Collaborative Engineering Programs at Frostburg State University

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Abstract
This paper describes the engineering programs at Frostburg State University, Maryland, developed jointly by the University of Maryland, College Park (UMCP), and Frostburg State University (FSU). The programs were established in 1997 to serve the students from the surrounding rural areas and thus to serve as a vehicle to enhance the economic development of the region. Nearly a three-fourth of courses in the program are taught by the faculty at FSU, while the remaining are taught over interactive television by faculty at UMCP. Six students from the first batch graduated in May 2001. The challenges encountered in the process so far and the resulting modifications made are described.

Introduction
Technology in recent years has enabled a viable alternative to the traditional university programs in the form of distance education. Distance education programs in different forms have existed for a long time. Correspondence courses were known to have existed in a primitive form in the nineteenth century[1]. Oxford and Cambridge offered extension courses in as early as 1858 to meet the people's demand for access to the educational resources provided by these universities[2]. Since then, several improvements occurred in distance education. The use of television in a variety of forms commenced in the 1960s and is now an important part in distance education[3]. With the advent of Internet in the recent years, the opportunities for distance education have widened. Today, distance education is primarily carried out using four types of media: print, voice, video, and computer[4]. Institutions such as the University of Phoenix, the United States Open University, Western Governors University, and the National Technological University are utilizing these media to offer complete undergraduate and/or graduate programs in distance[5].

While such programs offer the student more choices then ever before to earn a degree, only a limited number of opportunities exist for one to pursue an undergraduate degree in engineering. This is mostly due to the fact that a number of courses in such programs carry a considerable laboratory and/or design component, normally hard to offer in a distance education mode. This difficulty has often been overcome by universities such as University of North Dacota[6], by separating the theory and the laboratory component and offering the theory component in a distance-education mode and conducting the laboratory component in a compressed format during summers on campus.

On the other hand, limited options exist for those living in the vicinity of only a non-engineering university and desiring to pursue an undergraduate degree in engineering. One option for them would be to move to another location where a university offering an engineering degree exists. The second would be to participate in a 3+2 dual-degree program at the non-engineering university, if one exist, that utilizes the non-engineering university's resources for the non-engineering courses during the first three years of study, and the engineering university's resources for the engineering courses during the last two years of study. The current paper presents a third option that combines a traditional university program with distance education to offer undergraduate programs in engineering for the qualified students. Such programs were started five years ago at Frostburg State University in western Maryland. Seven students in all, six in mechanical engineering and one in electrical engineering, received their degrees from these programs so far. This paper describes the salient features of these programs, in particular the Mechanical Engineering (ME) program, and also lists the problems encountered so far and the resulting modifications.

Background

Frostburg State University (FSU) is a multi-purpose, largely residential, regional university, serving as a premier educational-center for Western Maryland. Founded in 1898, it is the University System of Maryland's only four-year institution west of Baltimore/ Washington metropolitan areas. The University offers Bachelors and Masters degrees in a variety of fields and has an average enrollment of 5,100 students[7]. Undergraduate programs offered by the university include physics, mathematics, computer science, business administration, biology, chemistry, art, and education. Physics (currently Physics and Engineering) is one of the seventeen departments in the College of Liberal Arts & Sciences, one of the three colleges at the University. The Department, prior to 1997, offered a B.S. degree in physics and a dual-degree engineering program in collaboration with University of Maryland, College Park.

University of Maryland, College Park, (UMCP), on the other hand, is a major public research university, located along the Baltimore-Washington, D.C. high-tech corridor. Regarded as the flagship of the University System of Maryland, UMCP has a student population of more than 33,000[8]. A. James Clark School of Engineering, one of the thirteen colleges and schools in the university, offers 13 graduate programs and 11undergraduate programs, including those in mechanical and electrical engineering. Departments of Mechanical Engineering and Electrical and computer Engineering form two of the seven departments in the College and offer Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

The notion for collaboration between the two universities was conceived eight years ago. The driving force behind the idea was to provide the regional students with an opportunity to receive an engineering degree from a nationally recognized engineering program while remaining in the small-university environment (about 150 miles away from the engineering university), and in a cost-effective manner for the universities. A second major purpose of the program was to serve as a vehicle to enhance the economic development of the region. Based on the inputs from local representatives and industry, only mechanical and electrical engineering options were considered.

After elaborate planning and procuring of the laboratory facilities, the programs began in the fall semester of 1997, with an enrollment of 39 students. Majority of the courses are taught at FSU, and for the remaining courses, distance education concepts are utilized because of the physical separation between the students and the engineering university. Laboratory, design, and non-engineering courses are taught at FSU, while the higher-level engineering courses are delivered over interactive video from UMCP.

Methodology for Delivery
Students apply to FSU for admission to the collaborative engineering program. They take FSU courses for the first two years (with the exception that mechanical engineering students do take a UMCP course in their fourth semester) and FSU courses and UMCP courses (via ITV) during the junior and senior years. After completion of 45 required credits, they apply for a 45-credit review process, as do their counterparts at UMCP. This occurs typically in the fourth semester of the program. Their applications are approved or rejected by the faculty coordinator at FSU, depending whether they satisfy certain requirements, such as passing four required courses with a C or better and maintaining an overall GPA of 2.0 or better. Students in these programs are regarded as UMCP students from the following semester, after passing the 45-credit review. Students pay FSU tuition for the first two years and UMCP tuition in their junior and senior years. FSU scholarships they may have secured during the first two years will become void once the first two years are over and they will need to apply for scholarships at UMCP, which tend to be much more competitive. Registration and other application activities are all performed at FSU, through the administrative aide at the Department.

Faculty and Staff
Two faculty members were hired for the program at FSU, one for mechanical engineering and the other for electrical engineering. An administrative aide was also hired at FSU to coordinate the program and a part-time technician to provide assistance with the machine-shop activities. The faculty member in mechanical engineering teaches courses such as the capstone design course, product engineering and manufacturing, fluid mechanics, heat-transfer, materials science, and mechanics of materials courses. Other required engineering courses such as introduction to engineering design, statics, dynamics, numerical methods in mechanical engineering, and electronics and instrumentation - I and II are taught by physics faculty. In electrical engineering, all but two of the required courses are taught by the electrical-engineering faculty member, while two are taught by an adjunct faculty. The administrative aide manages the program. She performs activities like scheduling of courses, monitoring the Interactive Television (ITV) courses, sending the student work to UMCP and distributing the corrected work, proctoring exams for the ITV courses, interacting with the faculty at UMCP for textbook orders, etc., keeping up the student records, student advising, and acting as a liaison between the Department and administrative offices, such as the office of the financial aid and office of the registrar.

Facilities
Laboratory facilities for all required courses in the program are in place at FSU. The different laboratories that students in the Mechanical Engineering program use consist of the Thermofluid Sciences Laboratory, Materials Science Laboratory, Electrical Engineering Laboratory, Microcomputer Based Laboratory (MBL), Active Learning Laboratory (ALL), and Engineering Computer Laboratory. All of the engineering laboratories have been funded by external grants and by funds from the University System of Maryland (USM).

The Thermofluid Sciences Laboratory is equipped to serve 12 students at the same time for performing experiments in fluid mechanics and heat and mass transfer. The equipment for experiments in fluid mechanics include a hydraulics bench, a flow-measurement device, a jet-impact device, two friction -losses devices, one for moderate Reynold's numbers and the other for turbulent flows, a transitional flow demonstration apparatus, a low-speed wind tunnel, a flow channel, and an air-flow bench. The heat transfer equipment include a laminar/viscous flow heat exchanger unit, a boiling heat transfer unit, a cross-flow heat exchanger unit, a thermal radiation unit, a conduction heat transfer setup, a Pentium computer, and several temperature-measuring devices.

The Materials Science Laboratory consists of an ultimate tensile-testing machine, a Pentium computer, a computerized thin-cylinder apparatus, an impact-testing machine, a hardness tester, a creep-measuring apparatus, a rotating-fatigue measurement device, a microscope, a gas-fired furnace, a hydraulic press, and a rolling machine. This laboratory is primarily used to perform experiments in the Materials Science and Mechanics of Materials courses and accommodate 12 students at a time.

The Electrical Engineering Laboratory has 11 student stations. Each station is equipped with basic equipment such as a function generator, a digital multimeter, a monitor, and related equipment, tools, and supplies. It also houses a computer equipped with a data acquisition system and virtual instrumentation and a Lab-volt electromechanical unit, consisting of several modular units in a dc generator/motor, a dynamometer, an induction motor, a synchronous motor/generator, and a three-phase transformer, with different resistive, inductive, and capacitive loading configurations. This laboratory is primarily used for courses in electrical engineering and for the two electronics and instrumentation courses in mechanical engineering.

The MBL and ALL laboratories are primarily used for instructing physics courses. The MBL laboratory consists of five hexagonal tables, each equipped with two computers. The computers are interfaced with various measuring devices to measure different physical quantities and parameters and host a variety of mathematical and engineering software. The ALL laboratory is similar to the MBL laboratory, with the exception that it has mobile computer units.

The Engineering Computer Laboratory houses 14 Pentium computers and 6 UNIX wok-stations. This laboratory is primarily used for engineering courses with computer content and also for providing the students with access to computers. In addition to the above, the Department also possesses another 9 UNIX workstations and 8 Pentium computers, for use by the engineering students.

In addition to the above, the Department also possesses a machine-shop, equipped with a milling machine, two drill presses and a precision drilling machine, a lathe, a grinding machine, and several other machine tools, power tools, and hand-tools. This workshop primarily serves as the area where the students can get parts made for their student projects. The department also provides another area with hand-tools to serve as an assembly/fabrication area for the design projects.

Finally, the distance-learning class rooms at FSU comprise interactive television equipment, capable of transmitting and receiving digital data through fiber-optic lines, thus providing a two-way real-time communication. The three available class rooms are each equipped with large screen monitors, a fax machine, a document camera, a telephone, a computer, video cameras, and microphones. The Department owns several laptop computers, which can be used by the students, should the need arise in the ITV courses.

Curriculum
The curriculum of the undergraduate program in Mechanical and Electrical Engineering is fairly typical for the respective fields (Tables 1 and 2). The engineering courses build on each other and are offered in sequence. Approximately three fourths of the required courses, including the courses in engineering science, some of the core courses in mechanical and electrical engineering, design courses, all courses having a laboratory component, mathematics and physical sciences courses, and courses in the general education program, are taught on the campus, at FSU. Some specialized courses in the respective engineering disciplines are delivered from UMCP, via ITV. As an example, there are three required courses in mechanical engineering that have a design component: ENES 100 - Introduction to Engineering Design, ENME 371 - Product Engineering and Manufacturing, and ENME 472 - Integrated Product and Process Development (capstone design course). All these courses require the students to design and fabricate an object of interest. Such courses would be hard to be delivered over distance, especially if the two institutions are not within commuting distance, and hence are offered on site, at FSU. Similarly, courses such as ENME 271 - Numerical Methods in Mechanical Engineering, ENME 331 -Fluid Mechanics, ENME 332 - Transfer Processes, ENME 350 and 351 - Electronics and Instrumentation I and II, and ENME 382 - Engineering Materials and Manufacturing Processes involve theory and laboratory and/or computer component. Such courses, once again, are taught by the faculty at FSU. Engineering Science courses such as ENES 220 - Mechanics of Materials and ENES 221 - Dynamics and all Physics, Chemistry, and Mathematics courses are taught on site, along with courses in general education.

The Mechanical Engineering program requires that six electives be taken, out of which at least one should be a non-technical elective, with a limit of two non-technical electives per student. All of the technical electives in the program are delivered by ITV from UMCP. In addition, ENME 320- Thermodynamics, ENME 392 - Statistical Methods, ENME 361 - Vibration, Controls and Optimization I, and ENME 462 - Vibration, Controls and Optimization II are taught by the faculty at UMCP via ITV.

Issues in Implementing the Program
Several concerns arose while implementing the program. Some of these are administration related, while others are distance-education related.

The administrative issues are mostly registration and financial-aid related. Registrar's Office at FSU encountered problems in separating the students in these programs from the regular FSU students. These students are different from the regular students that they take courses from both FSU and UMCP and that their registration and grade information should be passed onto UMCP. More problems were encountered from the fact that the students pay FSU tuition for the first two years and UMCP tuition during the junior and senior years. Further, students lose their FSU scholarships once they become UMCP students and will need to apply for scholarships at UMCP. Several problems were encountered in achieving a seamless transition of this procedure. Registration became a problematic area initially. However, the Registrar's Office came up with a method of registering the collaborative students: they requested that these students be advised prior to regular advising commences and that their registration slips be collected together by the administrative aide at the Department and sent to their office. They would then code the students appropriately and register them in both FSU and UMCP courses as required. At the end of the

Table 1: Undergraduate Program in Mechanical Engineering - Curriculum (126 credits)

FRESHMAN YEAR

Fall Courses	Credits	Spring Courses	Credits
ORIE 101 Intro. to Higher Education	1	MATH 227 Calculus II	3
MATH 226 Calculus I	3	PHYS 262 Principles of Physics II	4
PHYS 261 Principles of Physics I*	4	ENES 102 Statics	3
ENES 100 Intro. to Engineering Design	3	CHEM 101 General Chemistry	4
ENGL 101 Freshman Composition	3	General Education	3
General Education	3		
TOTAL FALL	17	TOTAL SPRING	17
TOTAL FRESHMAN YEAR CREDITS = 34			

SOPHOMORE YEAR

Fall Courses	Credits	Spring Courses	Credits
MATH 228 Calculus III	3	MATH 320 Multivariable Calc.	3
PHYS 263 Principles of Physics III	4	ENME 271 Numerical Methods in Mechanical Engineering	3
ENES 220 Mechanics of Materials	3	General Education courses	6
ENES 221 Dynamics	3	ENME 320 Thermodynamics	3
CHEM 102/133 General Chemistry II	3-4		
TOTAL FALL	16-17	TOTAL SPRING	15
TOTAL SOPHOMORE YEAR CREDITS = 32			

JUNIOR YEAR

Fall Courses	Credits	Spring Courses	Credits
MATH 432 Differential Equations	3	ENME 351 Electronics and Instrumentation II	3
ENME 331 Fluid Mechanics	3	ENME 332 Transfer Processes	3
ENME 350 Electronics and Instrumentation I	3	ENME 361 Vibration, Controls and Optimization I	3
ENME 371 Product Engr. & Mfg.	3	ENME 382 Engr. Materials & Mfg. Processes	3
ENME 392 Statistical Methods	3	ENGL 338/339 Technical Writing	3
TOTAL FALL	15	TOTAL SPRING	15
TOTAL JUNIOR YEAR CREDITS = 30			

SENIOR YEAR

Fall Courses	Credits	Spring Courses	Credits
ENME 462 Vibration, Controls and Optimization II	3	ENME 472 Integrated Product & Process Development II	3
ME Technical Electives	9	ME Technical Electives	6
General Education course	3	Non-ME Technical Elective	3
		General Education course	3
TOTAL FALL	15	TOTAL SPRING	15
TOTAL SENIOR YEAR CREDITS = 30			

= Interactive Video Course

Table 2: Undergraduate Program in Electrical Engineering - Curriculum (126 credits)

FRESHMAN YEAR

Fall Courses	Credits	Spring Courses	Credits
ORIE 101 Intro. to Higher Education	1	MATH 227 Calculus II	3
MATH 226 Calculus I	3	PHYS 262 Principles of Physics II	4
PHYS 261 Principles of Physics I*	4	ENEE 114 Programming Concepts	4
ENES 100 Intro. to Engineering Design	3	CHEM 101 General Chemistry I	4
ENGL 101 Freshman Composition	3		
TOTAL FALL	14	TOTAL SPRING	15
TOTAL FRESHMAN YEAR CREDITS = 29			

SOPHOMORE YEAR

Fall Courses	Credits	Spring Courses	Credits
MATH 228 Calculus III	3	MATH 320 Multivariable Calc.	3
PHYS 263 Principles of Physics III	4	ENEE 204 Basic Circuit Theory	3
ENEE 241 Numerical Techniques in Engineering	3	ENEE 206 Electrical and Digital Circuit Lab	2
ENEE 244 Digital Logic Design	3	ENGL 339 Technical Writing	3
CHEM 102/133 General Chemistry II	3-4	General Education courses	6
TOTAL FALL	16-17	TOTAL SPRING	17
TOTAL SOPHOMORE YEAR CREDITS = 34			

JUNIOR YEAR

Fall Courses	Credits	Spring Courses	Credits
MATH 432 Differential Equations	3	ENEE 306 Electronic Circuits Design Lab	2
PHYS 312 Electricity and Magnetism	4	ENEE 312 Analog Electronics	3
ENEE 302 Digital Electronics	3	ENEE 324 Engineering Probability	3
ENEE 322 Signal & System Theory	3	ENEE 381 Electromagnetic Wave Propagation	3
ENEE 350 Computer Organization	3	Math elective	3
		General Education course	3
TOTAL FALL	16	TOTAL SPRING	17
TOTAL JUNIOR YEAR CREDITS = 33			

SENIOR YEAR

Fall Courses	Credits	Spring Courses	Credits
Advanced Lab Elective	2	ENEE 408 Capstone Design	3
EE 400 Level Electives	6	EE 400 Level Elective	3
Non-EE Technical Electives	3	Non-EE Technical Electives	6
General Education Courses	6	General Education courses	3
TOTAL FALL	17	TOTAL SPRING	14
TOTAL SENIOR YEAR CREDITS = 31			

= Interactive Video Course

semester, they would extract the records of these students using the special code, and transmit the required records to UMCP. This procedure was implemented and has been working without any problems. Financial aid issues, however, persisted longer. Many students in the last two years complained of financial aid not being transferred smoothly at the end of the sophomore year. Apparently the problem has been due to lack of knowledge of this program at the Financial Aid Office at UMCP, which has been corrected since then, with help from the Undergraduate Affairs Office at UMCP and the Financial Aid office at FSU.

Several problems emerged with the ITV courses. Some of the problems are technical in nature: not being able to connect to the server on time, gradually disappearing image due to monitor problems, the time delay in transmission and receiving due to the compression and decompression (CODEC) of the data, audio problems, etc. Most of these could be corrected: dedicated personnel are now allocated for switching on the system before the class time and switching off after the class and monitors and microphones were replaced. Other type of problems also arose: cameras not following the faculty or the board well enough or remaining stationery for extended periods of time or not focusing well on the board. Communicating this problem to the cameramen or posing a question to the faculty also became a problem occasionally, as the TV monitors at UMCP course site had to be muted some times to eliminate noise. Such problems and possible solutions are being examined.

Performing demonstrations or occasional laboratory experiments in these courses also proved to be a problem in the early stages. Some times studios had to be performed in classrooms other than the ITV rooms at UMCP. These had to be videotaped and sent to students at FSU. These videotapes proved to be of poor quality on some occasions. These problems are solved by the faculty at UMCP, by inviting the students to UMCP for an entire day and performing the studios at UMCP specially for the FSU students, and by making trips to FSU and performing the studios at FSU. Other problems associated with these courses include receiving graded student assignments and exams much later than their counterparts at UMCP and receiving no direct help from the teaching assistants (TA). These problems and possible solutions, such as faxing the homework, allocating special TA hours, etc., are being examined.

Accessing the software and library facilities at UMCP proved to be another problem in the early stages. This problem was overcome by obtaining UNIX computer accounts at UMCP for the students. Using those computer accounts, the students can log on to the servers at UMCP from UNIX workstations at FSU and with proper graphic interface, can access the software available on UMCP servers. Likewise, library services such as electronic databases, full-text journal articles, etc. can be accessed using the same accounts. Students can then print these articles or save them on the local workstation. A drawback exists in this system: Articles published in the recent years only can be obtained, as libraries do not usually subscribe to the entire database. If papers published in earlier years are desired, the students will need to request an inter-library loan or make a trip to the UMCP library. Textbooks available at the UMCP library can also be borrowed using the inter-library loan privileges.

Benefits of Implementing the Program

The program appears to have achieved its primary goal of providing the local students with an opportunity to receive an engineering degree from a nationally recognized engineering program while remaining in the small-university environment. The program graduated seven students in 2001, six in mechanical engineering, and one in electrical engineering. Three Students have gone to graduate schools and four have gone to industry. Two out of the four graduates working are working for a local company, the Allegany Ballistics Laboratory.

From a student standpoint, the advantages of the program seem to outweigh the disadvantages with the distance education component. Most students taking the ITV courses were surveyed and have expressed satisfaction over the quality of transmission of the ITV courses. Even though the limitations in technology such as delayed response to questions and jerky video are somewhat distracting initially, they seem to become less noticeable over time. The largest advantage to most students from this program appears to be in the form of small class sizes and individual attention received from the faculty in FSU courses - all the recitation and laboratory sessions are taught by the faculty as no teaching assistants are available locally, as opposed to the courses offered at larger universities. The small numbers of students in classes also lets them perform laboratory studios individually or in groups smaller than those at UMCP. This individual attention and small class sizes seem to aide the success of most moderate students, who might otherwise have dropped out of the program (had they gone to a larger university). This fact also seems to have compensated for the problems faced in the delivery of the ITV courses. Further, improvements in technology will likely make the transmission of the ITV courses better, and consequently, the program is likely to become more attractive in the future.

From a faculty standpoint, the amount of additional planning and preparation time expended for the ITV courses makes them less attractive than traditional courses. However, faculty teaching these courses in this program are aware of this fact and are motivated to face the challenge. Because of the "distance" component entering as another obstacle to student learning, they have been making modifications in their teaching methodology, for example, by promoting brainstorming activities, group studios, and class discussions. To alleviate the problems such as the camera not following the faculty writing on the white board or following too fast or displaying only a limited amount of written material, most faculty now post their lecture notes on the internet. Some faculty have been engaging the students in computer activities, which they can witness on their monitor. They make trips to the local campus typically once a month to meet the students and some times transmit lectures from there back to the parent institution. The problems encountered in delivery thus make the faculty develop delivery methods that would overcome the problems, which is helpful in keeping the faculty abreast of new developments in distance education and/or developing new delivery methods.

Conclusion

This paper describes a collaborative engineering program that combines traditional courses with interactive television courses to offer students in the remote areas a degree in engineering from a reputed institution. From the first four years of experience, it appears that such a program can be successfully implemented. Seven students graduated from the program in 2001, six in mechanical engineering, and one in electrical engineering. Three Students have gone to graduate schools and four have gone to industry.

Surveys performed indicate that the students are satisfied with the quality of the program. Inputs from the constituents will be used to further improve the quality of the program.

To date, the collaborative engineering program experience has been a very positive one. The end result is a situation where every one comes out a winner: the student and the universities involved.

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