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Postgraduate management study options for engineers

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Abstract: Most professional engineers will spend a significant proportion of their careers as managers of technology, and large numbers of engineers seek formal education in management at the postgraduate level. Study options include the Master of Business Administration, Master of Engineering Management and Management of Technology programs. This paper reviews the literature on postgraduate engineering management education to examine the documented claims for and against particular options. The diversity of engineers and engineering practice will ensure a diversity of postgraduate management education needs, which will be best served by a diversity of options for study. Diversity of options is a strength, not a weakness; there is not a single ‘best’ option for management education for engineering graduates. As long as they offer relevance, convenience, interest and value, the various postgraduate management study options with their particular distinctions and emphasis on technology or management will find a ready audience.
1 Introduction

The disciplines of engineering and management have been intimately linked since the contributions of many practicing engineers to the development of the management science school of management thinking. It is the reality of modern engineering practice that most professional engineers will spend a significant proportion of their careers as managers of technology, projects, resources, plant, finances and people. This reality is evidenced by the large numbers of engineers who seek formal education in management at the postgraduate level. There is a range of study options available to the graduate engineer; the Master of Business Administration (MBA) has been a perennial favourite. Other options, including the Master of Engineering Management and Management of Technology programs, often claim superiority over the MBA, purporting to be more relevant to the practicing technology professional. This paper reviews the literature on postgraduate engineering management education to examine the documented claims for and against particular options, with an aim to assessing whether the Bachelor of Engineering plus MBA combination remains relevant.

2 The relationship between engineering and management
The modern disciplines of engineering and management are inextricably linked. Frederick Winslow Taylor (1856-1915), an American mechanical engineer, known as the ‘father of scientific management’, first developed methods of work study and attaching financial reward to performance. In 1911 he published the book Principles of Scientific Management, though these days he is more commonly remembered in the term ‘Taylorian’, used in a derogatory sense to describe work methods that are repetitive and dull. Henry Laurence Gantt (1861-1919), another American mechanical engineer, adapted Taylor’s methods and is known today for developing charts that graphed project activity versus elapsed time. The French mining engineer Henri Fayol (1841-1925) believed that management was the most important function in industrial organizations. His division of management into ‘planning, organization, leading, coordinating and controlling’ is still widely held today. Fayol was perhaps the first to note in print [1] the incomplete preparation of engineering graduates in the area of management skills:

“Our young engineers are, for the most part, incapable of turning technical knowledge received to good account because of their inability to set forth their ideas in clear, well-written reports, so compiled as to permit a clear grasp of the results of their research or the conclusions to which their observations have led them.”

It is well known that most engineers make the transition from technical to management responsibilities some time in their careers [2]. The career advancement of engineers depends principally on their ability to become effective managers of the
engineering function in particular, and of technology in general [3]. From the literature – Samson [4]:

“Few people would dispute the proposition that shortly after beginning their careers, many professional engineers move from spending the bulk of their time solving technical problems to doing other things,...They are managerial activities.”;

…and Kinsky [3]:

“Most graduate engineers in business...will devote only a small part of their working lives to traditional engineering activities...Instead, they will spend most of their working lives in activities which might be termed management activities...”.

In Australia, as far back as 1968 Lloyd [5] identified that, “In all phases of practice in the profession the technical work is coupled, to a greater or lesser extent, with engineering management.” More recently, the former Chief Executive of the Institution of Engineers, Australia (IEAust) reported [6] in 1996 that:

“Technical virtuosity is often necessary, but never sufficient. A major survey conducted for the Institution earlier this year revealed that 30% of members work in non-engineering roles, and over 40% are primarily involved in management.”
Engineering continues to be linked to management and business. Of the top 1000 publicly listed American companies in 1998, the most widely held qualification of the chief executive officer was engineering [7]. Engineers were prominent as leaders of organizations during the first industrial revolution, and are again commonly the founders/leaders of new organizations arising from the second industrial revolution based on communications [7].

But what is engineering management? The literature provides some definitions of engineering management, Thamhain [8]:

“...engineering managers are under pressure to achieve marketable results focusing on quality, cost, and speed. This requires effective planning, organization, and integration of complicated multidisciplinary activities across functional lines and a great deal of people skills.”;

…and Antil and Farmer [9]:

“Between the inception and completion of any engineering project there is a vast expanse of management and administrative tasks. Each of these, however, will be seen as connected with one of the six basic management functions:

- planning
- organizing
- staffing
- directing
- controlling
- coordinating”.
These definitions incorporate some form of the commonly accepted functions of
general management, that is ‘planning, organizing, leading and controlling’. So,
obviously, an engineering manager is not too far removed from any other kind of
manager, but not quite the same either. Perhaps this essential difference is best
described by Babcock [2]:

“The engineering manager is distinguished from other managers because he [or
she] possesses both the ability to apply engineering principles and a skill in
organizing and directing people and projects. He is uniquely qualified for two
types of jobs: the management of technical functions (such as design or
production) in almost any enterprise, or the management of broader functions
(such as marketing or top management) in a high-technology enterprise.”

Engineering management is the application of general management skills to the task of
managing engineering activities. This definition also highlights the general nature of
the management task - it is quite possible for an engineering manager to focus on the
management of technological activities, or to become involved in the management of
other activities that support the engineering function, or even to move completely into
general management. From a systems perspective, engineering management is the
factor that integrates all the elements of the engineering process.

3 Engineering management education
There is an international consensus that management skills and studies are an important component of the professional formation and on-going development of professional engineers. The American Society for Engineering Education (as far back as 1955) concluded [10]:

“It is clearly recognized that many engineers progress into managerial and top executive positions in industry and government. For such individuals the foundation should be laid in college for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build.”

The Higher Engineering Education for Europe (H3E) group report [11]:

“The real world is not as precisely defined as technical courses at school and university would lead students to believe...The varied problems that arise in daily professional life are not so restricted. They demand varied responses, with an integration of insights brought to bear from many different perspectives (technical, manufacturing, psychological, marketing, historical, economic, etc.).”

Engineering management studies can commence at the undergraduate level. In Australia, prior to 1997, the accrediting body for undergraduate engineering courses, the IEAust, had a mandatory requirement for 10 percent of undergraduate courses to management studies [12]. Since 1997 this requirement has been relaxed to, “...integrated exposure to professional engineering practice (including management and professional ethics). This element should be 10% of the total course content…” [13].
In the US the Accreditation Board for Engineering and Technology (ABET) includes engineering management amongst the more traditional undergraduate engineering course disciplines that it accredits [14].

While exposure to management principles during undergraduate formation is important for engineers, it is at the postgraduate level where the demand for formal management study becomes most apparent. In the United Kingdom 32 percent of MBA students are engineering graduates [15], this being the most common first degree discipline of MBA students [16]. In Australia the largest MBA program is one designed principally for engineers and focused on the management of technology [17]. A recent Australian review of continuing professional development in engineering identified that while only 3.5 percent of engineering graduates pursue a higher degree in engineering, the dominant competency chosen for formal postgraduate study is management, with 15 percent of engineers studying an MBA [18].

Undergraduate and postgraduate studies are just two phases in a continuum of lifelong learning required to attain and maintain technical and professional competence, and currency of knowledge. The importance and on-going need for management education for engineers is summarised by Hecker; in reflecting on the skills required for success in consulting engineering she identified three key issues [19]:

1. the need and importance of non-technical skills;
2. the importance of providing basic soft skills training in engineering undergraduate programs; and
3. measures that organisations can take to promote lifelong learning of these skills.
The literature shows that at the postgraduate level an MBA is a popular study choice for engineers, however, there are other options for the formal study of management principles and practice. In fact, there are a wealth of such programs. In 1994 Kocaoglu reported on the growth of technology management programs internationally since 1949, identifying a rapid increase in the number of programs offered during the 1980s followed by an even greater rate of new programs in the 1990s. He also reinforces the fact that most programs are at the postgraduate level [20]. Hauck [21] also notes the predominance of postgraduate programs in technology management education. The range of postgraduate study options in this field for engineers includes, but is not limited to:

- Master of Business Administration (MBA);
- Master of Engineering Management (MEM);
- Master of Technology Management (MTM);
- Master of Technology Administration (MTA);
- Master of Science in engineering management (MSc(engineering management));
- Practice-Oriented Masters Degree (POMD);
- Management Of Technology (MOT); and
- variants and combinations of the above.

Which of these or other competing options is the ‘best’ path for the aspiring engineering graduate to formally develop their academic qualifications in management is subject to wide debate. If the ‘market’ knows best, then the strong demand for MBA programs from engineering graduates (noted above) is a point in their favour. Greek notes not only the general popularity of MBA programs, but that many students of these
programs are company sponsored or funding their own enrolment, “…so the rewards must be worthwhile.” [22]. Merkel notes that engineering has been intimately linked to the MBA concept from its initiation at Harvard in 1908, where Frederick Taylor was invited to accept a key academic position in the new program, and that the sheer numbers of engineers in MBA programs established “…the concept of an engineering undergraduate degree coupled with the MBA as excellent preparation for dealing with the problems of modern technology management” [23]. Bellinger reports on the US National Science Foundation’s Engineering Workforce Project that found that pairing an MBA with an engineering degree led to tangible career benefits for the dual degree holders [24].

However, the MBA option has its critics. Chapple notes a 1987 US report from the National Research Council calling for technology management education to be taught in an interdisciplinary manner, rather than in isolation in management schools [25]. Over time Badawy has criticised both the MBA option, for being too academic and non-technical, and MEM options for being too variable in content, and both options for not adequately preparing technologists for a career in the management of technology [26]. He argues that the management of technology is an important discipline in its own right, with its own curriculum. He proposes that existing MBA and MEM programs could be improved by infusing them with elements of an MOT curriculum, and that the MOT curriculum could stand in its own right as a postgraduate level program clearly distinguished from the MBA and MEM [27]. Young dismisses the MBA option for engineers as “…not engineering orientated but offered to any graduate.” He proposes the MEM or MTM as more appropriate postgraduate programs for engineers, but notes that regardless of postgraduate academic qualification, if a candidate cannot demonstrate technical competence and capacity to communicate and supervise, then
they are unlikely to be promoted to even first line management [28]. Tobias suggests that managers in high tech organisations, and perhaps even all managers, need more than just a ‘vanilla’ MBA, they need to understand “…the business of technology”. He proposes the MOT postgraduate program as the preferred path for technology graduates, though he concedes that the MOT has some way to go to compete with MBAs as the corporate management credential, and that “…the MOT program was created not in response to demand, but in anticipation of it.” [29]. Zehner argues that MBA programs focus on defining what needs to be done in business, and Master of Science (in technology) programs focus on how to do it, but that modern competitive pressures require managers who can integrate both aspects of business, and that the MOT program is the best way to achieve this outcome [30].

4 Discussion

Many of those arguing for or against the MBA seem to see the postgraduate management study options for engineers, and presumably the needs and motivations of students, in rather black and white terms, perhaps due to their philosophical positions and/or affiliations with particular study programs. However, the different aims and implementations of study programs, and the differing goals and needs of engineering graduates mean that the real world exists in a grey scale with a very wide range. Merkel notes that the nature and content of both MBA and MEM programs vary widely between institutions, and offers the Practice-Oriented Master’s Degree as another postgraduate level study option to develop students by exposure to both the technical and managerial aspects of real engineering practice in the context of a
master’s level project in conjunction with industry. Amongst these options he suggests that, “Individual engineers will need to decide which of these approaches best suits their need for professional growth and development…” [23]. Greek also echoes the importance of the engineering student’s personal goals and choice in determining the most appropriate postgraduate management development path [22]. Gault acknowledges the on-going popularity of the MBA for engineering graduates, but echoes Young in the need to back this up with proven management skills in the candidate’s work experience. He also contrasts the MBA option with an MSc in engineering management, quoting an MSc program director as saying (with an apology for the generalisation), “the MSc…is for people who very much want to retain a technical role with a good underpinning of management ability. The MBA…offers an opportunity for people to move out into a broader role.” Ultimately, Gault suggests that both options have their place in fulfilling the differing needs of students [16].

Hauck [21] attempts to sum up the ‘unique’ character of technology management as:

“…more than just the interdisciplinary intersection of engineering and business. To be effective, managers of technology must demonstrate not only solid foundations in both these disciplines, but they must also possess basic skills in human interaction, teamwork, leadership, problem solving, and written and oral communications.”

However, there seems little material difference between this definition and those for engineering management noted above. While there appears to be much weight placed on subtle distinctions and semantics, there may be less difference across the ‘broad’ spectrum of postgraduate management study options for engineers than is immediately
apparent. There is no doubt that the discipline of engineering management has
developed over time to encompass more than quantitative techniques for project
management and optimisation, and the supervision of technical and manual resources.
Most modern definitions of engineering management would include the strategic
management and deployment of technology for the achievement of organisational goals.
Likewise, most MBA programs would also recognise the importance of the
management of technology and incorporate this theme in their structure.

Much of the criticism of MBA programs relates to their management school heritage
and content, and the lack of relevance to engineering or technology practice. This
rationale is often used as a justification for competing program options, such as a MOT
degree. However, Kocaoglu reporting on international trends in technology
management education found that, while the majority (77.9 percent) of programs with
the title ‘engineering management’ were based solely in an engineering school, for
MOT programs the single largest academic location (38.1 percent) was a business
school, and 64.3 percent of MOT programs were at least jointly based in a business
school [20]. It could be argued that the MOT has more in common with the MBA than
it does with the MEM.

Tobias identified the MOT program as “…a kind of MBA geared for the OEM.”
(original equipment manufacturer) [29]. If the MOT is an MBA for industry, then
MBA programs have not been slow to adapt their curriculum so as to be able to counter
that they offer the ‘technology’ degree for management. There are many examples of
‘techno-MBA’ programs in the context of both information technology [31] [32] and
engineering [33] [34]. It seems that the natural development of the disciplines of
engineering, technology, management and their intersections, as well as the varied and
changing interests of students, their employers and the state have driven a convergence
of thought, approaches and curriculum regarding the importance of technology management.

5 Conclusions

There is no doubt that the effective management of technology is a key factor in competitive success. The nature of professional engineering practice will continue to mean that the bulk of engineering graduates will eventually find themselves in a technology management role. A proportion of professional engineers will move into a general management role, where they will still find that the effective management of technology is crucial. Undergraduate studies cannot give anyone all the skills they will need in their professional careers; the limited duration of undergraduate studies and the advancement of knowledge in all disciplines mean that postgraduate studies (in fact, lifelong learning) will be an inevitable feature of professional life. Engineering graduates will continue to seek out postgraduate studies in management in large numbers.

Engineers as students seeking postgraduate studies in management will, as a group, have a wide range of reasons for selecting a particular study program. These will range from strong philosophical convictions as to why a particular type of program from a particular institution is ‘best’ (“it’s a Master of X from university Y, or nothing!”); to very pragmatic reasons based on the location and/or mode of offer of the program (Ubell notes that engineers are large consumers of on-line postgraduate programs, “…As any engineer knows, there is tremendous pressure to keep pace with the latest technology and the newest ways of doing business...Yet few engineers have the luxury
of attending classes on well-groomed college campuses.” [35]); to being ‘compelled’ to enrol in a particular program as a requirement of a structured development program sponsored by their employer.

Attempting to prescribe a single ‘best’ postgraduate management study option for all cases is based either on the assumption that all students have the same aspirations, interests, circumstances, capacities and career paths, or, that a single option can cater for all of the broad diversity of student characteristics. The first assumption is self-evidently flawed, and the second seems highly dubious. Engineering in particular encompasses a very wide breadth of discipline areas (engineering knowledge) and activities (engineering process) – so wide in fact that in a recent review of the contribution of engineering to society the UK Royal Academy of Engineering coined the term ‘the universe of engineering’ as the only practical means to describe the diversity of engineering activity, around which they could not put clear ‘boundaries’ or ‘horizons’ [36].

The diversity of engineers and engineering practice will ensure a diversity of postgraduate management education needs, which will be best served by a diversity of options for study. Diversity of options is a strength, not a weakness; there is not a single ‘best’ option for management education for engineering graduates. As long as they offer relevance, convenience, interest and value, the various postgraduate management study options with their particular distinctions and emphasis on technology or management will find a ready audience. As Gault says in a critical evaluation of the MBA and other postgraduate management study options [16]:

“How many engineers are so in love with their subject that they can’t bring themselves to think of boardrooms…Engineering companies may wish for crack
engineering managers; engineers may be dreaming of bigger things. The MBA is here to stay.”

References


