

# **Distance Education allows Small Liberal Arts Colleges to Offer ABET-Accredited Degrees in Chemical, Civil, Electrical, and Mechanical Engineering**

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## **Abstract**

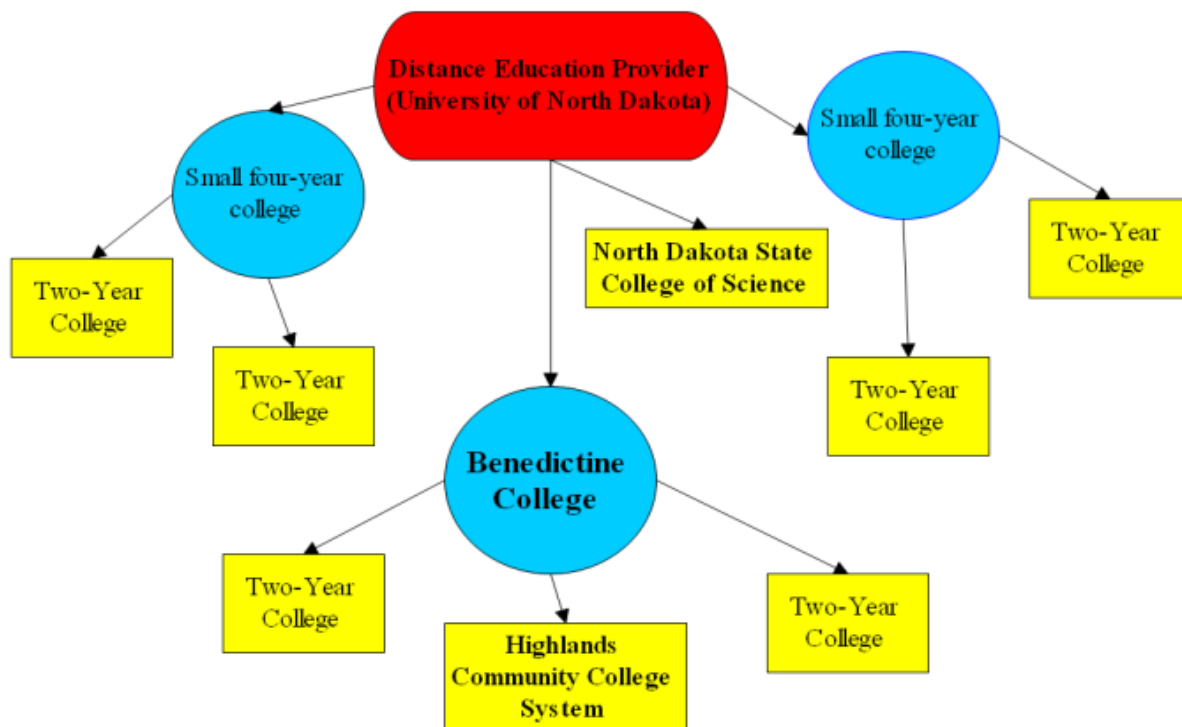
The Benedictine College (BC) Engineering Model uses distance education as a means to establish rapidly and economically engineering degree programs at four-year institutions that do not currently have the resources to offer an engineering degree or are concerned about the risks involved in starting new engineering programs. With modest costs and little risk, this flexible model can be replicated at many of the 86% of U.S. colleges that do not now offer engineering degrees. 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 3 years, the BC Engineering Department has grown rapidly to 130 students and has just produced its first graduates in Mechanical and Electrical Engineering. 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, some of the initial lessons learned, and some of the recently discovered benefits for laboratory and curriculum development during its implementation at Benedictine College.

## **Background**

The Accreditation Board for Engineering and Technology<sup>1</sup> lists 391 colleges with accredited engineering programs in 2011, which corresponds to only 14% of the total of 2774 U.S. institutions granting four-year degrees (according to the National Center for Education Statistics<sup>2</sup> most recent data as of 2010). For the remaining 86% of the nation's colleges, the *BC Engineering Model* will provide an economical means to initiate engineering programs, while 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. Since the start-up cost to implement the proposed model is 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 greatly enhance student recruitment in these start-up programs because they can offer ABET-accredited degrees immediately upon inception of the program.

Benedictine College has entered an agreement with the University of North Dakota Distance Engineering Degree Program to implement this model for expanding student access to engineering<sup>3</sup>. UND offers *ABET-accredited* B.S. degrees in chemical, civil, electrical, and mechanical engineering through distance learning. For more than twenty years, UND DEDP has been providing *ABET-accredited* undergraduate engineering distance education primarily to students working in industry. Through this partnership, students pursue these degrees while remaining at the BC campus throughout their degree program. BC professors teach general education, math, science, and freshman, sophomore, and some junior-level engineering courses, while UND DEDP teaches upper-level engineering courses. Upon completion of the program, students earn an *ABET-accredited* B.S. in chemical, civil, electrical, or mechanical engineering from UND as well as a BC liberal arts or general engineering degree.

Figure 1 shows an overview of the *BC Engineering Model* and designates relationships that have been or are in the process of being established. Under this model, each distance provider (e.g. UND) will establish engineering programs with several four-year colleges. These colleges in turn utilize distance courses for the development of pre-engineering programs with area two-year colleges<sup>4</sup>. Articulation agreements ensure seamless transfer of students between the two- and four-year colleges; since all institutions use courses from the same distance provider, students can transfer easily between institutions. This model addresses the issues described by the recent work of Santarelli and Shelley<sup>5</sup> who stressed that universities “need to partner with multiple community colleges in order to develop a sufficient pool of qualified transfer students” Although the full model includes the incorporation of two-year institutions, the focus of this study is implementation of the model at Benedictine College.



**Figure 1:** Benedictine College Engineering Model to initiate engineering programs using distance education

The current project can serve as a template for other colleges that wish to offer engineering degrees, but may otherwise consider it cost-prohibitive to do so. Using distance education allows flexibility of implementation: laboratories do not need to be established immediately as students can complete summer laboratories at UND (or other distance engineering education providers that become available); colleges do not have to invest in a critical mass of engineering faculty until the student population justifies such an investment, and the new program can attract more students by immediately offering *ABET-accredited* degrees. Moreover, the model can accommodate colleges that wish to maintain an extremely low-cost engineering program that uses distance education long-term, without building their own stand-alone programs. This is especially important in the current tough economic times when universities must cut budgets<sup>6</sup>.

This project is the first that utilizes existing ABET-accredited distance education to establish bachelor degree programs in engineering. The student-centered focus at BC and thousands of similar institutions in the U.S. will lead to greater success rates for students pursuing careers in engineering. Students will receive personal attention, with an emphasis on ethics, written and oral communication, and interpersonal skills for which liberal arts programs are well known. These are traits that employers seek when hiring engineers. For example, Steve Jobs stated<sup>7</sup> in 2011, “It’s in Apple’s DNA that technology alone is not enough—it’s technology married with liberal arts, married with the humanities, that yields us the result that makes our heart sing, and nowhere is that more true than in these post-PC devices.” Indeed, a recent article<sup>8</sup> in the *Chronicle of Higher Education* outlines the significant benefits of pursuing an engineering degree at a liberal arts college. Thus, the *BC Engineering Model*, which is currently proving to be extremely successful in its 3<sup>rd</sup> year of implementation, provides a means for the U.S. to make high quality education in science, technology, engineering, and mathematics (STEM) available to more students while minimizing costs.

Much discussion has taken place regarding the concern with the number of well-educated STEM graduates produced in the U.S.<sup>9,10</sup>. A recent review<sup>11</sup> concluded that one promising means of increasing the numbers of qualified STEM graduates is through the effective use of online education. The benefits of using distance education in engineering are significant and well documented<sup>12-17</sup>. Fisher and coworkers<sup>18</sup> 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.

The model will be a major step toward using distance engineering education to achieve the vision of Bourne et al.<sup>11</sup>, “...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.”

Fisher et al.<sup>18</sup> state that, “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.<sup>19</sup>, 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.<sup>11</sup>, shows no significant difference in learning outcomes between traditional and online students.

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 *BC Engineering Model* uses distance engineering education to initiate new engineering degree programs.

### **Distance Engineering Degree Program at the University of North Dakota**

The *BC Engineering Model* utilizes the existing UND Distance Engineering Degree Program. UND is the only U.S. institution that offers *ABET-accredited* B.S. degrees in chemical, civil, electrical, and mechanical engineering through distance learning<sup>18</sup>. The UND School of Engineering and Mines is uniquely positioned to provide distance engineering education because it builds on UND’s established leadership in this field. A study<sup>18</sup> 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 over 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<sup>20</sup> at UND, “DEDP delivery format includes streamed on-line lectures (with download or play options) available ten minutes 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 have access via Web browser. 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 2 is a screen shot of a typical online 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 (or writing on board) comprise most of the screen. In addition, professors can electronically ‘write’ 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<sup>®</sup>.

Thermo tells us:  
For a reversible reaction  
Rate Law must reduce to  
equilibrium constant

By definition:  
$$K_C = \frac{C_D^2}{C_A C_B^2}$$

At equilibrium:  $r_1 = 0$

For ①  $\Rightarrow$   
 $k_1 C_A C_B = k_2 C_D^2$

2 potential rate laws  
①  $r_1 = k_1 C_A C_B - k_2 C_D^2$   
②  $r_1 = k_1 C_A C_B - k_2 C_B^{-1} C_D^2$

Check to see if they are  
thermodynamically consistent

$k_1 / k_2 = \frac{C_D^2}{C_A C_B} \neq K_C$

$\therefore$  ① Can't be correct

Frank Biewman  
CHE 321 - Day 5 6

Figure 2: UND DEDP Lecture

## BC Engineering Model

Figure 3, presented previously<sup>3</sup>, shows the *BC Engineering Model* that BC is implementing, evaluating, revising, and disseminating. The model is flexible in that it has three distinct phases, each of which can become the final phase depending on the resources and goals of those institutions that adopt it.

Phase 1 involves initiating an extremely low-cost engineering program in four major disciplines, using UND DEDP (or another distance education provider) to teach nearly all of the required engineering courses. These programs will most likely be five-year, dual-degree programs in which students concurrently pursue an ABET-accredited engineering degree via distance learning with a complementary on-site degree in mathematics or science. Phase 1 can be implemented within a few months of establishing articulation agreements and provides substantial flexibility. 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. An on-site program director administers the program, advises students, communicates with UND, and may teach entry-level engineering courses. Laboratory equipment is not necessary as students will attend summer laboratory sessions at UND (two sessions, each lasting 3-10 days, depending on the program). Thus, Phase 1 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. Moreover, the model is flexible enough to accommodate colleges that may

wish to remain at Phase 1 long-term, with an extremely low-cost engineering program that uses distance education.

After completion of Phase 1, some colleges may elect to expand their program by implementing Phase 2 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 1. These faculty members teach more engineering courses on site and thus fewer courses are taught via UND 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 2. 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.

Also in Phase 2, on-site engineering laboratories will be developed efficiently by establishing those experiments that simultaneously fulfill UND laboratory requirements and also may be used in one or more of the discipline-specific engineering programs in Phase 3. This can be accomplished by selecting key laboratories offered by UND and reproducing them identically on site. Thus, in Phase 2, 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 2.

In Phase 3, 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 3, the relationship with UND can be maintained to augment the on-site engineering program by enhancing course offerings and electives. Moreover, new relationships will be developed with other established engineering schools as dissemination of the project results encourages more schools to begin to offer their ABET-accredited engineering degrees via distance learning. Note that the relationship with UND DEDP will also benefit on-site institutions during their ABET accreditation visit in Phase 3. Even though at that point the particular discipline would be taught by on-site faculty, the availability of UND DEDP courses would provide substantial stability for the program and supplement on-site faculty expertise. The laboratories required in Phase 3 can be established by using the experiments already developed in Phase 2.

During all phases of implementation, the on-site, four-year college can apply the model to its relationships with regional two-year colleges. One use of the model could be to develop pre-engineering programs at two-year colleges using UND DEDP freshman and sophomore engineering courses (Figure 1). When graduates of the two-year college enter the four-year program, they will do so with all of the required engineering courses that the on-campus students have completed. One advantage of the *BC Engineering Model* is that it serves two-year college

students that are bound geographically as they could finish their engineering degree at the regional four-year college rather than relocating to North Dakota. Currently, BC is adapting the model to establish pre-engineering opportunities for the 3200 students attending Highland Community College in northeast Kansas.

BC is implementing all aspects of a complete engineering program, while recognizing that the model is flexible enough to be scaled down and adapted to other institutions' plans. The BC Engineering Department is currently identifying the optimum on-site curriculum to complement each UND DEDP discipline-specific degree, developing a procedure for laboratory implementation, and designing student support structures for this unique program to provide a pathway for other colleges that wish to adopt the model. It is also currently exploring questions such as: What critical support services are required on campus to best support students? How can the on-site institution develop its own laboratories in Phases 2 and 3 to complement those at UND? What are the best program assessment methods (ABET accreditation) for this unique partnership between engineering programs? Since UND DEDP can provide stability and flexibility in course offerings, how many faculty are required for an ABET-accredited program for each engineering discipline?

	Phase 1. Initiate engineering programs based on distance learning	Phase 2. Establish engineering department and general engineering degree	Phase 3. Develop programs in major engineering disciplines
Benedictine College Activities	<div style="border: 1px solid black; padding: 2px; margin-bottom: 2px;">Hire Program Director</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 2px;">Use existing companion degrees in science and mathematics</div> <div style="border: 1px solid black; padding: 2px;">Dual degree programs/curriculum development</div>	<div style="border: 1px solid black; padding: 2px; margin-bottom: 2px;">Expansion of engineering faculty justified by enrollment</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 2px;">In house engineering degree as companion to UND degree</div> <div style="text-align: center;">↓</div> <div style="border: 1px solid black; padding: 2px;">Complements UND discipline-specific degrees</div>	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Student enrollment will indicate in what order disciplines should be established</div>
Laboratory Experiences	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Summer laboratories at UND</div>	<div style="border: 1px solid black; padding: 2px; margin-bottom: 2px;">Some UND laboratories still required</div> <div style="border: 1px solid black; padding: 2px;">On-site laboratory development</div>	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Build from laboratories established in Phase 2</div>
BC-UND Agreements	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Articulation agreements, financial arrangements</div>	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Teach more courses in house; update articulation agreements with UND</div>	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Relationship with UND adjusts to complement new program</div> <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <div style="border: 1px solid black; padding: 2px; width: 40%;">Increases number of electives</div> <div style="border: 1px solid black; padding: 2px; width: 40%;">Increases frequency of course offerings; greater scheduling flexibility</div> </div>
ABET Assessment		<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">ABET accreditation of general engineering degree</div>	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">ABET accreditation of each discipline</div>

**Figure 3:** Details of model implementation at Benedictine College

## Implementation of the BC Engineering Model

The barriers of implementing an engineering program, which are primarily the cost and risk, have previously prevented BC from initiating an engineering program. Like hundreds of 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, but determined that it would be prohibitively expensive. Because of the opportunity provided by UND DEDP, this initiative was reexamined, and *BC Engineering Model* provided the means to move forward with an engineering program of considerably greater scope with much less cost and risk than was previously considered.

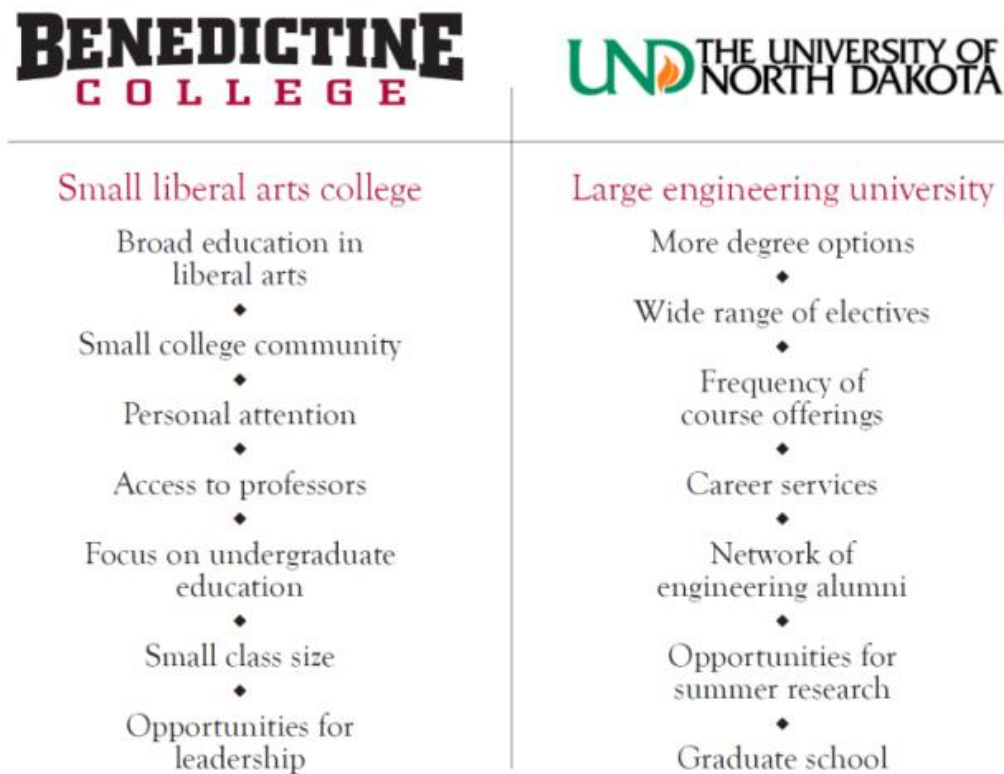
The BC-UND partnership provides an ideal proving ground for the model and will evaluate each of its essential components. This program not only provides students with high-quality distance education from the leader in this field, but students also enjoy all of the benefits of attending a small liberal arts college with a cohort of other students pursuing the same degree:

- 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 UND DEDP courses.
- All engineering faculty at BC are committed to incorporating the most effective<sup>29,30</sup> active learning and inductive teaching methods<sup>21-23</sup> into the on-site engineering courses. In every engineering course taught at BC, students are engaged in several of the following: group projects, inductive learning, in-class group problems, and discovery-, case-, and problem-based learning.
- Students 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.
- A BC faculty or staff member is assigned to monitor each distance course, during which students meet in a classroom at an established time and participate actively in the course. Because courses will be delivered to groups of students in a classroom, the students will be able to participate fully in group problems, case studies, and other active learning activities frequently employed by engineering faculty. This aspect of the model addresses the difficulty of incorporating active learning in distance classes<sup>24-26</sup>.
- Students will not be isolated. They will form study groups and participate in on-site engineering student societies (BC Engineering Club, AIChE, ASCE, IEEE, and ASME).
- Students receive the well-known benefits of personal attention from a small college with small-class sizes.
- 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 75% of the courses in the engineering curricula that are not taken via distance education 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 superior writing, reading, and interpersonal communication skills.



- Students will have the opportunity to pursue two complementary degrees (e.g. chemistry and chemical engineering; mechanical engineering and physics, electrical engineering and computer science, etc.).
- BC's strong commitment to ethics provides graduates with a solid moral foundation.

Thus the *BC Engineering Model* will combine 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. The authors are not aware of any work on this unique application of distance engineering education. The program goes well beyond the recommendation of Skurla et al.<sup>27</sup> 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.

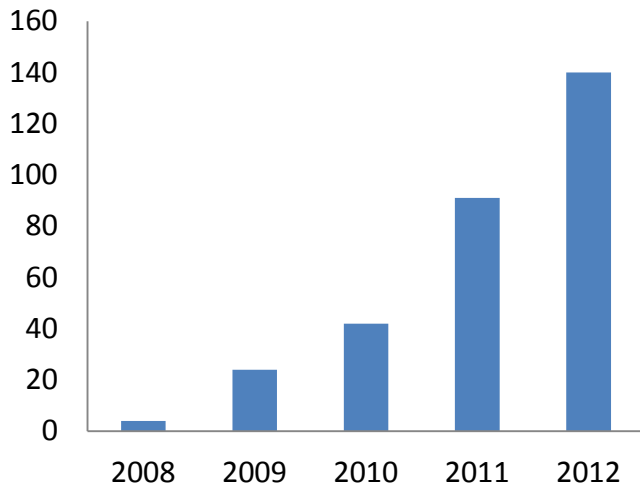


**Figure 4:** Advantages of offering engineering from a large state university at a small liberal arts college.

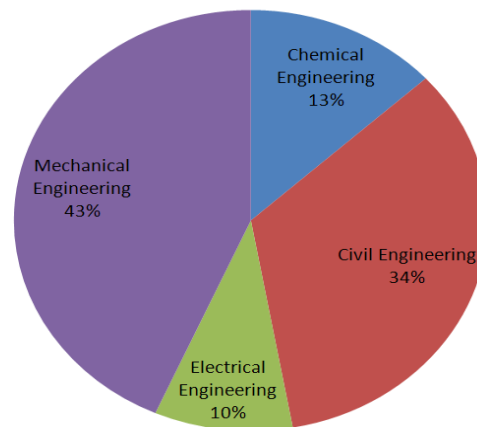
### *Enrollment*

A major indicator of success of the *BC Engineering Model* is enrollment of undergraduates in the new engineering department. The BC plan to initiate an engineering program was launched in 2008 with the establishment of an Engineering Physics major. After one year, the program had only four students who planned to continue into their sophomore year. Late in that year, BC initiated its collaboration with UND DEDP to offer its students the opportunity to pursue ABET-accredited degrees in four major engineering disciplines. Since that time the program has grown significantly. Figure 5 shows total engineering enrollment for Fall semesters of 2008-2012.

The incoming engineering freshman class of Fall 2011 was more than double that of 2010. In 2012, beginning freshman enrollment increased another 50% above the record enrollment of 2011. Figure 6 shows the breakdown of the population of engineering students (does not include freshman) by discipline.



**Figure 5:** Benedictine College Engineering Enrollment



**Figure 6:** Benedictine College Engineering students by discipline.

### *Phase 1 Results*

As mentioned above, Phase 1 of the model involves establishing dual-degree programs between the engineering disciplines offered via UND DEDP and the existing majors at the on-site location. BC has completed Phase 1 and the results that have been published previously<sup>3</sup> are summarized below:

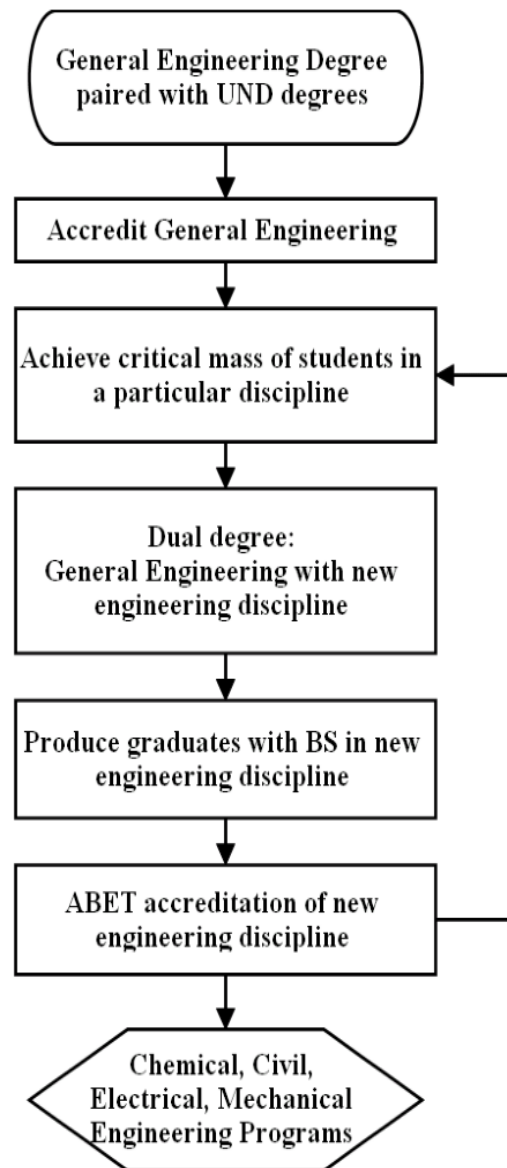
- BC Engineering established articulation agreements and designed five-year dual-degree programs (average load: 16 cr/semester) between the four UND engineering disciplines and BC Math, Chemistry, and Physics.
- The UND DEDP course offering frequency was increased to accommodate the five-year plans.
- Brochures were developed and BC Engineering faculty members attended several recruiting events to promote the new program.
- A complete analysis and articulation of general education requirements at the two institutions was completed.
- Faculty members at BC and UND assessed the project and measured student satisfaction and they continue to do so.
- Program methods developed for academic advising, exam proctoring, lecture monitoring, admission and payment, senior design, summer laboratory logistics, establishment of an engineering club and professional societies, engagement of traditional college students, and reconciling the general education requirements of two colleges. These details have been presented previously<sup>3</sup>.

### Phase 2 Results

Phase 2 involves the on-site establishment of an engineering department (BC completed 2011) that offers its own General Engineering degree (BC was approved by North Central Higher Learning Commission Fall, 2011) and concludes with that program becoming ABET-accredited. It also involves growth of the on-site engineering faculty, justified by undergraduate enrollment. In addition, the BC Engineering Department engaged in several activities to better support its students in the engineering courses taught both on campus and via UND DEDP and the lessons learned from these are discussed below.

**ABET Strategy:** Once the General Engineering degree has been established in Phase 2, it can be paired with each UND discipline-specific degree. When the first student graduates with a General Engineering degree, the on-site department can apply for ABET accreditation of this General Engineering degree. Subsequently, when the on-site department is ready to initiate a discipline specific degree (such as Mechanical Engineering) that degree could be paired with the existing on-site ABET-accredited General Engineering degree. When the first on-site Mechanical Engineering graduate is produced, that degree can be accredited and the process repeated for the other engineering disciplines. Note that this strategy guarantees that every student will receive at least one ABET-accredited engineering degree as the department establishes all of the discipline-specific degrees during Phase 3 of model implementation.

**Laboratory Development:** Another major component of Phase 2 activities is the development of on-site engineering laboratories. At BC, funding for equipment was provided by alumni donations as well as two grants from the National Science Foundation, two Westerman Foundation grants, and one grant from the W.M. Keck Foundation. Initially, enough “turn-key” equipment was purchased to teach the labs for the first time, with continued development in-house of experiments designed and built by students, faculty, and staff. Each laboratory course was designed to have a core set of experiments taken by all engineering students as well as a set of discipline-specific experiments. For the core experiments, students are assigned to multidisciplinary teams whereas teams are reformed along engineering discipline lines for the specialized experiments. This strategy serves multiple purposes. Firstly, it provides essential



**Figure 7:** Strategy to guarantee students at least one ABET-accredited engineering degree during program development.

experience for students to work on multidisciplinary teams. Secondly, it provides students with the opportunity for in-depth, hands-on exploration of concepts in their own engineering discipline. Thirdly, it allows the same laboratory course to articulate to different engineering disciplines at UND by targeting multiple educational objectives. Finally, it allows the development of the discipline-specific laboratories required for Phase 3 of the model, in which the on-site institution initiates discipline-specific degree programs.

Curriculum Design: As mentioned above, the on-site General Engineering degree was designed to complement each of the four discipline-specific UND engineering degree programs. It utilizes a set of engineering core classes taken by all students as well as emphasis areas that correspond to one of the UND degrees (students must select at least one emphasis area for their General Engineering degree). Similar to the strategy for laboratory development, this allows the curriculum to develop in each discipline for Phase 3.

The model also allows for another level of curriculum design. That is, the choice of which engineering courses will be taught on site and which taken from UND DEDP is largely a decision for the on-site institution. Thus, the articulation agreements with UND DEDP can be customized according to the interests and qualifications of the on-site faculty. Moreover, at BC the UND DEDP courses are carefully assessed on site and the overall program is designed so that only the best UND DEDP courses are used and the rest are taught by on-site faculty. The one constraint in this process is that a minimum of 30 credits must be taught by UND DEDP in order for students to earn a UND engineering degree. This strategy also invigorates the students as they realize that they are actively involved, through their feedback, in the curriculum design of the overall dual-degree program.

BC Engineering Mentorship Program: BC has an existing student mentorship team, made up of eleven recent college graduates, whose focus is to interact with students to help them develop personally and professionally. The BC Engineering Department has recently partnered with the existing mentorship program to provide four engineering mentors (one in each discipline) focused on supporting engineering students. These mentors, who will be part of the campus-wide mentorship team, will make substantial connections with the students and aid their learning. These recent graduates are selected specifically for their ability to: make connections with engineering undergraduates, act ethically, mentor students, and provide a strong example of an engineering professional. These mentors facilitate classroom learning during UND DEDP lectures, provide recitation and homework help sessions, and interact with students outside of classroom and academic activities. As these mentors have no grading duties, they are able to create strong bonds with undergraduates, as their only focus is to help students. Indeed, a significant portion of their time is spent interacting with students outside of an academic environment in order to build a relationship between mentor and student that could not be realized between students and faculty. Two engineering mentors have been hired for Fall 2012 and two additional mentors will be added over the next two years.

BC Engineering Career Fair: One challenge in the establishment of a new engineering program is the cultivation and development of industrial contacts to provide internship, cooperative education, and full-time employment opportunities to students. Students in the program benefit from the Career Services facilities of two institutions (BC and UND). Challenges exist however, in that the services of the established engineering school (UND) are located 650 mi. away and

the Career Services office at BC has not yet established relationships with engineering employers. Current initiatives in this area include the following:

- Providing funds for student transportation and lodging to attend Career Fairs at UND, Kansas State University, and Iowa State University.
- Establishing a BC Engineering Career Fair, that will be scheduled to complement the regional career fairs taking place at the University of Kansas and Kansas State University (located 50 and 100 mi. from BC, respectively).
- BC faculty to work closely with its regional advisory board members to visit regional engineering firms to establish relationships with them.

## 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. Nearly all of the BC Engineering students completed their UND DEDP courses satisfactorily and engineering enrollment is increasing at a rapid pace. The program produced its first batch of graduates in Mechanical and Electrical Engineering in 2012. All of the program's graduates received engineering employment offers before they graduated and all of them passed the Fundamentals of Engineering examination on their first attempt. Thus a successful engineering program can be established without the need for a large engineering faculty on site. That is, BC Engineering has shown that Phase 1 of the model can be successful. Current Phase 2 activities at BC have revealed additional advantages of the *BC Engineering Model* which include: a pathway to guarantee at least one ABET-accredited engineering degree for each student, flexible development of laboratory and curriculum, the opportunity to develop a hybrid curriculum that combines the strengths of UND DEDP and the on-site institution, and an innovative mentorship program to further enhance student learning on site.

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