Experiences in Implementing a Postgraduate Engineering Management Program

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***Abstract**: The majority of practising engineers are expected to possess managerial skills as well as specific technical skills. While many engineering graduates undertake a Master of Business Administration to gain the necessary knowledge to undertake their managerial tasks, there is also a demand for the development of managerial skills more closely related to engineering practice. These skills are likely to be more relevant to engineers if they are related to engineering tasks. Examples of such knowledge would include the impact of technology on society, sustainability, risk management, asset management and innovation management. The Master of Engineering Management program was developed by the University of Southern Queensland to provide these skills. While the courses in this program were initially developed for distance education only, several are also now delivered on-campus. This paper discusses the experiences of two of the academics involved with the development and delivery of courses in this program.*

***Keywords**: Management, engineering, education, postgraduate*

Introduction

The Master of Engineering Management (MEM) originated with the Master of Technology Management (Thorpe, 2004), which was developed by the Faculty of Engineering and Surveying at the University of Southern Queensland to provide practising engineers with specific engineering skills along with the principles of managing engineering projects and processes.

While the Master of Engineering Management has similar goals to the Master of Technology Management, it also has a number of differences to it. This paper briefly overviews the MEM, and then discusses experiences of two lecturing staff in the delivery of several of the courses in it and its predecessor program, with particular emphasis on the period after Semester 1 in 2004. The discussion not only outline the development and delivery process of this course, but also discusses how challenges in this process have been identified and met, and how this program might develop in future.

History of the Master of Engineering Management

The purpose of the Master of Technology Management was to produce graduates "that are equipped with essential management knowledge and an appreciation of the latest technologies much broader than the initial specialisation" (University of Southern Queensland, 2002, p.7), in order to equip them to manage complex technological or engineering businesses. The term "technology" was defined widely, so that it included all engineering and scientific disciplines. The program was developed out of the recognition that a large number of engineers and other qualified people aspire to managerial positions in a technology or engineering environment. In addition it was recognised that qualified managers of technology play a crucial role in technologically advanced as well as developing societies (University of Southern Queensland, 2002, p. 11).

Therefore, the Master of Technology Management was primarily aimed at attracting engineers and technologists who wished to develop management skills but wanted these to be in the field of technology management. It was designed to be completed by part-time external delivery mode, over a minimum of six semesters., and consisted of 12 courses, four of which were core Master of Business Administration courses and eight of which were specialised technology management courses. This program was complemented by an entry level Postgraduate Certificate (four course) and Graduate Diploma (eight course) programs, and a Master of Professional Engineering, which is 12 courses long but includes a significant project in place of some coursework. Selection between alternative study paths enabled learners to select an appropriate mix of courses to suit their needs.

Selected Individual courses in this program have been also been made available to other programs in the Faculty and also within the University as a whole. While these individual courses have been attracting a number of students, the student numbers in the overall Master of Technology Management program remained small. It was also seen as important that the focus of the program should be more on engineering rather than broader technological matters. Additionally, it was observed that a number of postgraduate engineering and other programs at the Master level elsewhere were equivalent in length to a one year full time study program (eight courses). It was also observed that while individual students from a wide range of disciplines (both engineering and non-engineering) undertook courses in the Master of Technology Management, students undertaking the program as a whole were either engineering technologists or professional engineers. For these reasons, it was decided to redevelop this program into the shorter Master of Engineering Management program that had similar objectives, but had a stronger emphasis on specialised engineering management. The postgraduate certificate, consisting of four courses, was retained, as was the Master of Professional Engineering. For professional engineers, there is a direct articulation path from the new Master of Engineering Management to the Master of Professional Engineering, which in turn articulates into the University's Engineering Doctorate program. The Master of Engineering Management was first offered in 2007.

Structure of the Program

The Master of Engineering Management consists of four core courses, and a number of electives, of which four must be undertaken to complete the program. At least two of the electives must be specialised management engineering courses. Figure 1 shows the structure of this program.

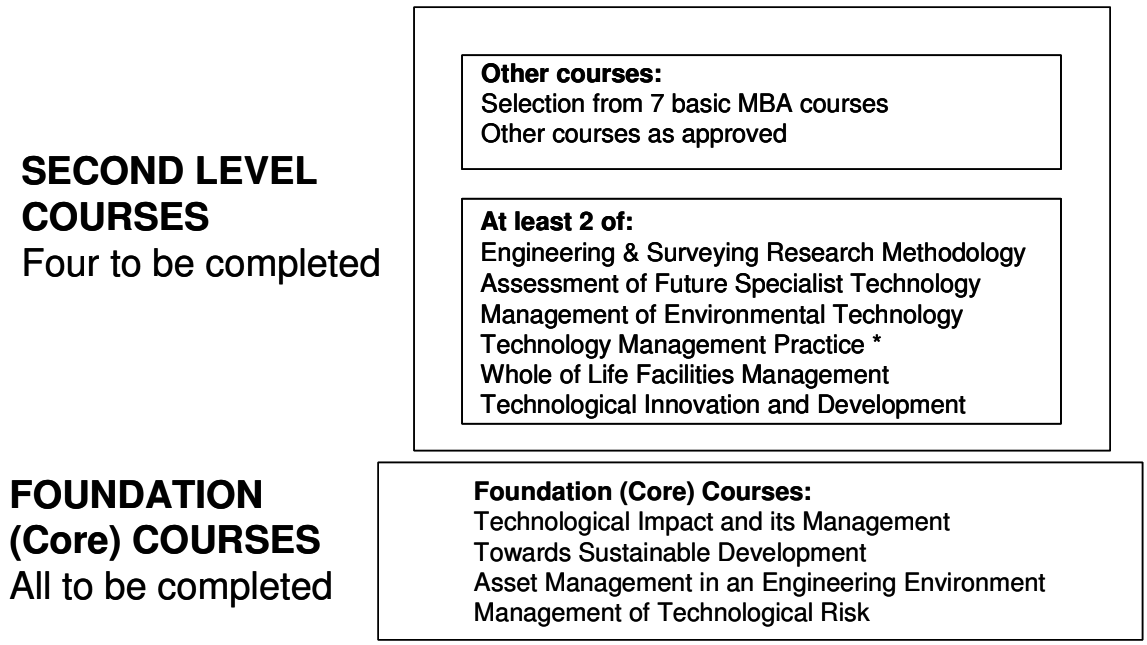

Figure 1: Structure of the Master of Engineering Management

The MEM program is founded on the premise that engineering management of the future needs to address contemporary issues, and in particular sustainability, which is seen from a practical point of view as outlined by Johnston (2003), who sees sustainability is as an ideal state of long-term social, economic and ecological stability - a target towards which we strive, rather than one we expect to reach.

The core (or foundation) courses in the Master of Engineering management are:

- Technological Impact and its Management
- Asset Management in an Engineering Environment
- Management of Technological Risk
- Towards Sustainable Development

These courses allow engineers to gain an appreciate of societal and environmental aspects of engineering management, to appreciate the issues in managing risk, and to understand the importance of taking a whole of life approach to managing engineering assets. All have been developed with the exception of *Towards Sustainable Development*, for which suitable substitutes exist in postgraduate business or science courses at the University. The other three core courses, together with the second level course Technology Management Practice, have been selected for delivery with the Master of Engineering Technology. These four courses and the course *Technological Innovation and Development* are briefly discussed below. Some courses previously described in Thorpe (2004) are included in this list for completeness.

Brief Description of Selected Courses in the Master of Engineering Management

Technological Impact and its Management

Technological Impact and its Management is based on the understanding that that the world of today is one in which there is dynamic change in the creation and development of technology. Therefore, it is necessary for managers of technology to understand the impact of technological development and the ways in which it can affect the society in which we live and the controls necessary to achieve a positive impact on mankind.

This course reviews current technological development, evaluates its impact on the world on we live in, examines the relationship between modern society and technological development, and discusses the role of technological development on wealth creation and business. It also assesses the overall social need to manage such development as well as technology creation, transfer and exploitation. While it does not specifically focus on asset management, it introduces the asset manager to the principles of strategically and innovatively managing technological development in a world that demands increasing social and environmental responsibility in the technological management process.

Asset Management in an Engineering Environment

Asset Management in an Engineering Environment recognises that that in the modern world one of the highest expenditure for any government is the cost of developing and maintaining engineering assets over their life cycle - identification of the need for the asset; provision of the asset; operation of the asset; and disposal of the asset (Austroads, 2007). Such asset management combines engineering principles with sound business practice and economic rationale, and provides suitable decision-making tools (Pakkala, 2002).

The course takes a strategic view of asset management and within this context firstly discusses the principles of the asset management process and asset management economics and then applies these principles to the asset management process. A follow-on course, *Whole of Life Facilities Management*, focusing on the tactical and operational process of asset operation and maintenance, may be developed in future.

Management of Technological Risk

Management of Technological Risk is based on the principle that risk management is a priority area for the modern engineering manager, and concentrates on the management of technological risk with

respect to both taking advantage of opportunities and minimising the effect of negative impacts. The first part of this course uses as a framework the Australian and New Zealand Standard for Risk Management (Standards Australia /Standards New Zealand, 2004). In the second part of the course, learners apply risk management principles to technological and engineering projects and processes, and discuss the future of risk management, which is an important tool in evaluating the likely benefits and costs of alternative approaches in the asset management process.

Technology Management Practice

In *Technology Management Practice*, learners are exposed to the principles of management and administration, as well as those of project and works management; engineering economics, probability and statistics, law (as related to engineering); and a number of the administrative functions related to engineering management. This course introduces the engineering manager to the principles of general management and administration from an engineering viewpoint, and can either stand alone as an introduction to the principles of engineering management or complement business management courses.

Technological Innovation and Development

Technological Innovation and Development builds on *Technological Impact and Its Management*, and is designed to enable learners to understand the commercial research and development process; appraise the factors which impact on innovation and its development from a managerial point of view; understand and apply the organisational, social and environmental factors which impact on product and process innovation; appreciate and manage the relevant risks; and understand key issues such as intellectual property management and commercialisation.

Development of the Master of Engineering Management

As previously discussed, development of the Master of Engineering Management commenced with the Master of Technology Management (Thorpe, 2004). Development of the Master of Technology Management was both a challenging and rewarding experience, and was aimed at meeting the following three criteria, which remain important for the MEM:

- focus of the program
- differing requirements and expectations of learners
- delivery of the courses by external study mode

As both engineering and its related technologies are dynamic in nature, and the organisations that deliver them are at differing stages of technological maturity of organisations, it has been important in the development process to understand that learners themselves, who come from a wide range of both Australian and international cultures, educational backgrounds and organisations in differing stages of technological maturity, will be quite diverse. This has required close consideration of the type and sophistication of the course material, which has been primarily pitched at the technologist level of engineering education. The development process has required considerable course development skill to ensure some degree of mathematical simplification while ensuring that the material has been sufficiently complex and interesting for meaningful development of more advanced engineers.

Similarly, requirements and expectations may differ across geographical and political regions. Therefore, course development has needed to consider both Australian and overseas practice. For example, *Management of Technological Risk* is primarily based on the Australian/New Zealand Standard for Risk Management. However, the course developer has had to appreciate that there are also other equally valid risk management methodologies (for example, see Chapman and Ward, 2003, pp 55-76) which need to be also considered.

The requirement to deliver the courses by external study provided a further challenge. The University supplies packaged study material (combined in many cases with a suitable text) to all distance education students and supplements this material by online discussion between lecturers and students, using at the moment the WebCT program. Lectures and tutorials may also be posted on the on-line resource material. This process combines the features of detailed written source material with the interactive capabilities of on-line course delivery (see for example Deeks, 1999; Macdonald, 2001).

It is noted that there is considerable development work in developing web-based teaching (Ferris, 2003). A similar argument can be mounted for the written material required for distance education, which needs to be concise, readable and suitable for students. The combination of good written material, selection of good texts and interactive on-line discussion with students appears to be the best way of reaching distance education students throughout the world.

Delivery of the Program

It was observed early in the delivery process that the students enrolling for the courses came from diverse academic backgrounds, including business administration, project management, technology management and engineering technology. This diversity of students justified the approach taken to course development, which was to keep the material in the courses at not too difficult a mathematical level, but at a level that challenged the professional engineer.

In 2006, the Faculty of Engineering and Surveying offered four of the courses in the program by on-campus teaching as well as through distance education. This additional delivery mode occurred as a result the offer of these four courses in other Faculty programs – in particular the Master of Technology Management - either as a technology management major or to replace a four credit point dissertation project for some students. This additional mode of delivery required the development of on-campus lectures and tutorials for delivery to classes, in which international students whose first language is not English have predominated. While it has provided a number of challenges for the lecturers involved, this initiative has been very successful, resulting in a considerable increase in student numbers.

The initiative to introduce the MEM to replace a longer program has so far proved successful, with 12 students in the program (compared with a very few previously) at the time of writing. The number of students in the individual courses in the program has also further increased over the number in 2006, and for the four courses discussed in the previous paragraph ranges from 27 to 45 students. Table 1 shows the number of students enrolled in selected courses by year as at the end of the semester (i.e., the number initially enrolled less drops).

Table 1: Number of Students Enrolled in selected postgraduate Technology/Engineering Management Courses by year

Course/Year	2004	2005	2006	2007
Technological Impact and its Management	2	8	7	33
Asset Management in an Engineering Environment	4	5	12	30
Management of Technological Risk	4	7	Not offered	43
Technology Management Practice	6	4	Not offered	28
Technological innovation and Development	NA	NA	2	2

Addressing the Issues

As part of a continual improvement philosophy, students in a number of the Master of Engineering Management courses have been surveyed regarding their perceptions of the way in which the courses were structured and delivered. The basic questions asked of students were interaction with the lecturer, usefulness of the assignment questions, level of understanding of the course subject after studying the modules, overall teaching of the lecturer and comments and suggestions for improvement. The results from these surveys have shown a number of aspects of potential improvement for the material delivered. The same questions were asked of distance (external) study students and on-campus students.

As a rule, only a proportion of students have responded to surveys. For example, in *Asset Management in an Engineering Environment*, there were only a total of four responses from 2004 to 2006. However, there were 11 responses (37% of students) in 2007, and therefore while this may not be a

statically significant sample, it does provide a guide to student thinking. Table 2 shows the positive and negative points from responses over the period of offer of the course, and any proposed action to address negative comments.

Table 2: Main Responses by Students – Asset Management in an Engineering Environment

Positive Comments	Negative Comments	Action on Negative Comments
Overall teaching	Discussion on course web page	Continually strive to improve within time constraints
Written course material	Higher weighting to assignments	Not being considered at this point
Lecturer interaction	Timing of on-campus lecture (was fortnightly in the afternoon)	Change time to better suit student timetables
Students gained valuable knowledge	Some modules hard to understand (asset management economics was seen as difficult)	Improving asset management economics module and its discussion
Response to emails	Accent on civil engineering	More emphasis to be on examples from other disciplines
Lecturer competence and knowledge	Usefulness of some assignment questions	Questions are being reviewed
Course overall	More examples on engineering economics	Have added more examples on Study Desk
	Stronger focus on sustainability	To be considered – course was written with sustainability focus
	More material in soft copy	Consider for future offers
	Material in one book	Not being changed at this stage

In summary, in this particular course, assignment questions have been modified, efforts are being made to make the course more cross-disciplinary material in the course, improvements have been made to the way in which engineering economics are taught, and there is a conscious effort to improve the use of the web based course Study Desk by students, and to make the discussion on that Study Desk more meaningful (including placing all lectures on the Study Desk)..

In addition to the above points, errors that have been identified in the material in the distance education study material have been corrected, and lecture and tutorial times are being reviewed. Consideration is also being given to redeveloping lectures and tutorials for delivery in a workshop environment as opposed to a formal lecture environment.

While external students in the most recent offer of this course have achieved very good grades (the average grade in 2007 was 5.2 on a 1 to 7 scale), there is room for improvement in the grades of on-campus students (whose average grade in 2007 was 4.7 on a 1 to 7 scale). This difference may be related to the need for improved communication with the on-campus students (many of whom are international students) in a classroom setting, the teaching and tutorial style, student motivation and prior knowledge, or other factors. As a result, an effort is being made to ensure that students better understand course material delivered in a language that is not their own first language, and to make lecture and tutorial sessions more interactive.

Master of Engineering Technology students undertaking Master of Engineering Management courses have also shown interest in extending such studies especially with respect to new product development. With this in mind the course *Technological Innovation and Development* would suit perfectly. Hence it is proposed to offer this course in this program along with the existing four Master of Engineering Management courses. Moreover even though it adds to *Technological Impact and Its Management* it can be run in parallel to it without complications.

Another initiative arising from the course material is the development by the Faculty of short courses based on its material, such as an engineering project management course delivered to local government that utilises material from relevant courses listed in Table 1. Further initiatives, such as possible alternative modes of delivery, are being considered.

Finally, should this program continue to be successful, it is anticipated that further courses will be developed in the future, and that the use of on-campus methods of delivery, which provide better exposure to course materials and the interactive discussion that is important for postgraduate students, will extend to additional courses in the program.

The Challenges Ahead

The Master of Engineering Management has been designed for professionals, and in particular professional engineers and technologists, who are interested in developing engineering management capabilities in addition to their technical skills. As such, this program can be a capstone to the engineering education of those engineers who see that their primary specialisation will be engineering management as opposed to expertise in a particular engineering discipline or sub-discipline. It also has potential to be a significant component of the fourth and fifth year of any future five year engineering degree for those students who desire a significant engineering management component in their degree.

It is therefore important that while the Master of Engineering Management has to date met the goals of providing learners with essential management knowledge and appreciation of latest technologies much broader than their initial specialisation, it is important to both maintain and increase its relevance to the needs of the engineering profession. This will need to be addressed by keeping in touch with current issues, anticipating future engineering and business trends, and continuing to enhance the flexibility of the development and delivery of the courses in the program.

One of the other challenges will be that this program continues to motivate professionals who desire to succeed in their chosen careers. It will accordingly need to be continually developed and updated in a climate of flexible delivery that meets the needs of both Australian and international engineering professionals, and links in with their work, family and cultural lives. For example, on-line delivery will continue to remain important and may need to be enhanced with on-line assignment and examination submission that meets the time requirements of learners. On-campus offerings of the courses in the program will similarly need to meet the time and resource requirements of busy professionals.

Part of the program development process will be ensuring that it meets the needs of engineering professionals in global communities, including developing countries. This will require continued and improved understanding and appreciation of technological development and social, environmental and economic values and needs, which in turn should improve the relevance of course material to learners in local communities and at the same time improve understanding of global issues by all learners.

Finally, there is the challenge of ensuring that the program and its courses will remain relevant to industry, and in particular to specific industries, some of which have approached the University for more specific training tailored to their industry along with the generic engineering management skills taught in this program.

Conclusions

The Master of Engineering Management combines business and engineering skills into an integrated package aimed at the innovative management of today's and tomorrow's technology based organisations, and is being developed in response to a changing world and changing demands, and is being delivered through both advanced distance education and on campus, and is aimed at attracting dynamic engineering professionals worldwide. It also has the potential to be both a capstone for engineering professionals requiring a management qualification that is engineering oriented and as the basis for industry training in specific areas like engineering project management.

For these reasons, this program requires a tight focus in terms of content and flexibility with respect to engineering discipline areas, delivery processes, and coverage of experiences and cultures of learners. Those staff involved in its delivery also need to be committed to a culture of continuous improvement

in areas like course content, delivery methods and assessment. They also require to be in touch with the needs of engineering professionals, industry, and local and global management and engineering trends and issues.

The challenges in developing and improving the Master of Engineering Management and its constituent courses are therefore considerable. So far, they have been met successfully, and have resulted in considerably increased student numbers. It is important that this momentum continues to be maintained, in order that this program can meet the needs of engineering management education both now and well into the future.

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