Master of Engineering: Past, Present, Future

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I. Introduction

The concept of Master of Engineering (M.Eng) developed in the 1960s in reaction to two factors. One factor was the recognition that a 4-year bachelors degree was not sufficient to properly educate an engineering professional. Various engineering-education reports identified more and more subjects that engineers needed in their first professional degree. In 1955, the ASEE Grinter Report[1] recommended that more mathematics and science be added to the engineering curriculum. In 1956, the Burdell Report[2] recommended that more humanities and social sciences be added to the curriculum. This was at a time when most Bachelors degrees in Engineering required over 140 semester hours of course work. Even then, the need to go beyond a bachelor's degree became more and more evident. Finally in the ASEE Walker report of 1968[3], a case was made extending engineering education beyond the bachelor's degree. To quote from the report [3,p. 376], "There is little doubt that during the next decade we will witness a rapidly developing consensus that the master's degree should be considered the basic professional degree in engineering."

The second factor was a movement to model engineering schools along the type of professional schools found in law and medicine, with a pre-professional program, followed by a professional program leading to a graduate degree. In 1965 Burr reported[4] on the Rensselaer Polytechnic Institute (RPI) efforts along these lines. At RPI a 3-2 program was developed, with 3 years of pre-engineering course work followed by 2 years of professional education, leading to a Master of Engineering degree. This program was reported in 1965 by an article by Burr[4]. To quote from Burr's article [4, p.287],

"The program centers on the creation of a new professional school of engineering. The program differs from current educational practice in that it recognizes that a broad preengineering experience must precede the professional education; further it acknowledges that postbaccalureate education is an essential qualification of the modern engineer."

It should be noted that the concept of an M.Eng. program was quite distinct from the Master of Science (M.S.) programs, which existed, in various engineering disciplines. The former was a practice oriented post-bachelors program, with emphasis on engineering design, while the latter

was a research oriented program, providing the preparation for further (doctoral) studies. Typically the M.Eng. required a design project, while the M.S. required a research oriented thesis. At most institutions that offered the M.Eng. degree, M.S. degrees were also available.

II. The Past

The February 1969 issue of the Journal on Engineering Education[5], reported 9 M.Eng. degree programs in the USA, out of a total 186 institutions granting graduate degrees. This does not include other "practice oriented" degree programs that were listed as "professional" degree programs. Typically the M.Eng. programs were 30 semester hours, and did not require a thesis. In July 1971, the National Society of Professional Engineers (NSPE) adopted a policy, NSPE Professional Policy No. 104, which advocated "professional education programs" for engineering, with a pre-professional period of education followed by a professional education period. Details of the proposed NSPE policy may be found in Reference 6. One of the first institutions to have implemented such a policy was the University of Louisville, Speed Scientific School, Louisville, Kentucky. In 1969 the Speed Scientific School had initiated a 3-2 professional degree program with 3 years of preengineering followed by 2 years of professional education, leading to an M.Eng. degree. While there were advocates for an extended period of education for engineers, to quote ASEE 1974-75 President, Wandmacher[7], "There is little chance that the four-year bachelor's program, in itself, will ever produce adequate education for the engineering professional of the future", the academic community was very divided on this issue. In the report by LeBold et al, published in 1966[8], which surveyed 156 institutions on "goals of engineering education", there was an equal division of institutions that felt that engineers should be education for at least 5 years, versus institutions that felt that a 4 B.S. degree was sufficient. Another problem, expounded by Grinter, in an editorial published in 1975[9], was that while law and medicine had only a single channel for professional education, engineering is open to many educational channels, e.g. physics, mathematics, chemistry. etc. Nevertheless, proposals for extended engineering education continued to appear because, in spite of all the difficulties, the need for such programs is not diminishing. Indeed with the reduction in semester hours required for a B.S. in Engineering, now down to 130 in most institutions, and the increase in subject matter that an engineer must know, the need for education beyond a 4-year B.S. degree becomes more and more urgent. In a 1987 article[10], a 4-3 program is recommended, with a 4-year Bachelor's degree in "preengineering", followed by 3 years of professional school, leading to a Doctor of Engineering (Eng.D). The Eng.D. is the most extensive education recommended so far for a first professional degree. The concept and need for a "first professional degree" will be explored further in Section IV.

In 1992, MIT reported[11] the initiation of an M.Eng. degree program in Electrical Engineering and Computer Science. The concept was that this would be the first professional engineering degree, although an engineering Bachelor's degree was preserved as preparation for the M.Eng. degree.

III. The Present

The 2002 publication on Graduate Programs in Engineering & Applied

Sciences[12] lists 39 M.Eng. degree programs at USA institutions, out of a total of 113 institutions (Listed in Section 1 of Reference 12). While this is a significant increase over the 9 programs reported in 1969, it is still only a small fraction of the total number of institutions granting graduate degrees in engineering. Even after three decades, the Walker Report prediction that, "...we will witness a rapidly developing consensus that the master's degree should be considered the basic professional degree in engineering" has not been realized. Indeed at the present time the only institution that recognizes the M.Eng. degree as a first professional degree is the University of Louisville (where only the M.Eng. degree is ABET accredited). At MIT, students in Electrical Engineering are encouraged to complete their professional education with the M.Eng. degree. However the Bachelor's degree is still the only accredited degree. The consensus at the present time appears to be that the 4-year Bachelor's degree is an adequate first professional degree in engineering. This seems strange when all the serious studies of engineering education over the past decades have stressed the to need to go beyond the Bachelor's degree. Indeed many other professions are now past the Bachelor's. For example, at the present time, pharmacy has the Doctor of Pharmacy (Pharm.D.) as the first professional degree. In most institutions it is a 2-4 program with 2 years of pre-pharmacy and 4 years of professional education. Just ten years ago, the Bachelor's degree was the first professional degree at most institutions. Pharmacy programs are no longer accredited at the Bachelor's level.

Cornell University has one of the oldest (formulated in 1967) and most extensive M.Eng. degree programs in the USA. Although M.Eng. programs differ somewhat from institution to institution, the Cornell program is very typical, hence we will provide a short description of the program here to present the current structure of the M.Eng. degree, and point out some contrasts with the M.S. degree.

Elements of Present M.Eng. Degree Programs

* 30 semester hours of course work.
* Design project, versus research thesis.
* Bachelor's degree with 2.7 GPA for admissions, versus 3.0 for the M.S. degree.
* Practice oriented course work, versus research-oriented courses.
* Administration in Engineering School, versus Graduate School.
* Specializations in classical engineering discipline, e.g. Chemical Engineering, Civil Engineering, Electrical Engineering, and Mechanical Engineering, but also other specializations, e.g. Environmental Engineering, Materials Engineering, etc.

M. Eng, degree programs at the present time span a wide range of disciplines. Some, as the MIT program in Electrical Engineering, are focused on classical engineering disciplines, others are interdisciplinary. M. Eng. Programs are also being used as “engineering management” degrees. The University of Wisconsin, at Madison, has had a program of this type in place since 1994. The management oriented M.Eng. degree offered at the University of Wisconsin is designated as an, “M. Eng in Professional Practice.”

The 1994 Centennial Issue of the Journal of Engineering Education includes a number of papers that deal with the issue of first-professional degree, in particular see the articles Cranch, "The Next Frontier in Engineering Education"[13] and Harris et al., "Reflections on the Grinter Report"[14].

It should be noted that in 1998, (ASCE policy statement No. 465), the American Society of Civil Engineers (ASCE), formally declared its support for the Master's degree as the first professional for the practice of civil engineering. Nevertheless there is no strong consensus across the engineering disciplines on this issue at the present time. Perhaps one of the greatest obstacles in the establishment of more practice-oriented M.Eng. degrees, is the culture found in the engineering academic community, where the focus on pure research is so strong. Very few faculty in engineering have extensive experience in engineering practice.

IV The Future

Separate from the issue of first-professional-degree, there appears to be considerable agreement on the need for practice-oriented post-Bachelor's education in engineering. In many institutions this need is being met with no-thesis M.S. degree programs. But the coursework in most of these programs is still oriented towards research and preparation for Doctoral studies. A practice oriented M.Eng. program would better fit the needs of most engineering students. Hopefully, more institutions will develop programs of this type.

It would be useful to standardize the structure of M.Eng. programs. The 2-3 Louisville University model, with 2 years of pre-engineering, appears to have a number of advantages. One major advantage of this model is that it clearly divorces engineering education from the 4-year Bachelor's constraint. However, it is likely that in the near future, most new M.Eng. degree programs will have a 4-1 structure, with a 4-year Bachelor's as prerequisite for the 1-year M.Eng. degree. If a year of internship is to be included in professional engineering education, then a 2-4 program, as in Pharmacy, may be most appropriate, leading to a degree such as the Eng.D. degree.

V. Conclusions

The need to extend engineering education beyond a 4-year Bachelor's has been recognized for many years. With the explosion in modern technology, and the requirement of an ever-broader education for engineering practice, the problem is becoming more and more critical. As a first step it would be helpful for more institutions to develop practice-oriented M.Eng. degree programs. When the number of institutions offering the M.Eng. reaches a critical value, at least a majority, then the M.Eng. can made the only accredited engineering degree. At some point, especially if a period of "internship" is viewed as critical, the only accredited degree could evolve into an Eng.D., as in the case of Pharmacy and the Pharm.D. degree. The Accreditation Board for Engineering Education (ABET) obviously has a key role to play in this issue. However, ASEE also as a key role, especially in defining the future direction for engineering education. Perhaps the time is right for ASEE to undertake an updated study of "Goals of Engineering Education."

Bibliography

1. Grintner, L.E., "Report on Evaluation of Engineering Education," *Journal of Engineering Education*, vol.46, no. 1, 1955, pp. 25-63.
2. Burnell,"General Education in Engineering," *Journal of Engineering Education*, vol. 46, no. 8, 1956, pp.619-735.
3. Walker, E.A., "Goals of Engineering Education," *Journal of Engineering Education*, vol. 58, no. 5, 1968, pp. 367-446.
4. Burr, A.A., "Problems of Developing a Professional-School Program in Engineering," *Journal of Engineering Education*, vol. 55, no. 10 1965, pp.287-291.
5. *Journal of Engineering Education*, vol. 58, no. 6-Part 2, 1968.
6. *Challenge for the Future...Professional Schools of Engineering*, NSPE, Wash., D.C., 1976.
7. Wandmacher, C., "Professional Education", President's Message, *Journal of Engineering Education*, vol. 65, no. 6, 1975, p. 447.
8. LeBold, W.K, R. Perrucci, J. Singleton, V. Salvo, W. Howland, and G.A. Hawkins, "Educational Institutional Views of Undergraduate Goals of Engineering Education," *Journal of Engineering Education*, vol. 56, no. 6, 1966, pp. 213-219.
9. Grinter, L.E., "Defining a Professional School of Engineering," Guest Editorial, *Journal of Engineering Education*, vol. 65, no. 4, 1975, p. 279, pp. 354-355.
10. Friedland, B. and P. Dorato, "A Case for the Doctor of Engineering As a First Professional Degree," *Engineering Education*, vol. 77, nos. 7-8, 1987, pp. 707-713.
11. Penfield, P. Jr., J.V. Guttag, C.L. Searle, and W.M. Siebert, "Shifting the Boundary: A Professional Master's Program for 2000 and Beyond," ASEE Frontiers in Education Conf., Nov. 11-14, 1992, pp. 645-648.
12. Graduate Programs in Engineering and Applied Sciences, Book 5, Petersen's, Lawrenceville, NJ, 2002.
13. Cranch, E.T. "The Next Frontier in Engineering Education: The Master's Degree," *Journal of Engineering Education*, vol. 83, no. 1 1994, pp. 63-68.
14. Harris, J., E.M. DeLoatch, W.R. Grogan, I.C Peden, and J.R. Whinnery, "Journal of Engineering Education Round Table: Reflections on the Grinter Report," *Journal of Engineering Education*, vol. 83, no.1, 1994, pp. 69-94.

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