THE MASTER OF ENGINEERING AS THE FIRST ACCREDITED DEGREE

James C. Watters
Chemical Engineering Department
University of Louisville
Louisville, KY 40292

The Speed Scientific School, the engineering school of the University of Louisville, offers the 5-year, integrated, professional Master of Engineering (M. Eng.) degree, with mandatory co-operative internship, as its first ABET-accredited program. Currently we are the only chemical engineering program in the country accredited by ABET at the advanced or master's level. There are a few other accredited master's programs in the other branches of engineering, and recently some schools have instituted professional master of engineering degrees to complement their accredited B.S. programs. There are positives and negatives to our procedure as with any other, and the following article attempts to put these in perspective. The reader who wishes a more in-depth background and rationale should consult a previous article on our program by Deshpande and Plank[1].

BACKGROUND

The Speed Scientific School was founded in 1925 with first graduates in chemical engineering in 1929. An M. S. program in chemical engineering started in 1934, while doctoral work was initiated in 1955. The concept of cooperative education was an integral part of the undergraduate program *ab initio,* as one of the intents of the Speed family in endowing the school was that graduates should be versed in "hands-on" engineering as well as academics.

In 1970, a five-year program leading to the graduate professional degree, Master of Engineering (M.Eng.), was introduced, keeping the required cooperative internship during the first four years. This program has now been in place for 25 years, and its value was reaffirmed by the school faculty during discussions held in the early 1990's. The M.Eng. degree is administered by the Speed School as a professional engineering degree, and it thus differs from a traditional

M.S. degree which typically is under the purview of a Graduate School. In addition to the M. Eng. program the chemical engineering department offers traditional M. S. and Ph.D. degrees through our Graduate School.

CURRICULUM

The M.Eng. curriculum has undergone a number of changes in its twenty-five year life, though it still remains a nominal five-year master's degree program which includes one year of industrial experience and an independent research project which results in a thesis. Table 1 presents the current curriculum for in-phase students. The five years are divided into three categories -- pre-engineering (PE), basic studies (BqS) and graduate professional (GP). During the pre-engineering year, which is to some extent common for all engineering disciplines, the student completes general chemistry, basic calculus (analysis), English, mechanics (Physics I), FORTRAN programming, basic graphics and some of the humanities requirements. Upon completion of a minimum of 30 hours, which must include freshman chemistry and calculus, with a GPA of 2.5 or better, a student may apply to the department. Thus, an on-phase student applies in the early summer of the BS- 1 year. The student then completes basic sciences and mathematics, takes physical and organic chemistry, and the material and energy balance course before going on co-op in the Spring semester of the BS-1 year. A student is required to pass both material balances and physical chemistry before being considered qualified for co-op. All students co-op and the Speed School maintains an OffIce of Cooperative Education and Placement which coordinates interviews and company contacts. This office performs a Trojan job each semester in placing all of our eligible students in co-op positions in all but the softest job markets. Co-ops get their jobs by competitive interview with company representatives just as permanent placement candidates do, and just as for permanent placements, those with the highest GPAs usually land the best paying jobs.

The BS-2 and BS-3 years following an alternating pattern of work and school, so that by the end of the BS-3 year, the in-phase student has finished all academic requirements for a BSChE degree, including one year of industrial experience. Out-of-phase students typically have their first co-op in the Fall of the BS-3 year, with the third co-op being in the summer following the BS-4 year. Students apply to the GP or fifth year during the Spring or summer semester of BS-4, depending on whether they are in phase or not. Unconditional admission to the GP year requires a GPA of 2.5 or better, though exceptions maybe made in special circumstances. The course content of the fifth year is not unlike that of many M. S. programs, except that we are somewhat constrained in our elective offerings to meet the ABET advanced accreditation

TABLE 1: CHEMICAL ENGINEERING PROGRAM 1996

	PE 1st Year	BS-1 2nd Year	BS-2 3rd Year	BS-3 4th Year	GP 5th Year
SUMMER		EMCS 201 ANALYSIS III 4 PHYS 299 PHYSICS II 4 PHYS 296 PHYSICS LAB II 1 CHE 253 MATERIALS SCIENCE 3 EG 214 COMPUTER-AID DESIGN 1 SEMESTER TOTAL 13	EE 252 ACTIVE & PASSIVE 3 CHE 288 CO-OP SEMINAR 0 CHE 311 CHE THERMODYNAMICS 3 CHE 331 PRIN FLUID DYNAMICS 3 CHE 401 SAFE, HEALTH, ENV 1 SEMESTER TOTAL 10	CHE 488 CO-OP 2 SEMESTER TOTAL 2	CHE 562 PROCESS CONT LAB 1 CHE 595 SEMINAR 0 CHE 610 ADV THERMO 3 CHE 620 TRANS PHENOM I 3 CHE 697 MENG THESIS 1 SEMESTER TOTAL 8
FALL	GES 100 CAMPUS CULTURE/ENGR 1 CHEM 201 GEN CHEMISTRY I 3 CHEM 203 GEN CHEM LAB I 1 EMCS 101 ANALYSIS I 4 ISDP 170 FORTRAN PROGRAM 2 ENGL 101 COLLEGE WRITING I 3 EG 105 ENGR GRAPHICS 1 HUM/SS 3 SEMESTER TOTAL 18	EMCS 202 DIFF EQUATIONS 3 CHEM 341 ORG CHEMISTRY I 3 CHEM 343 ORG CHEMISTRY LAB I 1 CHE 288 CO-OP SEMINAR 0 CHE 251 PHYSICAL CHEMISTRY 4 CHE 305 MAT & ENERGY BAL 4 HUM/SS 3 SEMESTER TOTAL 18	CHE 389 CO-OP 2 SEMESTER TOTAL 2	CHE 430 COMP APPLICA IN CHE 3 CHE 435 MASS TRANSFER 3 CHE 471 STRATEGY DESIGN 3 CHE 485 UNIT OPS LAB I 2 IE 570 ENGR DES ECON 3 PHIL 32X ETHICS ELECTIVE 3 SEMESTER TOTAL 17	CHE 574 TECHNIQUES OF RESEARCH 3 OR 3 CHE 686 CHE ANALYSIS 3 CHE XXX CHE DESIGN ELECTIVE 3 CHE XXX CHE ELECTIVE 3 CHE 697 MENG THESIS SEMESTER TOTAL 12
SPRING	CHEM 202 GEN CHEMISTRY II 3 CHEM 205 GEN CHEM LAB II 2 EMCS 102 ANALYSIS II 4 PHYS 298 PHYSICS I 4 PHYS 295 PHYSICS LAB I 1 ENGL 102 COLLEGE WRITING II 3 HUM/SS 3 SEMESTER TOTAL 20	CHE 289 CO-OP 2 SEMESTER TOTAL 2	EMCS 360 ENGR PROB & STAT 3 CHEM 342 ORG CHEMISTRY II 3 CHE 288 CO-OP SEMINAR 0 CHE 434 HEAT TRANSFER 3 CHE 441 KIN & CHEM REACTION 3 XXX XXX SCIENCE ELECTIVE 3 HUM/SS 3 SEMESTER TOTAL 18	CHE 436 SEP OPERATIONS 3 CHE 461 ELEM PROCESS CONT 3 CHE 486 UNIT OPS LAB II 2 CHE 572 PLANT PROC DESIGN 3 CHEM XXX CHEMISTRY 3 ELECTIVE 3 HUM/SS SEMESTER TOTAL 17	CHE 641 ADV REACTOR DESIGN 3 CHE XXX CHE ELECTIVE 3 CHE XXX CHE ELECTIVE 3 CHE 697 MENG THESIS 4 SEMESTER TOTAL 13
	SUBTOTAL 38	33	30	36	33
	CUMULATIVE 38	71	101	BS TOTALS 137	170

1. CHE XXX, CHE DESIGN ELECTIVE, MUST BE FROM 638, 653, 662, OR 687 OR ANY OTHER COURSE WHICH CONTAINS 3 HOURS OF DESIGN.

REVISED 02/02/96

2. XXX XXX, SCIENCE ELECTIVE, FROM APPROVED LIST.
3. PHIL 32X, ETHICS ELECTIVE, FROM APPROVED LIST.
4. CHEM XXX, A 500 OR 600 LEVEL CHEMISTRY ELECTIVE.
5. CHE XXX, CHE ELECTIVE, 500 OR 600 LEVEL CHE OR OTHER APPROVED ELECTIVE.

engineering design requirements. Typical elective courses with considerable design components include Advanced Process Control, Advanced Design of Stagewise Processes, and Polymer Processing. Other graduate/professional electives include Industrial Waste Management, Pollution Prevention, Polymer Science, Rheology, Genetic Engineering, Catalysis, Membrane Processes, etc. Electives may also be taken from other disciplines if appropriate to the student's area of interest.

An integral part of the fifth year is the Master of Engineering thesis. A student may usually pick a thesis topic from an array of research areas of interest to the faculty. The student then carries out independent work in consultation with the faculty advisor and produces a written document which must be defended before a committee just as is normally required of an M. S. student. A judicious choice of thesis area and elective courses allows the student to specialize in a specific sub-discipline of chemical engineering, e.g., Process Control, Polymers, Separations, or Waste Management. Many of these M.Eng. theses result in refereed publications, while others may develop new or improved undergraduate laboratory experiments[2]. In yet other instances M.Eng. thesis work may involve fleshing out of faculty ideas or generating preliminary data for subsequent research proposals. Some M.Eng. projects are sponsored by local industries or on grants or contracts.

Obviously student enrollment fluctuates with the strength of the prevailing job market; however, in the past 3 or 4 years, our fifth year class has averaged about 25 students. This represents about 60% of the fourth year class and about 80% of those students eligible to proceed forward. Some eligible students chose not to pursue the fifth year for a variety of reasons including financial problems, a job offer one cannot refuse, graduate school in chemical engineering or another field, at U of L or elsewhere, or pursuit of a professional degree, e.g., each year a number of our BSChE graduates enter medical or law school. None-the-less, those who remain with us allow us to maintain a reasonable level of research in the department.

PROS AND CONS

The success of a program can be measured by a number of metrics. These could include the quality of the employers who hire the graduates; a comparison of starting salaries with national levels; and graduate performance in industry. A large number of companies recruit annually at Speed School for both permanent hires and for cooperative interns. Represented among these are several Fortune 500, "blue chip", chemical, petroleum and polymer companies who are known to hire only the best qualified graduates. Also, many of our students receive what amounts to automatic job offers following their cooperative internships with these same high calibre companies. Generally, these same companies do not consider hiring graduates with the unaccredited BSChE degree, though there have been some notable exceptions. BSChE graduates who go directly to work usually find positions with smaller companies, consultant groups or state government, though we do not keep good statistics on these graduates.

The average starting salaries of our M.Eng. graduates in recent years have been at least comparable to the national M. S. chemical engineering averages, while individual salaries have, in some cases, far exceeded the average M. S. figures. We attribute this to the co-op experience, and indeed, many employers comment on our graduates' ability to "hit the ground running" during their first week on the job, while graduates from other schools tend to have a longer "breaking in" period. Our M.Eng. students also tend to start at higher salaries than graduates of traditional B.S. programs, attesting to the value of the graduate level courses and comprehensive thesis which our students have completed. Table II summarizes salary data for Speed School chemical engineering M.Eng. graduates for the past several years, and compares these to average M. S. **and** B.S. chemical engineering graduate salaries in 1994 and 1995.

How do our M.Eng. graduates fare on the job? We believe they do very well, though much of our evidence for this is anecdotal or heresay. Periodic surveys of the employers of recent graduates note that our graduates are valued and advance at least in step with their peers. Discussions with recruiters indicate that our graduates progress and impact the company at at least a normal rate. Many of the faculty keep up personal and professional contacts with their M.Eng. mentees and so become aware of their advancement within the companies. Though we consider the M.Eng. to be a professional degree, and for most students it is a terminal degree, occasionally one of our graduates will pursue the PhD after obtaining the M.Eng. Since these students already have master's degrees and have taken much of the typical M. S. coursework, they have been readily accepted into PhD programs with few further requirements than qualifying exams and research. Thus they usually complete their doctoral studies in 2 to 3 years,

There are, of course, no programs without some negative aspects, and it is only fair to mention that ours has some. However, we believe that the positives far outweigh the negatives. By far the strongest negative is the fact that the student who leaves with the B SChE does not have an ABET-accredited degree. The course content of the BS, though, is certainly comparable with what is taught in most accredited BS degrees. Indeed, it was setup that way in the late **1980's** when ABET was considering the dual accreditation option. So the BS graduate is truly qualified to work in industry as a chemical engineer though the student with less than a 2.5 GPA from any B S program will have trouble finding employment, especially in a buyer's market. Also, a non-accredited degree may make it difficult for the graduate to obtain a professional engineer licence in some states.

Another aspect of the program that is seen by some as a negative is its rigor. In order to graduate within the five years prescribed, a student is required to take up to *20* hours in some semesters to makeup for taking a lighter load in the summers which are abbreviated 10 week terms instead of the regular 15 week semesters. Also, the student is continuously either in school or at work for the whole five years. The net result is that many students do NOT finish on time. In any year only about 20°A of those entering the fifth year in summer, graduate in the following Spring. A further 40 to 50'% take one to two semesters longer, while the balance require a year or more beyond the nominal five years and some never finish. "Academic burnout" surfaces for some students, particularly at the end of the fourth year, though some return after a "time-out" of a few semesters.

Another potential negative is that the M.Eng. program may lure BSChE graduates away from our traditional M. S. program. However, it is more likely that many of those who pursue the fifth year would not attend a traditional graduate program in the absence of the M.Eng. program. Thus the M.Eng. program has a very positive effect on departmental research productivity. Finally, the M.Eng. program could become counterproductive when a soft job market is mixed with a swelling pipeline of undergraduates. The student load on a small faculty (we are 8 people) could become overwhelming, while the incentive to promote "make-work" projects may become strong. Thankfully, we have yet to reach these extremes, though the possibilities cannot be ruled out in the future.

CONCLUSION

To summarize, we believe that the five-year integrated M.Eng. program with co-op is a very viable way to balance the many demands on a modern chemical engineering department. It provides students with a firmly anchored education which has depth, breadth and independent work. It gives the faculty a positive outlet for research and creative activity. And it provides industry with graduates who are ready to go to work with minimal on-the-job training. The program is not without problems, but we believe the positive aspects far outweigh any faults.

REFERENCES

1. Deshpande, P. B., and C.A. Plank, 'A Combined Bachelors-Masters Program', CEE, Summer 1979, pp 138-140 and 144.

2. Watters, J. C., 'Use of Masters Theses to design Experiments for Undergraduate Laboratories', presented at AIChE annual meeting, Los Angeles, CA Nov 1982.

3. Data compiled by Office of Cooperative Education and Placement, Speed Scientific School, University of Louisville, Louisville, KY, 1989-95

4. Salary Survey compiled by National Association of Colleges and Employers, Sept. 1995.

JAMES C. WATTERS is Professor and Chairman of Chemical Engineering at the University of Louisville where he has been on the faculty since 1977. Originally from Dublin, Ireland, he holds a B.E. (Chemical) degree from the National University of Ireland and M.S. and Ph.D. degrees from the University of Maryland at College Park. His research interests include control of RO processes, energy and waste assessments, and teaching and learning styles.

TABLE II
ChE Graduate Salary Data Comparison:
Speed School versus the National Average ($/year)

	SPEED M.Eng. GRADUATES[3]			U.S. DATA[4]	
Year	**High**	**Low**	**Average**	**Average M.S.**	**Average B.S.**
1990-91	**42,700**	**35,000**	**37,662**	**N/A**	**N/A**
1991-92	**45,500**	**36,500**	**43,097**	**N/A**	**N/A**
1992-93	**44,880**	**34,500**	**41,838**	**N/A**	**N/A**
1993-94	**46,260**	**32,500**	**40,460**	**40,457**	**39,204**
1994-95	**47,880**	**42,500**	**46,308**	**41,757**	**39,880**