34th Australasian Association for Engineering Education Conference
3 - 6 December 2023 – Gold Coast, QLD

Investigating types of Managerial skills in Master of Engineering Management (MEM) courses in Australia

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ABSTRACT

CONTEXT

Engineering and management are two distinct fields, with engineering concentrating on technically challenging abilities and management prioritising administrative and people-centred skills. Master of Engineering Management (MEM) courses incorporate content from both disciplines to equip students with appropriate skills so that they can perform both technical activities as well as management and administrative functions.

PURPOSE OR GOAL

This study aims to identify what universities in Australia present as the common management concepts and skill attributes their students would learn. To understand the skills development priorities, the various subjects offered at six universities have been examined by taking into consideration of main themes and the Course Intended Learning Outcomes (CILOs) associated with these courses.

APPROACH OR METHODOLOGY/METHODS

A qualitative research strategy is used by collecting data from two sources. First, the study has thoroughly investigated and analysed numerous relevant articles from the literature to demonstrate relevant skillsets in the field of engineering management. Second, publicly available course information of MEM courses from six universities in Australia is accessed to find the common management concepts taught across universities. This paper used these data to derive common themes of management concepts and skill-attributes associated with them for engineering managers.

ACTUAL OR ANTICIPATED OUTCOMES

By exploring the course's intended learning outcomes in MEM courses, we were able to identify several management concepts and associated skills attributes like project management, decision-making and strategic management, quality management, financial management and teamwork. The emphasis on these management concepts and skills is also corroborated by the relevant literature in the domain.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The MEM courses are offered to gain some managerial skills to help engineers to move into managerial positions. Relevant literature also highlights the importance of management concepts and organisational skills to be an effective and efficient engineering manager. Universities need to consider their offerings to engineering students who are interested in management roles. Our list from different universities might assist in benchmarking MEM courses offered by universities and guide their curriculum development.

KEYWORDS

Engineering management, MEM, managerial skills, management concepts, Course Intended Learning Outcomes (CILOs)

Introduction

Engineering and management are two distinct fields, with engineering concentrating on technically challenging abilities and management prioritizing administrative and people-centred skills (Aucoin, 2018). While engineers are renowned for being problem solvers and technical experts, they frequently find business and management ideas challenging. Master of Engineering Management (MEM) programs function as a tool to strengthen the connection between the management skills needed in the boardroom and engineering/technological abilities. Additionally, engineering management courses offer a well-rounded education in leadership, ethics, finance, and business administration.

Engineering managers are managers who, due to their previous engineering responsibilities, are aware of the technical elements. They can perform high-level technical activities and administrative functions such as collaboration, budgeting, and project management (Riley et al., 2013). Studies point out that most engineers move into a management or leadership role after their first 3-5 years of employment (Yeh, 2008). As engineers advance into managerial positions, their job demands and expectations increase due to the inclusion of management responsibilities (Yeh, 2008). In a business environment, a manager understands how to bring their team together to solve an issue by recognising everyone's strengths and applying them to the company’s objectives. This approach is no different for engineering managers who must communicate effectively and provide constructive feedback. These managers are expected to think strategically during projects, assign roles and tasks, and handle project updates (Ahmed & Anantamula, 2017). Engineering managerial jobs take far more responsibilities, activities, and priorities than engineers. As a result, these engineering managers must gain managerial skills during their careers. Skills such as negotiation, active listening communication, emotional intelligence and teamwork can be acquired through management courses (Mihail & Kloutsiniotis, 2017).

This study investigates different managerial skills students of MEM courses in Australia would learn. The length of the degree varies among universities for either two semesters (12 months) or three semesters (18 months). The major management concepts introduced in MEM courses’ core subjects are reviewed by analysing course learning outcomes from publicly available information in six different Australian universities. Managerial skill attributes are determined from the analysis. This paper is organised as follows. Background information on engineering management and some core management concepts are discussed in the next section. The research method is briefly described in the following section. Then, a summary of course intended learning outcomes from six Australian universities and common themes of management concepts are discussed. Finally, a conclusion is drawn with some recommendations for future research.

Background

As more and more business leaders ascended the corporate ladder in the United States during the 1950s, the demand for Engineering Management began to grow. The 1970s oil crisis contributed to a significant rise in this demand. Until the early 1990s, business and engineering institutions offered a minor in engineering management because engineers needed to understand how business models worked, and business graduates required to understand technology (Cetindamar et al., 2021; Spohrer, 2013).

Engineering managers can be distinguished from other managers due to their technical skills. Luthans et al. (1988) studied 457 managers to better understand their significant tasks. The managers would need to have excellent writing and verbal communication skills for routine communication, which primarily includes exchanging information, pitching to the clients, and handling all the paperwork. Planning, scoping, decision-making, controlling, and administration are traditional management tasks that are correlated with an individual's judgement and capacity to develop strategies. Engineering managers manage the technical and broader business functions such as marketing in an engineering firm (Morse et al.,2004).

In their research, Shageeva and Kraysman (2020) stressed the relevance of professional communication as a skill for future engineers in professional careers. They believe university students should have a broad technical understanding and general managerial skills such as time management, management, teamwork, business communication, and problem-solving. Tshamano (2020) investigated and analysed the essential management factors to help engineers become better managers; 34 participants were involved in the qualitative study; 13 of them were engineering managers. This particular study concluded that most of these engineering managers needed to gain the necessary skill sets because they were primarily educated in technical skills at their universities rather than management skills, which are essential to becoming a competent manager (Tschamano, 2020). A similar study by Senashenko et al. (2019) argued that engineers' technical skills should not be separated from their administrative qualities in the twenty-first century. Effective communication and presentation skills, and the engineer's intrinsic technical abilities, are critical in making the right decisions and building effective teamwork (Shageeva & Kraysman, 2020).

The daily tasks of managers include a significant amount of networking and relationship-building. They will need to be sociable and interactive, which calls for excellent speaking and listening abilities, both with their co-workers and with others. Human resource management focuses primarily on hiring new employees, interviewing techniques, encouraging and correcting subordinates, avoiding contradictory decisions, and providing training as needed. Excellent leadership abilities and the capacity to accept and carry out obligations are required to be a manager (Parkin, 1996). Farr and Brazil (2000) argue that leadership has become vital for engineers managing interdisciplinary teams. Their study concluded that engineering managers would gain a competitive advantage by combining technical expertise with business knowledge to maintain relevance and connectivity in an era of increased outsourcing and global competition. A similar study (Wearne, 2004) in the United Kingdom exploring management skills identified that project management and leadership are the most significant managerial skills for engineering managers, in particular for higher levels of executive responsibility.

In recent years, empathy has been explored as a critical skill for engineers. According to Hess and Fila (2016), when looked through ASEE's conference proceedings in January 2016, they found that in 2015, 69 articles explicitly mentioned the term. In 2014, there were 38 mentions, in 2013, there were 23, and in 2012, there were 17, with a decreasing trend thereafter. This suggests that empathy is gradually becoming a central area of interest for engineering education researchers and educators. Litvinov et al. (2020) emphasised empathy as a desirable attribute to build during engineering studies. Engineers must have abilities like empathy, design thinking, communication, and ethical reasoning. Their study also reiterated the fact that technical education teaches problem-solving skills but not how to differentiate right from wrong. Empathy should be included while designing engineering courses for students. According to Zhu et al. (2021), as the complexity of a project grows, so does a manager's capacity to channel their emotions, which puts their other soft skills to the test. This finding implies that managers' performance can be enhanced by having accurate perceptions and understanding of emotions as a foundation for management decision-making. These managers must be able to coordinate the interests of all project participants while maintaining good mental stability (Zhu et al., 2021). Moreover, Marinelli et al. (2022) emphasise that interpersonal attributes like empathy and compassion have been recognized as essential employability traits for professionals, and they are vital for long-term success in upcoming work settings. Within the field of engineering, which is considered a socio-technical profession, empathy and care serve as fundamental pillars supporting numerous skills and qualities demanded of both existing and aspiring engineers. According to a PMI report from 2022, the importance of enhancing empathy is especially significant for project leaders. This emphasis on empathy enables them to cultivate a human-centered approach, which ultimately empowers teams to execute projects that genuinely make a difference. Additionally, it ensures that teams collaborate effectively to address challenges.

Methodology

The goal of this research article is to discover the key skill sets that are necessary for engineers to advance to managerial positions. By examining the Australian universities that provide engineering management courses, we investigate the common skill sets their courses focus on for students.

We browsed the public sites of all Universities that offer MEM courses. Out of 11 universities, six have the course information publicly available. Table 1 below shows the website links to the handbook (course information) from those universities:

Table 1. Course information link for MEM courses

University	**MEM Course information Link**
La Trobe University	https://www.latrobe.edu.au/courses/master-of-engineering-management
Macquarie University	https://coursehandbook.mq.edu.au/2022/courses/C000177
Queensland University of Technology (QUT)	https://www.qut.edu.au/courses/master-of-engineering-management
University of Melbourne	https://handbook.unimelb.edu.au/2021/courses/761em
University of Technology Sydney (UTS)	https://handbook.uts.edu.au/courses/c04275.html
University of Wollongong (UoW)	https://courses.uow.edu.au/courses/2022/1506

The handbooks and subject guides offered by each university on their websites (shown above in Table 1) were examined to understand the skill development priorities. The core subjects offered by each university are reviewed to find the common skill sets deemed necessary to be an engineering manager in Australia.

We have reviewed each core subject and its corresponding learning outcomes. A summary of learning outcomes from each university is analysed to link them to work related skill sets their students could gain from the degree. The skill attributes were derived using an online work-related competency list from the 123test.com site. Each skill from the engineering course was examined, and the closest attribute was chosen after comprehending the management concept and associated skill set. For example, the skillset offered by one of the universities includes: “Working in teams, to formulate problems and to provide solutions to these problems.” This particular skill set is categorized under the group of ‘teams’ and ‘providing solutions.’ Furthermore, according to the competency list, they are mapped with attributes ‘teamwork’ and ‘brainstorming’.

Later, common core subjects and their learning attributes from six universities are subsequently analysed to identify and categorise common themes. This short review discusses a list of preferred skill sets in MEM courses in Australian Universities.

Findings

Summary of CILOs from six universities

- **Macquarie University**

This curriculum focuses on learning various abilities along with the knowledge required for effective project management. Students are taught how to assess project commercial feasibility and develop appropriate procurement strategies. They learn to comprehend and analyse contract papers, evaluate bidders, and identify potential engineering project risks. A contractor's perspective on cost estimation, tendering processes, and financial decision-making is provided. Students also obtain management skills around decision-making processes, strategic planning, organizational behaviour, and workplace challenges. They also look at ideas like quality control, risk and safety engineering, and supply chain management. The program places a premium on teamwork, communication, and professional reporting abilities.

- **University of Melbourne**

This course is designed to help students improve their analytical abilities for engineering assignments. Within a collaborative setting, students learn to analyse and identify major concerns, develop challenges, and give answers. The emphasis is on collaboration, brainstorming, and team Effective verbal and written communication is stressed for interacting with team members and other engineers. The course fosters problem-solving, critical thinking, and qualitative decision-making through case studies and activities studies and activities, the course fosters problem-solving, critical thinking, and qualitative decision-making.

- **Queensland University of Technology (QUT)**

QUT course outline focuses on improving fundamental engineering skills such as problem identification, study design and planning, literature search, and effective communication through reports and presentations. Students also receive hands-on instruction in constructing a real-world enterprise resource planning (ERP) system utilizing industry data. Additionally, the course covers project management methodologies, frameworks, procedures, and essential knowledge areas, providing students with a thorough understanding of project management.

- **University of Wollongong**

This university course provides a complete overview of strategic management, emphasising the implementation of the strategy formulation process and strategic analytical techniques. Students learn to think strategically and make informed strategic judgments. The significance of incorporating economic, technological, and human factors in managing strategy for engineering enterprises is emphasised. Effective teamwork in strategy planning and compelling campaigning for stakeholder support are highlighted. The course emphasises that strategy rarely delivers easy answers and that acquiring relevant knowledge and convincing communication with stakeholders is critical to successful plan acceptance and implementation.

Furthermore, the course provides expertise and understanding of innovation and design processes for engineering structures, components, and systems. It investigates the relationship between design and product longevity and emphasizes the importance of collaboration in successful design execution. Financial, regulatory, and human factors influencing engineering design are also discussed. Logistics' role in maintaining effective material movement across supply chains is examined, as are strategic, tactical, and operational decisions influencing logistics systems. The role of information systems and technology in logistics is investigated.

The course discusses the importance of project management within more extensive strategic plans and involves students in engineering management research planning, including data analysis. Financial modelling, decision-making data requirements, cost management, and basic financial modelling methodologies for engineered asset management are reviewed. Overall, this course prepares students for strategic thinking, effective decision-making, teamwork, and the management of engineering projects and assets.

- **La Trobe University**

This La Trobe University course covers a variety of topics like innovation, critical thinking, market research, and strategic decision-making. Students examine present and future main areas of global innovation. They learn to do market research and collect primary data in order to develop realistic project and commercial objectives. To uncover viable answers to complex problems, the course stresses high-level brainstorming and problem analysis. Students learn to critically analyze business and economic conditions to establish effective company and marketing strategies. They also develop self-branding, presentation, and engagement skills.

Effective communication skills for both technical and non-technical audiences, as well as the ability to generate well-structured documents, are stressed. Accounting and finance principles, budgeting, pricing, and production decisions are covered in this course. It also covers themes including organizational behaviour, economic decision-making, statistical analysis, professional communication, and the evaluation of business strategies for innovation. There is a discussion of ethical and societal issues, as well as risk management and teamwork. The training also covers systems thinking, problem-solving, and managerial decision-making.

- **University of Technology Sydney**

This course available at the University of Technology Sydney, focuses on many areas of project management, decision-making, risk management, and systems thinking. Students learn to identify and implement the necessary knowledge and skills for effective project management. They gain skills in project documentation construction while working in a team atmosphere, and they consider the impact of personal and professional judgments on created plans. The course examines organisational behaviour as well as the challenges that technical professionals encounter while making managerial decisions. Students use logical and analytical decision modelling to assess and offer solutions to common administrative difficulties. They also investigate the psychology of judgment, the role of psychological elements and social norms in decision-making, and the advantages and disadvantages of group decision-making.

In addition, the course emphasises the inclusion of Indigenous cultural values and history in risk analysis studies and risk management plans. In engineering projects and systems, students learn to identify stakeholders, boundaries, and uncertainties, as well as assess, evaluate, prioritise, and treat risks throughout the project lifetime. To evaluate complex systems and design technical solutions, systems thinking is used. Teamwork, collaborative behaviour, and professional written and vocal communication skills for presenting research findings and recommendations are stressed. In addition, students create a professional project management strategy for exploring a research topic. Overall, the course prepares students for effective project management, critical decision-making, risk management, and systems analysis.

Most common skill attributes (Managerial skills)

Each course's intended learning outcomes are carefully analysed, and skill attributes are derived by referring to the competency list available in the competency list from this site (www.123test.com). The derived skill attributes are used to create Word Cloud to determine the list of managerial skills MEM courses offer their students.

The list of skills culled from engineering management courses at Australian universities is summarised in Figure 1. The keywords used to describe courses through learning outcomes are aggregated to create a word cloud, highlighting the characteristics and skill sets that engineering management studies.

Figure 1. Skills at Australian MEM courses

The word-cloud exercise shows the top four skill attributes or managerial skills: Critical Thinking, Teamwork, Project Management, and Communication.

Discussion

After reviewing CILOs and deriving skill attributes emphasised by six universities in Australia, we examined the relevant literature to find how the courses are aligned.

In the industry, most engineers spend the majority of their time managing projects and some of them perform better than others as their training, attitudes and principle varies (Aucoin, 2018). For this reason, companies are demanding universities to broaden curricula and to produce engineers who have desire for lifelong learning, are able to lead multidisciplinary teams and have knowledge in both technical and business fields (Farr & Brazil, 2015).MEM courses at Australian universities have integrated various management concepts and leadership skills to equip their students and prepare for those challenges in the industry.

Project management is one of the most common management concepts taught/covered by MEM courses. It equips them for successful careers in engineering project management, team leadership, and delivering value to stakeholders. Project management is an essential skill in engineering management courses because it offers students an organised methodology, tools, and procedures for efficient planning, execution, and successfully deliver engineering projects with consideration of technical, managerial, and organisational elements.

Although project management is among the top skill sets in universities' curricula, which was not given much importance in the relevant literature review. Other management skills like financial management, decision-making, teamwork, communication, and presentation have been deemed necessary by previous studies (Bass 2019; Senashenko & Struchkova, 2019; Shageeva & Kraysman, 2020). These managerial skills also form part of project management.

Since empathy could enhance the learning of various professional skills like effective team management, communication, collaboration, ethical decision making and care, it is important to embed empathy in engineering courses (Litvinov et al. 2023). New course development should incorporate conceptualisation of empathy to better prepare modern engineers and engineering managers.

Conclusion

This short review draws on data collected from engineering management courses offered by six Australian universities and the literature review in the engineering management domain. By analysing the themes and CILOs of courses, we listed major categories of skills they intend to develop for their engineering students based on the literature review themes. Our findings might draw the attention of engineering managers, researchers, and practitioners to better equip engineering professionals to cope with managerial challenges by improving their skills for a future-proof career. Universities should regularly consider their offerings to engineering students interested in management roles. Empathy has been recognised as an attribute that can be incorporated in the engineering management courses. Our list from different universities might help their benchmarking efforts during curriculum development.

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