track students' progress towards degrees at both institutions. In addition, BC faculty travel at least annually to UND to remain updated with the UND engineering curricula requirements.

Admission and payment

Student admission to the program uses nearly the same criteria that have been established for UND's on-campus students. Students at BC do not incur any *additional* charges to participate in the program. That is, students enrolled in the proposed program pay the same annual tuition rate as other BC students. Payment has been arranged directly between UND and BC, so the cost is transparent to the student. The DEDP cost structure is such that its per-credit course charges are comparable to those at BC. Thus the proposed model is financially attractive even for small, private colleges.

Examinations and evaluation

Because a major concern in administering examinations to distance-education students is academic honesty, usually some form of proctoring is instituted[2]. DEDP assigns proctors to distance-education students and the proposed project utilizes BC faculty in this role.

Senior design

For almost two decades, UND has taught senior design via distance learning. Typically, distance-education students are assigned a faculty advisor, form design groups, conceive a design of their choosing, and produce the same deliverables as do on-campus students. The only difference between distance and on-campus students is the means of communication (teleconferences, chat sessions, and e-mail, rather than face-to-face). The BC Engineering Model improves on the traditional distance-education model as BC students will form traditional design groups and interact with both BC and UND faculty as advisors.

Engagement of traditional college students

The typical DEDP student already is working in a technical field and is looking for an opportunity to increase his or her skill set for future advancement. These students are generally older than the on-campus students (average age ~35 years), are employed full-time (97% of DEDP students), and have families. Although these students have historically been the market for distance engineering education, the new model will serve primarily the typical on-campus college student. Thus, a challenge to the proposed program is the engagement of students, particularly underclassmen. Collins et al.[9] list challenges to distance education, which includes the increased student discipline required of distance-education students, faculty-student interaction, and student-student interactions. In addition, Fisher et al.[2] opine "By comparison, we feel that it is unlikely that a *fully online program* would be optimal for the traditional college-age undergraduate student who lacks such exposure to engineering; such students would likely need the benefits, supports, and interactions best provided by the traditional undergraduate experience." (emphasis added)

The authors agree that it is not reasonable to expect many young undergraduates to possess the self-discipline required to finish a *fully online* program. Thus the model was designed with student engagement in mind. The program aspects designed to improve engagement of young students are as follows:

At BC, the DEDP courses are scheduled identically to typical on-site courses. The students meet in a classroom at a specified time where a BC faculty member presents the UND lecture. While viewing the DEDP course in the classroom, these students participate in the same active learning sessions as the UND on-campus students, such as group problems, case studies, discussions, etc. Thus, BC students will not be isolated as are traditional distance students. They also form study groups and participate in on-site engineering student societies. Typically, distance-education programs attempt to increase faculty-student and student-student interactions, by setting up online environments to encourage a "virtual community" between students.[10] In this new model, student communities are formed in the traditional means, as students interact with each other on-site.

The UND faculty members strive to implement engagement teaching methods in their distance classes. A recent article[13] outlined one successful strategy for incorporating engagement teaching methods in DEDP (for traditional distance-education students) and concluded that distance-education students received sufficient engagement to produce comparable performance to on-campus students. The BC Engineering Model allows for easier implementation of engagement teaching methods, such as in-class problems, because BC students meet at a scheduled time in a classroom to participate in DEDP lectures as a group.

Due dates for all assignments (homework, projects, papers, exams) are identical between UND and BC students. Thus, BC students have the hard deadlines with which they are familiar. When BC students have questions, they will not only have access to UND faculty members through e-mail, telephone, and chat sessions, but they also will be able to ask questions of the BC faculty members. Students have access to all necessary engineering software through the DEDP server. Faculty members at BC provide mentoring, advising, and frequent interaction with students to encourage them and monitor their progress in the distance courses. Also, in accord with FERPA guidelines, BC faculty advisors have access to student records so they can track their advisees' progress in DEDP courses.

Implementation of UND summer laboratories and BC student experiences

One of the major questions regarding the implementation of undergraduate distance engineering education is the issue associated with laboratory courses[4,15], particularly the role of hands-on experiences[16,17] and ABET accreditation.[2,18] Feisel and Peterson[18] summarize the problem, "Despite the widespread use of remote labs, experience has shown that they should not fully replace traditional hands-on laboratories…it is difficult, if not impossible, to address all of the educational objectives for laboratory based courses in a Web-only environment. (Remote laboratories) target only 4 of 14 educational objectives recognized by ABET". Their statement is echoed by another study[2] which notes the following: "The vital importance of a comprehensive laboratory experience in the engineering curricula is widely acknowledged by all constituents and reflected prominently in the ABET Engineering Criteria 2000".

During Phase I, students travel to UND to attend summer laboratory sessions, which solves the problem of providing *hands-on* laboratories for students while minimizing program start-up costs. For the past 20 years, UND has offered engineering laboratories for distance-education students through intensive, two-week laboratory sessions. Students are housed at UND and have full access to the school of engineering resources (laboratories, faculty instruction, staff support, computing facilities, etc.). Typically, they spend two weeks at UND collecting experimental data, producing several written reports, and giving one oral presentation. Additional written reports are due throughout the remainder of the summer, after students leave UND. Generally, each engineering degree requires two summer laboratory sessions, but on-site laboratories, established at BC in Phases 2 and 3, will reduce this requirement.

The Phase I summer UND laboratories ensure that distance-education students receive the required hands-on learning that is essential for engineering[17]. Students interact with state-of-the-art equipment, are forced to troubleshoot when the experiment or equipment does not work as they envisioned, and are required to think critically about their results by drawing on their experiences in the collection of the data. The authors and other UND Engineering Faculty agree with Lindsay and Good[19] that different modes of laboratory delivery produce different learning outcomes, and they consider the "hands-on" experiences as essential to engineering education.

Currently, one EE student has attended a DEDP summer laboratory session, and his experience was positive. The UND instructors provided him with the opportunity to complete all of the required experiments as soon as he was able. The student worked diligently in data collection during the day, and worked on the laboratory reports in the evening. He was able to complete the laboratory requirements in less than one week and return home to his summer employment. Throughout the remainder of the summer, he completed the laboratory reports on schedule.

Student experiences with DEDP lecture courses at Benedictine College

Over the past year, BC faculty members have experimented with the amount of support they provide to students who are enrolled in DEDP courses. Faculty support has taken one of two forms: (1) monitoring in-class DEDP lectures or (2) allowing students to view them independently. Currently, BC has several cadres of students that have taken DEDP courses: Two EE sophomores, one EE junior, four ME juniors, and two CE sophomores. During Fall 2010, BC faculty experimented with allowing these cadres of students to participate in their DEDP lectures without a BC faculty member present in the classroom during the DEDP lectures. That is, class meeting times were scheduled and BC professors were available to answer questions, but the students were responsible for downloading and viewing lectures as a group without faculty oversight. The CE and the two EE groups worked diligently in keeping up with viewing the lectures on schedule, submitting homework, and taking exams. In particular, the EE junior has been enrolled in more DEDP courses than any other student and is making satisfactory progress with minimal BC faculty oversight even though he is taking DEDP courses by himself.

The group of four ME juniors completed one DEDP course in Fall 2009 and enrolled in two DEDP courses in Fall 2010. In 2009, all students completed successfully the DEDP course, which was monitored by a BC faculty member. As mentioned above, in 2010 these same students were expected to view the DEDP lectures without a BC faculty member in the classroom. These students met the required homework and exam submission deadlines, but decided that viewing the lectures was not necessary for the two particular ME courses in which they were enrolled. Their decision was based partly on the technical difficulties that resulted from the BC Engineering Department moving to newly renovated classrooms that had to be made ready for DEDP lecture viewing. Near the end of the semester, some of the students in this cadre requested that BC professors help solve some technical issues as well as provide accountability to help them remain on schedule in viewing the DEDP lectures. With these actions taken, all of the students completed these courses satisfactorily.

This initial experience has shown that the amount of on-site faculty support required depends primarily on the maturity of the students enrolled in the course, the difficulty of the course material, and the DEDP instructor. The BC faculty decided to perform on-site course evaluations for every DEDP course and use this information to determine which DEDP courses were the most challenging and target these courses for additional support from BC faculty. This additional support will take the form of in-class monitoring by BC faculty and required help sessions at which BC faculty will provide additional instruction, answer questions, and work in-class practice problems. The level of BC faculty support of DEDP courses will be determined by evaluating the self-discipline of the BC student group, the difficulty of the DEDP course, and the results of course surveys from previous years. Although the degree of BC faculty support for DEDP courses must be factored into the overall faculty load, the presence of DEDP provides additional degrees of freedom to reduce BC faculty load by using DEDP courses to replace other courses taught by on-site faculty.

Several other approaches exist to maximize the efficiency of BC faculty. For example, a departmental "technician" could be utilized to monitor the majority of DEDP courses, with a BC faculty member assigned to help answer student questions for each course. In addition, the possibility exists of employing certain upper-classmen (e.g. fifth-year seniors) to serve as teaching assistants for DEDP courses. These teaching assistants would monitor the lectures and help with student questions, with a BC faculty member ultimately responsible for each course.

Thus, BC faculty concluded that implementation of DEDP courses provided the opportunity for additional on-site instruction to enhance student learning. The presence of DEDP allows BC faculty load to be adjusted to maximize its impact on student learning, whether that involves BC faculty teaching a course in the traditional sense or targeting specific DEDP courses in the curriculum that would benefit from additional faculty instruction and support. Assessment activities will be focused on optimizing the balance between the number of engineering courses taught on site and the degree of support that on-site faculty provide for DEDP courses. One potential advantage of the model is the opportunity to teach students time-management skills and develop ownership of their learning. These skills may be developed by carefully allowing students more independence in their DEDP courses as they progress through the program.

Summary

The BC Engineering Model will provide for establishing, for the first time, substantial engineering programs at four-year colleges that otherwise would not be able to initiate and maintain them. These new programs would provide the opportunity for students to pursue ABET-accredited engineering degrees immediately upon their establishment. The model will impact engineering education by allowing U.S. engineering faculty to reach more students and utilize existing facilities more efficiently, particularly as more engineering schools provide undergraduate distance education. The model is flexible in that it allows each college that adopts it to determine the amount and timing of resources committed to establishing engineering degree programs. It mitigates the financial risks involved in establishing engineering degree programs by reducing drastically the startup costs of such an endeavor. The BC Engineering Model combines the strengths of small liberal arts colleges with the benefits provided by large engineering universities. Graduates will benefit by receiving two complementary degrees (e.g. chemistry and chemical engineering, mechanical engineering and physics, etc.), hands-on laboratory experiences, and the essential face-to-face interaction with on-site faculty members who advise students and are available to help answer questions.

Initial experiences at Benedictine College revealed that incoming college students are open to the idea of a portion of their engineering education delivered via distance learning. Moreover, the majority of the sophomore- and junior-level students who participated in distance lectures completed these courses satisfactorily with little or no faculty supervision. Thus a successful engineering program can be established without the need for a large number of engineering faculty on site. Student learning can be improved, however, with on-site faculty support of distance courses. The level of on-site faculty monitoring and support of distance courses depends primarily on the maturity and independence of the particular students in a cadre as well as the particular distance course/instructor. The flexibility of the model allows on-site faculty to adjust their teaching load to optimize the balance between the number of engineering courses taught on site and the level of support provided for specific courses and student groups that are targeted for additional support. Thus, colleges that implement the BC Engineering Model should develop assessment plans that will allow on-site faculty to maximize their efficiency in achieving this balance.

Acknowledgments

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