A Graduate Engineering Program
at a Liberal Arts College

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Introduction

Loyola College in Maryland is a small liberal arts college. In 1977, Loyola, then predominantly an undergraduate college, started a graduate program in Engineering. There existed at that time an undergraduate department in Engineering Science, Computer Science and Physics (ENSCAP). The goal of the undergraduate department was to provide a rigorous engineering program for students who also wanted to have a background in the liberal arts. It was our conviction then, as it is now, that engineers, in addition to being well trained in their disciplines, should also know how to write and speak and appreciate the classics. The graduate program originally was in the ENSCAP department. The goal of the graduate program was initially to provide quality graduate courses for engineers who were having difficulty keeping abreast of the changes in the world of electrical and computer engineering, changes brought about largely because of the rapid growth of the microelectronics industry.

Beginning of the Program

In the 1950's, Loyola College, a small liberal arts college with a good reputation in the sciences, added an engineering physics option to the Physics major, a major which had existed for many years. The engineering option was intended to allow students to take their first two years at Loyola, taking mainly liberal arts courses, which included math and physics, and then transfer to the Johns Hopkins University. Hopkins is only about a mile away from Loyola. The student would then attend Hopkins for three years to complete his degree requirements. The combined program took the student 5 years and he finished with a bachelors degree in engineering. Because of the 5 year completion time, the program was not extremely popular. Loyola then started to add engineering courses of their own, allowing the student to finish Loyola College in 4 years with a degree in Physics Engineering and then go on to Hopkins where the student could get a master's degree in a year, concentrating on a particular major such as Electrical Engineering, Civil Engineering or Materials Engineering. Thus the student could receive a bachelors degree and a masters degree in the same 5 year span as it previously took to receive just a bachelors degree. This program was much more popular with the students. The courses offered at Loyola concentrated on the basic engineering courses in statics and dynamics, electricity and magnetism and materials plus advanced courses in areas such as mathematical physics. When our graduates competed with students from more traditional engineering programs, the advanced theory courses allowed them to hold their own even though they did not have all of the undergraduate courses normally taken in engineering schools.

The four year program at Loyola gradually evolved into an Engineering Science program that was recognized by all of the major engineering graduate schools and our graduates went on to a variety of graduate schools across the country. In fact, industry also recognized the value of having engineers who were trained in ways other than the traditional engineering school way and our graduates were recruited right out of Loyola with a bachelors degree in Engineering Physics.

During the early 1970's, not too many small colleges had their own computers. Being the innovative program that it was, Loyola's Engineering program was fortunate to have access to computer resources through a variety of different paths. Two different industrial corporations, one in electronics and one in civil engineering, allowed our students to use their computer facilities after work hours. Our good working relationship with Johns Hopkins University even allowed computer facilities to be available on our campus using "timesharing" through the Hopkins switchboard. And finally, largely as a result of a National Science Foundation (NSF) grant, we were able to purchase a small minicomputer, a DEC PDP11/20, which was housed in the Physics and Engineering department and used in a local timesharing mode. It was the first computer on campus. With these facilities now available, there was a demand for computer courses to be offered by our department, courses which had never before been seen as necessary. Courses in BASIC and FORTRAN were originally offered by professors of Engineering and Physics. There were few Computer Science professors in 1972, in fact the discipline was just starting. The demand was so great for computer courses that by 1976 enough courses were being offered by our department that a major in Computer Science was introduced. It quickly became the fastest growing major on campus. A separate department was not formed at that time. The Computer Science discipline was added to the Department of Engineering Science and Physics. It became the department of Engineering Science, Computer Science and Physics (ENSCAP). Because of this original orientation, Computer Science has had, and continues to have, a strong engineering flavor at Loyola.

Since the field of Computer Science was new and industry did not have enough engineers well trained in this field, knowledgeable professors were sought by industry as consultants. This arrangement benefited both industry and the university. Industry had help gearing up for the microelectronics revolution and were in touch with the very people they needed to inform about their personnel needs in the next year, five years and longer. The university professors on the other hand had the opportunity to experience what was going on in an emerging field, what was needed for the future, a future that would impact the lives of everyone on earth.

Beginning of the Graduate Program

An immediate advantage of this professor/industry relationship occurred when engineers working in industry came to realize in the 1970's that the developments in microelectronics, and the microprocessor in particular, made much of what they had been trained for in college obsolete. Most engineers who received their BS degrees before 1970 had not had any training in computer architecture or programming languages except for some mainframe programming in FORTRAN. The new computer designs were starting to incorporate microprocessors and these new chips had to be programmed, often in assembly language. The engineers sought out the college and university professors and requested courses and programs which would bring them up to date on

the new technology. In 1977, Loyola responded to these needs with a Master's level program in this new technology. The program initially was a mixture of hardware and software and was entitled a Master's of Engineering Science (MES) in Digital Systems.

Target Audience

The intended audience of the program has changed quite a bit since the program's inception in 1977. The original audience was almost entirely hardware and software engineers. It was designed primarily for engineers who had been out of school for more than 10 years and who needed to be brought up to date with the current state of the art. Today the typical student is not trained as an engineer but has found that the demands of his or her profession are such that he or she will profit from taking formal engineering or computer science courses. Today the Computer Engineering track is popular among students who have software backgrounds but feel they could understand the systems they are working on better if they had a better knowledge of the architecture and design of computers and the tools used in these design and fabrication. The Electrical Engineering track specializes in Communication theory and Digital Signal Processing. In the Baltimore/Washington area where Loyola's graduate programs are offered, there is a very large number of companies involved in telecommunications, ranging from small startup companies to large industrial giants. The designers of these telecommunications systems have recently been found to be in very short supply.

The students in the Computer Science track have gradually gone from being almost entirely engineers to being about two-thirds non-engineers. The enrollments recently have come from students working in banks, investment houses, health care, insurance and government. We have responded to this shift by offering courses in a variety of topics such as Object Oriented Programming, Java Programming, Windows Programming, Local Area Networking and Network Performance Management.

As the engineering profession undergoes change, the MES program has also undergone change. When the program first started, 3 large engineering corporations provided over 95% of the student body. These corporations were primarily defense oriented. When the cold war came to a close starting about 10 years ago, the number of engineers employed by these companies was cut drastically. Takeovers and buyouts changed the way companies did business. For long periods, new engineering hires, which were the mainstays of our program, no longer existed. During this period the makeup of our student population changed dramatically. Instead of 80 to 100 students from each of 3 major companies, we went to 1 to 4 students from each of over a hundred different companies, large and small. Our recruiting approach changed as our competition became keener. Our product had to be the best or our program would cease. The task of maintaining full classrooms over the past 10 years has been challenging.

Makeup of the Faculty

Approximately one third of the total number of courses offered each Fall and each Spring are taught by full-time faculty members. Every full-time member of the Computer Science Department and over half of the members of the Engineering Department participate in the

graduate program. The remainder of the courses in the program are taught by adjunct faculty members, adjunct being defined as not full time. This mix is deliberate. It was decided when the program started that in order to keep the program up to date with what was needed in the workplace, we would ask the experts who were in the workplace to design and offer courses in the program. Since our program is decidedly hands on, this approach has worked very well for the students in the program. The courses they are taking are immediately applicable to what is going current in industry, but since there is a good mixture of students from all industries, the program does not have the flavor of an in-house course. The cross-fertilization of students from various companies has had a very positive effect upon the level of the courses offered in the program as well as the interest in these courses. If we were applying for ABET accreditation, this high percentage of adjunct faculty would probably cause a problem, but in order to offer a large number of mostly specialized courses, we have little choice. The adjunct faculty member is very important to the program.

Location of Classes

When the program first started back in 1977, it was decided to hold classes off the main campus. This was done for a number of reasons. First of all, classes had to be held after work hours and there was (and still is) a parking problem at Loyola's main campus. Many of the prospective students felt that one of the reasons they had not signed up for graduate courses at some local universities which did offer graduate engineering programs was the long drive to the school after work and then the parking problem which faced them once they got there. For these two reasons, Loyola decided to hold the graduate engineering classes off campus at a location close to where the student's would be coming from. This was an easy decision because 95% of the original student body came from 3 corporations which were all located in a large industrial park within 3 miles of one another. There was an inconvenience for the professors teaching the courses who had to leave campus at the end of their workday and drive to an off campus location 16 miles away from the main campus. The thinking was that it was better to inconvenience one faculty member than the 25 or so students who made up the class. The faculty found no problem with this arrangement. Participation in teaching in the evening oriented graduate program was and continues to be voluntary. The graduate course counts as on of the 3 required courses a faculty member must teach each semester but no engineering or computer science faculty member is required to teach in the graduate program if he or she does not wish to. The response to requests to teach in the graduate program have thus-far been very positive. In fact, most faculty members look forward to their assignment in the graduate program as an intellectual and professional challenge.

As the makeup of the student body has changed, the students and their employers are no longer concentrated in one industrial park. They come from a wide range of locations. Still, they like the off campus site because there is no parking problem. There are other advantages also. About 8 years ago, the MES program expanded to a second off campus site, again about 20 miles from the main campus which is in Baltimore. The two off-campus locations are in two counties adjacent to Baltimore, one north of the city and one west. These locations are devoted entirely to graduate programs and the students like this. They like not sharing facilities with the undergraduate programs. This Fall, the location north of the city is moving to a new and larger

location not far from the present location. Loyola rents space in the present location as it has since 1977, even though it has grown in size many times since the first courses began. Loyola will own the new facility which will be available for the Fall 1998 semester. It will incorporate many of its graduate programs, which are now scattered over many locations, in the new facility. The executive MBA programs, the entire graduate Education program, the nationally known Speech Pathology program and a new Physician Assistant program will be anchored at this new location in addition to the Master's of Engineering Science program. The off campus site for the part-time graduate program was a good choice and probably has much to do with the continued success of the program.

Introductory Courses

The first three advanced courses were Introduction to Microcomputer Programming, a predominantly software course, Introduction to Microprocessors, a predominantly hardware course, and Introduction to Digital Signal Processing, a Digital Systems course. It soon became apparent that not only did hardware people want to learn more about software but software people wanted to learn more about hardware. Both types were attracted to the new program. It also became apparent that many hardware people were having trouble with software and that many software people were having trouble with hardware. In the first two courses, the hardware course and the software course, the classes were split dramatically. Some of the students were having lots of problems while the remainder were having no trouble at all. In the second course, we found the same thing only the groups were by and large reversed. To counter this, we added 4 Introductory courses to the program in addition to the Advanced courses which were required of all students. The Introductory courses provided background for new students who needed it before starting the program. These courses could be waived without replacement if the student didn't need them. We placed the Introduction to Microcomputer Programming , Introduction to Microprocessors,   and Introduction to Digital Signal Processing in this category. This solved two problems. If the student had a good background in a subject, he or she did not need to waste time taking a course that wasn't needed. Also, students who really needed help in a subject did not have to stressed while the rest of the class learned quickly.

As the number of tracks have grown, we have added more and different Introductory courses. The purpose of the Introductory courses is to provide background for the student before he or she embarks upon the Advanced courses and possibly finds out that they are not prepared for them. We recommend them but we don't insist upon them. It is up to the student to decide whether they need the Introductory courses or not.

Additional Tracks

As we said, the original program offered a MES in Digital Systems. As courses were added, the majority of them fell into the software variety. Courses such as Data Structures, Structured Programming, Compiler Theory and Operating Systems were added to the program as the need arose. Eventually, we added a Computer Science concentration, or track, in addition to the Digital Systems. Later the Digital Systems track was further refined into a Computer Engineering and an Electrical Engineering track. Each track requires students to take 8 advanced courses in

that track. At least 20 courses are offered in each track. There is some overlap between tracks. For example, Operating Systems is an advanced course in both the Computer Science (CS) track and the Computer Engineering (CE) track while Coding Theory is an advanced course in both the Computer Science (CS) track and the Electrical Engineering (EE) track. At present, we are considering two new tracks, one in Network Engineering (NE) and one in Computer Applications (CA). These new tracks will be announced later in the year.

Required Courses in each Track

Of the 8 required advanced courses, 4 are specified in each track. The remaining 4 advanced courses can be selected from any of the remaining courses in that track listed in the catalog. This list changes from year to year as we strive to keep up with the needs of the student and the current state of the art. Courses are added and deleted on a regular basis although some courses have been on the books since the program started in 1977. In most tracks, the student has some choice even within the 4 required courses. For example in the CS track, a student may elect Compiler Theory or Algorithm Design for his Theory component. The reason we chose to specify 4 of the 8 track courses was that, since a student did not need an undergraduate degree in a particular area to enter a track, we had to make sure that he mastered a certain common body of knowledge before being granted a Master's degree in, say Computer Engineering. It is the belief here that with 4 specified Introductory courses and 4 specified Advanced courses, we could ensure that the student had acquired this minimum common body of knowledge.

Advanced Elective Courses

In addition to the 8 courses in a particular track, each student is required to take 3 advanced elective courses which can come from anywhere in the program (and in some cases, in an entirely different program). This requirement can be satisfied in a number of different ways. First of all, the student can simply take 3 more courses in his or her concentration. This gives the student the maximum number of courses in an area that he or she has the most interested. Secondly, a student can take courses in a different track. Many students want to get more expertise in a particular track, e.g. CS, but want some exposure in a different area, e.g. EE. This allows them to sample up to 3 courses without committing to an entire track. For this reason, we allow students in one track to elect Introductory courses in another track as elective courses since these courses are prerequisites to the advanced courses in that track. And finally, students can take courses in other programs at Loyola with permission of the director of the program. A new Masters of Business Administration (MBA) option allows students who may be in management to take some business courses while still taking all of the technical courses they need. Typical courses in the MBA option include Introduction to Business Administration, Introduction to Marketing and Introduction to Financial Management. These courses then also count toward an MBA degree if the student decides to pursue that degree after attaining the MES degree. We have a similar arrangement with the department of Education. This is especially useful for a high school teacher who wants a technical degree but needs 2 or 3 courses to get or maintain state certification.

Admission and Graduation Requirements

A bachelor's degree in any subject, 2 letters of recommendation, transcripts from all accredited colleges and universities attended and a completed application are required for admission into the program. The Graduate Record Exam (GRE) is not required nor is any minimum grade point average (GPA) necessary although we normally look for a 3.00/4.00 minimum. If an applicant is below this mark but has outstanding recommendations, perhaps explaining why the GPA was low or what the applicant has accomplished since graduation, there is a possibility of conditional acceptance. This condition is usually the attaining of a 3.5/4.0 in the first 3 courses taken. At the time of application, a request to waive Introductory courses is also submitted along with the application for admission. The Admissions Committee decides which Introductory courses will be waived and which need to be taken. The applicant has the right to appeal this decision and the director of the program makes the final decision on Introductory courses after meeting with the applicant. We do this so that the student feels like it is a cooperative effort between him and the department as to where he starts. Where the student starts is very important to both Loyola and to the student.

Normally the admission process takes 2 or 3 months. Getting transcripts and letters of recommendation together takes time. If a prospective student has only recently learned of our program or perhaps has recently moved into this geographical area and wants to start the program immediately, we have a Provisional Acceptance policy. If the applicant signs a form attesting that he or she has a bachelors degree from an accredited institution and intends to go through the application process during the coming semester, that student can be accepted into the program provisionally and take 1 or 2 courses while completing the paperwork involved in application. If the paperwork is not completed by the end of that semester, the student cannot proceed in the program. If the paperwork is completed, and the student is accepted, the student immediately acquires regular student status.

Once accepted into the program, the student needs 4 Introductory courses and 11 Advanced courses to graduate. Of the 11 Advanced courses, 8 must be in one of the 3 tracks which the student desires to concentrate, CS, CE or EE. Of those 8, 4 must be the required courses specified in that track. The remaining 3 courses can be from anywhere in the program. Furthermore, the student needs at least a 3.00/4.00 GPA to graduate. There are no exceptions to this requirement. A student is automatically dismissed from the program upon receiving one F or 2 C grades. The dismissal may be appealed, first to the director of the MES program and, if the problem cannot be resolved at that level, to the Dean of the College of Arts and Sciences.

Lab Facilities

When the program first started, it took a few years to develop quality laboratory facilities. During this time, the laboratories on the main campus, where facilities were readily available, were used on weekends. This was not a good arrangement for a number of reasons. First of all, the graduate labs were competing with the undergraduate department for space. When undergraduates came to the campus to use the lab facilities for remedial work or junior/senior research projects, they found that they were not available on Saturdays. Second, there were many competing events on

campus on weekends, and parking was sometimes very difficult. Third, many students who were willing to give up an evening or two during the semester for class, couldn't (or wouldn't) give up a weekend as well. So, one of our primary objectives early in the program was to assemble the correct quantity and quality of laboratory equipment to hold the laboratories at our off campus sites on weekday evenings. This was accomplished within two years and has worked out well. It has been thoroughly appreciated by all of our students. We now provide 7 day a week, 24 hour a day access to the labs by using cipher locks whose combination changes every semester and whose combination is given out to students currently enrolled in the program. So far there has been little or no theft of equipment, including computers, at these off campus sites, in fact probably less than occurs on the main campus where there is 24 hour security.

Hands-on Approach

The program is designed for a hands on approach to learning the material. Every course has a laboratory associated with it. Some are hardware labs, some are software labs while many are both. The theme of the program is to learn the theory and then put that theory into immediate practice. Every software course requires programming of some kind. Every hardware course requires laboratory design which is done either in the hardware lab or on the computer using an electronic simulator. Furthermore, every professor is encouraged to include a term project in every course if possible. Students are nearly unanimous in expressing that they learn much more in a course requiring a term project than in one which does not. These term projects can be case studies, large programming assignments, hardware design projects or even research on the Internet.

Independent Study and Thesis Requirement

The independent study course is popular with many students who want to delve further into a topic than a particular course has time to cover and for which there is no follow-up course on the books. The student approaches a faculty member and proposes a topic that he would like to pursue and asks the professor to sponsor the course. If the professor agrees, a proposal is written which states the goals and the workload of the course to the director of the MES program. If acceptable, this outline becomes a contract between Loyola and the student. If the student accomplishes what has been set forth, credit is granted for the course. Only one independent study course can be taken in a student's curriculum.

Students find this an excellent way to go deep into a topic at their own pace. A final paper is required which gives a detailed description of what was done in the independent study. A copy of all independent studies is kept in the department office so that other students can profit from previous independent studies. There is no requirement to present the paper before any group except the faculty sponsor if the sponsor desires. Usually the papers are simply submitted to and graded by the professor and a grade is assigned for the course.

In the MES program, a Master's thesis is optional. If a student opts to do a Master's thesis, it counts as 6 credits or 2 courses. The time limit for these two courses is one calendar year but sometimes it takes a student longer. Most students do not attempt the Master's thesis option

because it is usually much more time consuming than taking 2 courses. For those who do, the experience is usually quite rewarding. A semester is spent in researching the topic and gathering data and a semester is spent writing up the results for publication. It is not required that the student actually publish the paper, but it is stressed that the paper should be written with this in mind. The topic should be something new and original, often flowing out of some common work that the student is doing in his or her coursework and at his or her place of employ. If the thesis topic is related to work being done at the student's place of employ, we stress the fact that the topic cannot be proprietary and permission must be obtained from the student's employer to do the work and publish it if possible. The thesis must be turned in to the faculty adviser and defended formally before the entire department.

Conclusions

The MES program is in its 21st year. It has constantly evolved over these years with new courses being added as the need requires and older and more obsolete courses being dropped. Advanced courses are pushed down into the Introductory level as we find our students are coming to us better prepared. Introductory courses are dropped as we find they are no longer relevant. New tracks are added as we find that today's technology requires it. But as the program changes in size and scope, one thing that stays constant is our belief that in order for graduate engineering to survive in a small liberal arts college, we must provide a very helpful and friendly interface for our students. When a student calls to inquire about our program, we realize that this might be the only opportunity we will have to get this student interested in our program. We are not nationally known, so we try to have our staff cut through artificial barriers as much as possible and use this first opportunity to make the prospective student feel as at home with our program as possible. We have numerous Information Sessions throughout the year at the two sites where the program is held. The director, associate director and assistant director attend these sessions and we try to put our best foot forward. We encourage the prospective student to walk around the labs, talk to students if classes are in session, talk to any full time or adjunct faculty who are in attendance (there are always a few of each) and especially talk to the assistant director who will be the principal contact as the applicant works through the application procedure. Getting the application, personal essay, transcripts, and letters of recommendations together can seem like a huge task and sometimes turns the prospective student off right there. Having an informed source available to call can simplify this task immeasurably and in many cases even make it enjoyable as one waits to see if he or she is accepted into the program and feels the accomplishment that comes when accepted. Our assistant director is our liaison with the outside world. This position is one of the most important and critical in the entire program. A potential student can be turned off with a single phone call but can also be captivated with the program in that same call. Websites are nice but personal contact by voice or in person cannot be beat.

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