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Relevance of Engineering Management courses to managerial skills in the industry

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***Abstract*—Digital technologies have radically influenced the modern workplace, which is exacerbated by the Covid-19 pandemic making it possible to work from home or remotely. Furthermore, these changes have been assimilated, so it is now necessary and difficult to separate ourselves from the flexible working environment.**

This study examines the various engineering management courses offered by Australian institutions to compare the skillsets taught and those deemed significant by engineering managers. The goal is to determine this connection in the current digital age, where re-skilling, digital intelligence, and empathy are some of the themes identified in the literature review.

The study is based on a review of 20 relevant research articles, interviews with ten Australian engineering and technical managers transitioning from engineering to managerial and team leadership roles, and an analysis of six Australian university curriculums. The findings highlight the importance of digital and emotional intelligence for managers. The study shows that most of the skillsets offered by the Australian university curricula did not include key skills.

***Index Terms*—Engineering management, managerial skills, digital skills, digital intelligence, curricula.**

I. INTRODUCTION

The impetus for digital transformation has been enhanced by the Covid-19 pandemic, which has compelled many enterprises to adopt digital services overnight. According to the Gartner dictionary, digital disruption is an effect that alters basic assumptions and behavior in markets or industries by leveraging digital capabilities and assets. In contrast, digital transformation is how firms use digital technology for non-digital services and operations [1]. The struggle to survive the imminent crisis of digital disruption results in digital transformation, referring to organizational transformation that continuously changes organizational value creation, structure, and business model to keep up with digital technologies [1-4]. Challenges concerning managing digital transformation necessitate digital skills [2]. Competency is an ability or talent that can be learned and developed through training, education, work experience, and other experiences [3]. The World Economic Forum (WEF) identified that digital competency is becoming a key competence for firms. Hence WEF added the competence of "Technology use, monitor, and control" to its top ten competencies list in 2020 [4].

Digital technologies, ranging from 5G, the internet of things (IoTs), big data, distributed ledger technologies (DLT), artificial intelligence (AI), and multi-cloud environments to autonomous vehicles and 3D printing, are creating new opportunities to transform strategy and operations [5]. For example, the concept of "Industry 4.0" or "fourth industrial revolution" indicates radical changes in the manufacturing sector through digitalization [4]. According to the World Economic Forum [4], by 2025, more than half of all employees will need to reskill due to increased technological use and the pandemic's effects. That is why the developments of digital technologies and their role in various industries have attracted various academic studies in engineering management [6].

Recent studies have focused on understanding the impact of the digital age on professions, including designers and innovation managers [1; 6]. Inspired by these studies, this article explores the implications of digital technologies on skill sets for engineering management professionals.

Some studies have a broad focus on skills with no discussion on education. For example, one research [6] examines how digital technologies affect professionals in technology management by listing the trends and potential changes. Although some studies [16; 21] have explored the importance of digital skills for engineers, none have comprehensively examined the issue. Thus, this research formulates the following two research questions (RQs):

- RQ1: What skill sets do engineering managers need to acquire to prepare for the digital age?
- RQ2: Are these skills mentioned in literature aligned with university courses or the needs of engineering managers in practice?

We conducted a systematic literature review of research papers to answer the first question. After identifying the expected skill sets from the literature, we chose Australia as a study context to shed light on the second question. Australia has an internationally advanced and high-quality education system, which received 37.6 billion Australian Dollars in revenue for exporting education in 2019, the equivalent of 1% of the total gross domestic product [20]. Hence, it is an appropriate environment to observe what universities are offering to engineering managers through their programs. This study draws on a qualitative analysis of six engineering programs at Australian universities. We also conducted interviews conducted by ten engineering/technical managers to learn the perspectives of practicing engineering managers in Australia.

Our analysis of the extant literature indicates a list of capabilities of a digitally competent engineering manager. However, our analysis of university programs and interviews with managers in Australia shows a mismatch between theory and practice, indicating a gap that higher education institutions must address. Hence, researchers and policymakers need to realize the changes in industry needs from engineering

managers and take action to review university education programs that can supply what is in demand.

This paper has six sections. After this short introduction, Section 2 explains the background and the methodology used in this study. Section 4 presents our literature review and qualitative analyzes, followed by a discussion section bringing all findings together. The final section concludes with a summary, implications for research and policymakers, limitations, and suggestions for future studies.

II. THEORETICAL BACKGROUND

Engineering and management are two distinct fields, with engineering concentrating on technically challenging abilities and management prioritizing administrative and people-centered skills [8]. Engineering managers are managers who, due to their previous engineering responsibilities, are aware of the technical elements. They can perform high-level technical activities as well as administrative functions such as collaboration, budgeting, and project management [9]. Studies point out found that most engineers were moving into a management or leadership role after the first 3-5 years of their employment [10]. As engineers advance into managerial positions, their job demands and expectations increase due to the inclusion of management responsibilities [10].

In a business environment, a manager understands how to bring their team together to solve an issue by recognizing ‘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 [11]. Engineering managerial jobs should take far more responsibilities, activities, and priorities. 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 gained through management courses [12].

According to the World Economic Forum [4], by 2025, more than half of all employees will need to re-skill due to the increased use of technology. Similarly, a McKinsey analysis claims that by 2030, more than 375 million workers will need to retrain to cope with the digital economy as their professions evolve in response to advances in digital technologies [13]. The shift of required skills poses challenges for workers and managers. For example, over 40% of executives who participated in a 2021 McKinsey Global Institute (MGI) productivity survey said they planned to invest in their analytics capabilities in the following three years [14].

Even though all these changes are taking place, key institutions such as the Project Management Institute (PMI) fail to recognize digital competencies in their existing standards, which only consist of knowledge, performance, and personal competencies. The PMI recognizes that to keep up with technology, project managers will need digital capabilities [15]. What these digital abilities should be and how proficiency will be assessed are not immediately apparent. The absence of digital competencies from these standards reveals a problem and the need for further study [15].

Besides technical competencies, several studies point out two new critical skills associated with emotional and digital intelligence for engineering managers [16; 17]. The former refers to the ability to detect and control one’s own and other’s emotions positively and having skills that range from critical thinking and problem-solving to self-management abilities such as resilience, stress tolerance, and adaptability [18]. Digital intelligence comprises the ability to implement and acquire the essential skills related to digital advances and be aware of the most recent digital tools [19].

The details on skill sets are further presented in the Findings section as an outcome of the detailed qualitative study (see details in the following Methodology section).

III. METHODOLOGY

This qualitative study employs a mix of data sources, including a systematic literature review, curriculum information, and interviews with engineering managers.

We conducted a literature review since reviewing past relevant literature helps identify well-studied research areas and discover research gaps that require further investigation [22]. Sometimes knowledge remains disintegrated, restricting accessing collective expertise in a specific domain. This concern causes a need for a systematic literature review as a research method. Our goal in this paper is to comprehensively understand the skillsets needed for engineering managers, producing a scientific summary of the research conducted within the engineering management knowledge area.

Besides the theoretical discussions, we wanted to observe whether the skill requirements mentioned in the literature review have been put into practice by universities or companies, indicating our second research question. Hence, we first analyzed online university curriculum data for engineering management courses in Australia. Then, we interviewed engineers/technical managers actively managing a team of engineers in their current roles. These observations from universities and companies have facilitated the identification of gaps between theory and practice in engineering management.

A. Systematic Literature Review

For this section, we selected several databases to identify articles that could fulfill the research objectives and answer research questions. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Flow diagram from Moher et al. [22] has been employed to filter research articles, as shown in Figure I below. It follows three simple steps: initial search, selection, and review. The initial search used specific keywords such as ‘engineering management,’ ‘digital,’ ‘emotional intelligence,’ and ‘university.’ The search was run multiple times with keywords like ‘transition’ and ‘technology management.’ Figure I shows 326 articles were listed across five major databases (EBSCOhost, IEEE Xplore, Science Direct, Scopus, and Web of Science).

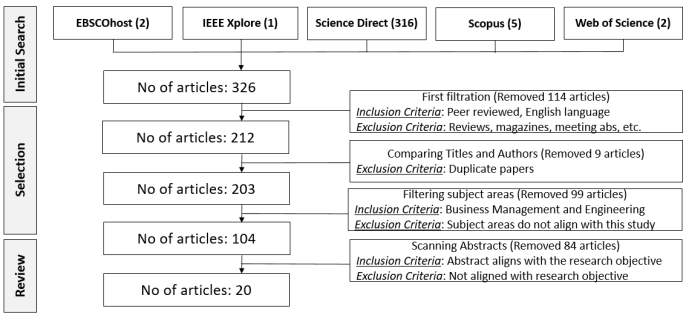

FIGURE I. PRISMA Flow Diagram

The first selection method included only 'peer reviewed' and was written in English. Any articles which are reviews, magazines, abstracts, book reviews, editorials, etc., were excluded. Ten duplicates across different sources were removed from the list next. It was further refined by selecting the subject areas of Engineering and Business Management and excluding 99 research articles from various disciplines. Abstracts of the remaining 104 articles were scanned to check whether the article was suitable for this study. With careful consideration, 84 research articles were excluded and only selected 20 articles for further analysis (See Appendix A for details).

Thematic analysis guides identifying, organizing, and gathering patterns of meaning (themes) across a data set [23]. Selected 20 research articles were read multiple times, and several patterns were noted. The emerging themes are discussed in the Findings section.

B. University Curriculum Information

The goal of this research article is to discover the key skillsets that are necessary for engineers to advance to managerial positions. By examining the Australian universities that provide engineering management courses, we investigate the relevance of these course structures to the industries.

To do so, we utilized the data found in the public domain. Through our examination of 43 Australian universities which offered Master level courses [22], we identified 11 universities that provide an engineering management program [23]. Only six publicly provided their course descriptions online in their course handbooks. Details for each university course based on skillsets are given in Appendix B.

Since the prerequisites for each course differed, it was presumed that students from various educational backgrounds pursued them to advance their careers [23].

Although each university's major courses and electives differ, students graduate with managerial skills and a grasp of and capacity to contribute to the technical components of the projects they work.

The handbooks and subject guides offered by each university on their websites were examined to understand the skill development priorities. The subjects provided have been discussed, and the common learning attributes and themes have been identified and mapped. This study's results will help fill in any remaining comprehension gaps about the various management concepts taught in Australia and their application to successful career development. After identifying these attributes, a word cloud has been generated, which shows the most popular skills/attributes emphasized by the universities. It attempts to establish a link between digital intelligence and managerial skillsets.

C. Interviews

The primary qualitative data source for this study is semi-structured interviews. The interviewees are engineering managers from different engineering disciplines currently performing managerial duties. Interviewees are selected based on their educational backgrounds, as engineering managers and managers working with engineering teams are the preferred sample for the interview. Out of the 12 engineers contacted, 10 of them accepted our invitation. The interviews were conducted between October to December 2022. Each interview took around 30 minutes of open-ended question-and-answer sessions recorded with their consent.

The questions in the interview were mainly focussed on the following themes that are identified through the literature review (see the detailed list of interview questions in Appendix C):

- Digital skills for managers to stay more competent in this digital age
- Professional skills for managers to remain more relevant
- Leadership responsibilities and their opinion on re-skilling
- Importance of empathy for managers

While selecting participants for the interview, engineering managers who came from different technical backgrounds, went on to earn engineering degrees, and are now employed as managers in engineering organizations were chosen. Although they had mechanical, civil, telecommunication, software, and mechatronics engineering backgrounds, they underwent extensive training and transitions to assume their current managerial positions. Their professional platforms were browsed through to learn about their experiences and form questions accordingly.

The questions were divided into three sections. The main topics of questioning were related to an understanding of their current positions and duties within the company, their educational backgrounds, and the impact of digital intelligence on their abilities to function as capable engineering managers. All the interviews were conducted via Zoom and recorded for transcribing with their consent. Another third-party software Kaltura was used to transcribe the recordings.

Ten engineering managers, aged 30 to 51, made up the sample. Table I consists of the participants' list, educational background, and current roles in engineering companies.

TABLE I
LIST OF PARTICIPANTS

No.	Pseudonym	Educational Background	Current Role
1	Participant 1	Mechanical engineering	Project Manager
2	Participant 2	Mechatronics engineering	System safety assurance engineering manager

3	Participant 3	Mechanical and marine engineering	National tenders manager
4	Participant 4	Telecommunications engineering	Resource and Project Manager
5	Participant 5	Civil engineering	Senior IT Project Manager
6	Participant 6	Civil & environment engineering	Project Director
7	Participant 7	Chemical engineering	Program Manager
8	Participant 8	Management	Team Leader for a Motorsports Team and a Start-up founder
9	Participant 9	Bachelor of Science and Technology Honors	Chief Operating Officer
10	Participant 10	Bachelors of IT	Senior software engineer at an engineering start-up

IV. FINDINGS

A. Findings from the Literature Review

After reading and analyzing the full content of each paper, co-authors of this paper collaboratively identified several categories of patterns and meanings. Similar categories were put together to highlight the focus of each paper, thus, the literature review has been structured thematically. After several iterations of categories, the main four themes emerged from the respective articles, as shown in Table II. Each theme is discussed in the following sub-sections.

TABLE II
MAJOR THEMES FROM THE LITERATURE REVIEW

	Themes	Sources
1	Digital skills	[13; 16; 21; 24; 25; 37; 38; 39; 26]
2	Professional skills	[28; 29; 30; 40]
3	Leadership skills	[31; 32; 33; 44]
4	Empathy skills	[34; 35; 36]

1) Digital skills

According to Marnewick & Marnewick [16], Industry 4.0 necessitates online communication, collaboration, and digital literacy. Their study argues that understanding technology and digital capability in the form of digital literacy are prerequisites for knowledge-based employment and education. Digital literacy refers to the variety of cognitive-thinking methods used by digital information users [26]. Improving digital competencies entails more than just using technology; it also entails developing cognitive abilities and discovering new methods. It has been stated that in this digital age, building managerial and digital competencies is critical for even labor-intensive industries such as construction [21]. Hence, digital literacy becomes one of the core digital skills expected from engineering managers.

Some studies bring a more macro approach by introducing the concept of digital intelligence as one of the core digital skills [28, 29]. The ability to learn and use new skills and expertise connected to digital technologies such as social, mobile, analytics, cloud, and cybersecurity is called digital intelligence [21; 45-47]. It addresses questions such as what, why, where, when, who, how, and how much of digitalization. By doing so, it aims to improve efficiency, productivity, and results of digitalization rather than the ability to use digital tools. Cismaru et al. [28] described how the world of daily interaction has transformed because of 'today's highly digital culture, which is built on universal access to computers, smartphones, and other gadgets with internet connections. The availability of information from numerous sources, whether institutionalized or not, can have positive and negative effects [28]. This increased use of digital communication requires digital intelligence skills from engineering managers.

Another study discusses how digital intelligence improves digital talents by increasing their problem-solving digital skills, and AI coordination [13]. Rajahonka and Villman [29] found that digital skills help establish a digital identity. Hence, building these digital skills helps managers to advance in their careers and deal with digitalization.

According to research on digital skills for managers, these abilities can have a major impact on a 'manager's performance and their team's achievement. Harvard Business Review research discovered that managers with excellent digital abilities are better equipped to lead their teams, make better judgments, and foster innovation within their firms [26].

2) Professional skills

In their research, Shageeva and Kraysman [30] 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 [30].

Tshamano [31] investigated and analyzed the essential management factors to help engineers become better managers. He invited 34 people to participate in the qualitative study; 13 were firm engineering managers. He observed through his research that most of these engineering managers lacked the necessary skillsets because they were largely educated in technical skills at their universities rather than management skills, which are essential to becoming a competent manager [31].

Senashenko et al. [32] 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 [30].

According to Bass [33], strategic and tactical planning, persuasive communication, problem analysis, financial decision-making, team building, conflict resolution, and

interviewing are just a few of these abilities. Although most engineering managers naturally possess the qualities of a leader, these technical skills must be deliberately developed [33].

3) Leadership skills

Farr and Brazil [34] argue that leadership has become vital for engineers managing interdisciplinary teams. They 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, which is critical in 'today's business world [34].

Wearne [32] examines the results of a questionnaire he produced for engineering residents in the United Kingdom on the management skills they needed at work in his study. Using factor analysis, he identified project management and leadership as the most significant managerial skills. He concluded that these skills are required for higher levels of executive responsibility [32].

According to Hartmann and Jahren [33], technical knowledge is not required for the nine most essential leadership characteristics. Leadership is a long-term process that necessitates a lot of willpower and work. Taking on challenges and being self-aware are essential qualities of a great leader. The Green Report 1994, widely considered as having substantially impacted engineering education, stated that team skills, leadership, communication skills, and ethics are essential for an expedited educational experience [38].

4) Empathy skills

In their study, Litvinov et al. [39] emphasized empathy as a desirable attribute to build during engineering studies. Engineers must have abilities like empathy, design thinking, communication, and ethical reasoning. They also stated in this study that such qualities should be taught in engineering schools because some decisions and behaviors require empathy. It also emphasized strengthening the idea that technical education teaches problem-solving skills but not how to differentiate right from wrong. Empathy and other entrepreneurial skills were determined to be included in the engineering curriculum. Empathy should be a documented course/skill for students and a learning opportunity for them [39].

Emotional intelligence is a significant aspect that influences a project 'manager's performance. Emotional intelligence is essentially about our interaction with others, while digital intelligence is fundamentally about our engagement with technology [38]. According to Zhu et al. [40], 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 project managers must be able to coordinate the interests of all project participants while maintaining good mental stability [40].

Altındağ and Kösedağı [41] investigated the impact of emotionally intelligent managers on the performance of other employees in an organization. Emotionally intelligent managers deal with circumstances with empathy and analyze the situation logically, making their performance more efficient. Employees are not under much stress or strain due to understanding and empathetic managers, which improves the working atmosphere. According to Altındağ & Kösedağı [41], the ability to do new activities more effectively while adhering to the 'organization's policies and making judgments on their own with the help of emotions has been demonstrated to be a beneficial exercise.

B. Findings from the Analysis of University Courses

The list of skills culled from engineering management courses at Australian universities is provided in Figure 2. The keywords used to describe courses are aggregated to create a word cloud, highlighting the characteristics and skillsets that engineering management studies. This exercise helped to determine the applicability of these engineering courses to real-world management careers,

The attributes were discovered using an online work-related competency list [42]. Each skill from the engineering course was examined, and the closest attribute was chosen after comprehending the concept and keywords. For example, the skillset offered by one of the universities in Appendix B (page 11) includes: "Working in teams, to formulate problems and to provide solutions to these problems." This particular skillset is categorized under the group of 'teams' and 'providing solutions.' Furthermore, they are mapped with attributes 'teamwork' and 'brainstorming' according to the competency list, as shown on Page 11.

FIGURE 2. Word cloud from engineering management courses

By generating the word cloud, the top four attributes/transferrable skills/management skills were identified: Critical thinking, Teamwork, Project management, and Communication. Other than project management, the remaining traits were consistent with the skill set deemed significant for managers in the literature review under the theme – "Professional skill set for managerial roles."

C. Findings from the Interviews

Interview data have also been categorized under the four key themes from the literature review.

1) Digital skills

Despite coming from various engineering backgrounds and the industries they work in, one element that all of them have had in common is how they respond to and view current technological breakthroughs in digital technology. In addition, they all agreed there is a need to up-skill to be digitally smart. They all stated that being digitally savvy positively affects their ability as engineering firms' managers. In fact, they also agreed that, due to the recent pandemic and everyone working from home, digital technological tools have often replaced traditional working methods.

As some of the participants explained:

"To ensure that the project is more efficient and that the management part of it is highly effective, we should always seek new systems or change our systems as necessary" [Participant 1]

"I believe that utilizing digital tools effectively requires that we develop ways to … And once again … adaptability is what I would call a soft skill that is helpful in both presumably day-to-day business and digitalization." [Participant 2]

"These kinds of methods for obtaining quick data … obtained those fantastic real-time insights. Therefore, I believe those are the advantages we have." [Participant 4]

One of the participants also believed that being digitally intelligent has made people more efficient and focused:

"Teams in the technology sector, everybody is comfortable using technology for communication, … for collaboration. … made people a bit more efficient in the way they interact. Because when you're interacting virtually with other teams… you put … your time … You want teams actually to focus on the agenda and drive towards an outcome." [Participant 7]

Some other participants also believed that being digitally intelligent has helped their team create a sense of connection:

"I think for a lot of the basics … making sure we have scheduled meetups … being able to use stuff like Slack for communication. A sense of a connected team when you 'don't see each other face to face because 'we're fully remote. I think 'we've got a decent balance of it that is not like 'it's hard to know if 'that's as good as it could be." [Participant 9]

Another participant replied that being digitally intelligent helps them stay more relevant to the various innovations:

"I'll probably answer that question in keeping up with innovation in the industries. Finding solutions for problems that might not even exist yet is critical. Being innovative is one thing. And understanding how you might be able to use technology to solve a problem … information to be able to solve the problem." [Participant 6]

2) Professional skills

A pattern was observed amongst most of these managers after the interviews were conducted regarding the professional skill set required for managerial roles. Participants emphasized certain skill sets that they believed are necessary for effective managers in engineering organizations. Most said interpersonal skills, such as communication and negotiation, were crucial. Being self-motivated and managing relationships with clients and stakeholders is essential in every industry. Other critical qualities listed were having the capacity to work well in teams, assigning duties as necessary, and being responsible. They also believed that effective time management is crucial and that managing tasks and keeping records of everything is essential for scheduling.

Some participants believed teamwork and empathy to be important attributes:

"A competent manager can create a collaborative environment that considers some "employees' remote work arrangements." [Participant 5]

"Mentorship, teambuilding…being organized. I think you have to be organized and prepare, prepare for meetings, prepare for conversations." [Participant 6]

One of the managers agreed that project management is a critical skillset:

"I mean to say being able to manage time properly with scheduling for project …. Mainly project management is important … calculating risks for projects, stakeholders for the project." [Participant 3]

Communication is another skill set most managers believe to be essential to be competitive:

"I guess the communication skills and some of the softer skills required in the workplace. These skills may include giving better feedback or even proper instructions… I think this two-way exchange is needed." [Participant 2]

"The more successful engineers that may be able to move quickly up the career ladder… those who can communicate, demonstrate they can lead managed direct reports, et cetera." [Participant 5]

3) Leadership skills

All interview participants agreed that re-skilling is an excellent concept for engineers who specialize in technical skills and want to perform better in their management roles. Re-skilling is primarily described as the process of learning new skills in order to execute tasks more effectively and to undertake wholly different duties. The World Economic Forum (WEF) has also claimed that the world is amidst a re-skilling crisis [42]. They all agreed it would help them become more proficient in their respective sectors.

"There is absolutely a need, in my opinion, for re-skilling for that … that there is frequently still a bit of a gap with an increasing need for digital intelligence." [Participant 2]

Good leadership also requires continuous training to stay up to speed with the latest skills:

"I found that I got a lot of continuous learning, leading … business training that we have internally within our organization have a huge amount of training materials available, tools in other roles. " [Participant 4]

Two of the participants who were team leaders agreed that re-skilling is a good idea:

"When 'you're facing difficult decisions, that training to lead a team in the right direction really, really helps. It gets easier to pass out the problem and narrow down on a solution … In my experience … plenty of training in people, regarding dynamics of behavior, power, things like this, motivation." [Participant 8]

"Oh yeah, 'they're very important … we have a lot of different types of people that I look after always and in order to be in line with the tasks, we have to re-skill….Always learning new things." [Participant 9]

4) Empathy skills

Most managers thought empathy in management is a vital skill set that would lead to employees opening up and sharing their feelings and ideas with their peers.

Some participants expressed their views on the importance of empathy:

"Yeah, most definitely, fostering trust, empathy. Empathy is everything. Technical ability can be learned. But attitude is everything." [Participant 6]

"Empathy is critically important in a small company … more valuable because 'you've got less people … leaves a much bigger deficiency and your capability to get, to get the job done. Having the empathy to understand what 'they're doing, making allowances for that … trusting them to be able to carry out the work they do." [Participant 10]

Trusting their employees was a vital part of being empathetic:

"That's why you must be approachable and reliable… need to be trusted … People don't just trust you. You have to be trusted to deliver outcomes. Identify solutions to difficult challenges and follow through on them. " [Participant 5]

"And also, understanding the differences in individuals motivations are really important. Being able to identify ways in which to motivate people is a big one." [Participant 8]

Based on the interviews, all of the engineering managers in the sample believed having a solid understanding of digital intelligence and digital transformation was crucial to their future professional success, regardless of their technical educational backgrounds.

V. Discussion

Digital abilities are becoming increasingly vital for managers in today's business sector. These abilities can range from technical skills, such as using specific software or programming languages, to more general abilities, such as successfully communicating and working with team members utilizing digital technologies [43]. While Participant 1 believed that these digital skills help make project execution more efficient, Participant 2 argued that using these digital tools is also vital for managers. It is now a soft-skill immensely helpful for day-to-day management activities and our move toward digitization. Participant 4 also believed that being digitally intelligent is an advantage, making our processes quicker.

These digital tools could also be used with the other discussed skillsets deemed crucial for competent managers. Project management software, such as MS Projects or Trello, can assist managers in keeping track of assignments, delegating work to team members, and ensuring that projects stay on schedule. Tools such as Slack, Microsoft Teams, and Google Hangouts make it simple for managers to interact with team members and cooperate on projects. Knowing how to use these tools can help managers manage remote teams and keep everyone up to date. Using tools like Excel or Google Sheets to analyze data can help managers make more educated business decisions.

Marnewick and Marnewick [16] also stated that being digitally literate allows for greater online cooperation and that understanding digital technology is required for project managers to meet work requirements. Being a competent manager also implies knowing how much digital technology should be applied to the work processes to get desirable outcomes, and Boughzala [45] discussed this from an economic angle.

Cismaru et al. [28] also discussed how communication in this current age revolves around smartphones and other internet-connected gadgets. Margarov and Konovalova [13] have discussed how being digitally intelligent improves problem-solving digital skills by creating a sense of connection. During the interview, Participant 9 also discussed how digital technologies had created this connection even with remote working, where they use tools like Slack to improve communication which helps them in problem-solving and making decisions. According to Participant 6, being digitally literate has helped their team find solutions for a problem that might not exist at this moment, but they have the information they might need.

Overall, our analysis found that digital intelligence as one of the critical digital skills is not given that much importance in Australian university curriculums. Most engineering management course structures focus on people's skills or social skills like communication and decision-making but are not formulated for the digital age where to be a competent manager, being digitally intelligent or digitally literate is a necessity rather than a requirement. These observations lead to the first proposition:

Proposition 1: Digital age requires a higher level of digital intelligence from engineering managers.

Our analysis of the extant literature indicates a gap regarding the capabilities of a digitally intelligent manager. Our analysis of university programs and interviews in Australia further supports that this gap is not yet on the agenda of higher education institutions. Hence, researchers and policymakers need to realize the changes in industry needs from engineering managers and take action to review university education programs that can supply what is in demand.

Most critical skills regarded as necessary by managers are not among the top skills taught at universities, for example, digital intelligence, teamwork, collaboration, and even mentorship and guidance emphasized by Participants 4,5,7, and 6.

Communication is a common skill set highlighted in all data sources in this study. Most of the universities' curriculum has prioritized communication as a skill set, which can be observed even in the literature review. It is one of the most crucial professional skillsets identified in the literature [30; 32]. This

skill ensures a broader understanding among managers and employees during project-related decision-making. This finding also aligns well with the interviews with the managers, where Participant 2 and Participant 5 believe it is a critical skillset required to be a competent manager. All participants also thought that to advance in their careers, they must be able to communicate and manage their teams by distributing duties and handling conflicts.

While analyzing the professional skills of managers, the teamwork and collaboration skills appear to be aligned with the university curriculums, literature reviews, and interviews. Two participants (P 5 and P 6) highlighted how being organized and being able to collaborate within teams in this current digital age, where everything has become remote, is an important attribute. They have also emphasized the importance of teamwork to be a competent manager. A study by Bass [33] highlights how teamwork is essential for making critical decisions and managing conflicts. Farr and Brazil [35] have also discussed how managing interdisciplinary teams becomes a vital aspect and a competitive advantage for their leadership, which is a necessity in the current times. Teamwork is amongst the top attributes emphasized through the universities' engineering management curriculums. Hence, our study proposes the following:

Proposition 2: Digital technologies increase the need for emotional intelligence, covering various skills like communication and team management skills.

Project management is another attribute among the top transferrable skill sets at universities' curriculums, which was not given much importance in the relevant literature review. Although other management skills like financial decisions, teamwork, communication, and presentation have been deemed necessary by Bass [40] and Senashenko and Struchkova [30], few papers have highlighted project management as an essential skill set for managers. Although, during the interviews, Participant 3 believed that having project and time management capabilities is vital for a competent manager.

VI. Conclusion

Rather than analyzing the broad impact of digital technologies, this paper sheds light on two key questions that could be instrumental in preparing engineering managers for a digital future. First, what skill sets do engineering managers need to acquire to prepare for the digital age? Second, do these skills mentioned in theory aligned with courses taught in universities or the needs of engineering managers in practice?

The study conducted a literature review, a content analysis of university curriculums, and interviews to respond these two research questions. The results strongly highlight digital intelligence as one of the critical digital skills for engineering managers. While some of these managers believed that digital technology has helped their teams create a sense of connection while working remotely due to the pandemic, some also thought these digital tools have made their work more efficient and straightforward. Digital tools like Slack have helped improve communication and improve decisions.

The interviews have also shed more insight into the nuances of the skills, issues, and various thought processes each engineering manager underwent while becoming a manager. Besides highlighting the common skills deemed necessary by engineering managers, the study compares them with the ones provided by universities.

Implications for theory

This paper is a qualitative study combining three different data sources to identify skill sets for engineering managers. By doing so, the paper contributes to discussions on professional challenges for engineering managers [48]. Through our analysis, we developed propositions highlighting the crucial role of digital and emotional intelligence skills for engineers targeting a managerial career in the digital age.

Our work seeks to make two unique contributions to the engineering management field. First, we offer a comprehensive approach to studying the alignment of theory and practice concerning the skills of engineering managers. This approach improves our understanding of education issues revolving around engineering management in the digital era. We highlight how communication and team management keep their key role in the career advancement of engineers, as previous literature points out. But further, we expand the list by bringing two skills into attention, namely digital intelligence, a broad spectrum of digital skills, and emotional intelligence. Second, our article highlights how universities fall behind in needs arising in practice, showing a gap in engineering management education.

Implications for practices

Our article also has a contribution to practice. We draw the attention of engineering managers, researchers, and practitioners to tackle the challenges of managing digital technologies, and to equip engineering professionals better to cope with them by improving their skills to have a future-proof career.

Digital skills are critical to becoming a good manager in today's business world. According to research, managers with excellent digital abilities are better able to lead their teams and create organizational innovation. Managers can benefit from training programs, online courses, and networking opportunities with other managers to build and improve their digital abilities.

Engineering managers can use various resources to develop and enhance their digital abilities, such as training programs and online courses. Engineers aiming to become managers can also keep current on technological and digital advances, seek opportunities to learn new skills, and gain expertise with digital technologies.

Implications for policy

Policymakers need to be aware that the digital divide has grown for individuals and many organizations, despite the acceleration of digitalization under Covid-19. Still, universities and policymakers need to consider how to help engineers pursue re-skilling and up-skilling efforts to become more capable engineering managers.

Moreover, universities should re-evaluate their course structures to include this critical skillset in their curriculum.

Technology and digital tools are increasingly being used in a variety of businesses. Incorporating digital intelligence into engineering management curriculums can help these managers prepare for the ever-changing labour market and advance their careers. Managers can also acquire in-demand abilities such as problem-solving and critical thinking using digital tools, which are helpful in many areas.

Limitations and Suggestions for future studies

This article has two main limitations arising from its descriptive nature, which can provide as an opportunity for future research. First, we have limited the literature review to peer reviewed articles in English language. Other publications such as book chapters, and grey literature might likely include relevant studies. Second, the study is conducted in Australia, preventing to generalize of the findings to all countries. Conducting studies in different countries might generate data that could help comparisons and observe factors influencing the relationship between skill expectations from engineering managers and specific country conditions.

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APPENDICES

APPENDIX – A: LITERATURE REVIEW PAPERS

Number	Title	Author	Year	Reference number
1.	Interdisciplinary competencies needed for engineers in the digital economy	G. Margarov, and V. Konovalova	2019	13
2.	Digital intelligence: A must-have for project managers	C. Marnewick, and A. Marnewick	2021	16
3.	Development of Digital and Managerial Competencies and BIM Technology Skills in Construction Project Management	T. Mandičák, P. Mésároš, M. Behún, and A, Behúnová	2020	21
4.	The rise of digital intelligence: challenges for public relations education and practices	D. M. Cismaru, P. Gazzola, R. S. Ciochina, and C. Leovaridis	2018	28
5.	Women managers and entrepreneurs and digitalization: on the verge of a new era or a nervous breakdown	M. Rajahonka, and K. Villman	2019	29
6.	Digital literacy: Definition, theoretical framework, and competencies	M. D. Osterman	2013.	26
7.	Digital Intelligence: A key competence for the Future of Work.	I. Boughzala	2019	27
8.	Today's CEOs need hands-on digital skills	D. Graves	2021	46
9.	Building skills in the context of digital transformation: How industry digital maturity drives proactive skill development.	E. Ostmeier, and M. Strobel	2022	34
10.	Development of the ability for professional interaction in future engineers at a research university.	F. T. Shageeva and N. V. Kraysman	2020	27
11.	Managerial Factors Contributing to Being a Successful Engineering Manager	K. Tshamano	2020.	29
12.	Educational model as an important factor influencing on conjugation between higher education and labor sphere	V. S, Senashenko, and E. P, Struchkova	2019	32
13.	What is leadership?" In *Leadership in Surgery*	B. L. Bass	2019	33
14.	Leadership skills development for engineers	J. V, Farr, and D. M. Brazil	2009	35
15.	Professional engineers' needs for managerial skills and expertise	S. Wearne	2004	36
16.	Leadership: Industry needs for entry-level engineering positions	B. Hartmann, and C. Jahren	2015	37
17.	Embedding leadership in civil engineering education. *Journal of professional issues in engineering education and practice*	Bowman, B. A., & Farr, J. V	2000	38
18.	The presence of empathy in entrepreneurial subject outlines for IT and software engineering students	A. Litvinov, A. Gardner, and S. Pradhan	2020	39
19.	Project manager's emotional intelligence and project performance: The mediating role of project commitment	F. Zhu, X, Wang, L, Wang, and M. Yu, M	2021	40
20.	The relationship between emotional intelligence of managers, innovative corporate culture and employee performance.	E. Altındağ, and Y. Kösedağı	2015	41

APPENDIX - B: UNIVERSITY SKILLS MAPPED TO ATTRIBUTES

University 1: University of Melbourne

https://handbook.unimelb.edu.au/2021/courses/761em

SKILLSETS OFFERED BY UNIVERSITY	ATTRIBUTE DERIVED
Analytical skills, analyzing and identifying key issues in engineering projects	Analytical thinking
Working in teams, to formulate problems and to provide solutions to these problems	Teamwork, brainstorming
Teamwork, develop and enhance their abilities to work in a team environment	Teamwork
Communication skills, be able to interact effectively with people especially with other engineers to broaden their knowledge and achieve successful outcomes in an engineering project	Communication, Interpersonal skills
Management skills - in terms of ability to realistically assess the scope and dimensions of a project or task, and employ appropriate planning and time management skills to achieve a substantial outcome	Project management
Problem solving skills and critical thinking, which should be fostered in the seminar program where students will apply theoretical material to actual case studies;	Problem analysis, critical thinking, qualitative decision making
Collaborative learning and teamwork, which should be enhanced through exercises, role- plays, and simulations that are incorporated into the seminar program;	Collaboration, teamwork, problem analysis
Evaluation, interpretation and analysis of data;	Quantitative decision making
Accessing data and other research information from a range of sources, which should be facilitated through the assignments and preparation for the exam	Conceptual research, analytical thinking
Developing oral and written communication skills.	Communication

University 2: Macquarie University

https://protectau.mimecast.com/s/dIIDCQnM2Quj4RqYFx0ZbI?domain=coursehandbook.mq.edu.au

SKILLSETS OFFERED BY UNIVERSITY	ATTRIBUTE DERIVED
Evaluate the commercial viability of engineering projects and decide an appropriate procurement strategy for a particular project.	Product knowledge, Project management, procurement management
Interpret the scope and meaning of contract documents for the delivery of engineering projects.	Project management
Analyze and assess tenders, articulate fundamental knowledge of contract law, identify potential risks associated with engineering projects.	Analytical thinking, risk management, business acumen
Conduct cost estimation and tendering processes from a Contractors perspective.	Commercial awareness, financial management
Identify and describe models employed in management decision making to solve problems	Problem analysis
Apply finance, accounting and economic theories, frameworks and methods to make sound business decisions	Commercial awareness, business acumen, finance management
Critically analyze the implications of a firm's decisions/strategies for a range of stakeholders in view of the firm's sustainability considerations	Critical thinking
Evaluate a range of business indicators to measure and track the firm's value creation	Business acumen, critical thinking
Identify key workplace issues and use theory to explain and evaluate their impact.	Problem analysis, conceptual thinking
Critically assess different perspectives on, and approaches to, work and management and assess their implications for organizational outcomes.	Critical thinking, organizational sensitivity
Utilize research and critical analysis skills to critique current debates across a range of workplace issues.	Analytical thinking, research skills
Employ ethical frameworks to analyze management decisions.	Analytical thinking
Synthesize an innovative enterprise strategy for IT strategic planning.	Creative thinking
Apply information systems models and methods to analyze the Impact of IT on industries, markets and organizations.	Problem analysis
Comprehend the impact of IT leadership on innovation, outsourcing and enterprise level strategic change.	Critical thinking
Apply interdisciplinary knowledge from engineering, business, and management in engineering project management.	Situational awareness, critical thinking
Apply knowledge of organizational behavior and expertise to the management and leadership of people and organizations.	Situational awareness, critical thinking, communication
Implement advanced and integrated knowledge of engineering management, with a specific focus on project management, supply chain solutions, engineering leadership, and human resource management.	Project management, supply chain management, leadership, human resource management, critical thinking, problem analysis
Utilize research skills to develop new knowledge, data, interpretations or information in the field of engineering management.	Problem analysis, qualitative decision making, quantitative decision making, research skills
Apply international standards for quality control and quality improvement.	Quality management
Apply knowledge of quality control to evaluate the impact on the engineering discipline and on business management, supply chain solutions and project management.	Quality management, critical thinking
Conduct total quality management, including determining productivity and cost relationships, utilizing quality systems and their components and the interaction between quality and design functions.	Quality management, Commercial awareness, financial management
Synthesize advanced and integrated knowledge of process capability and improvement studies, control charting, techniques for quality studies and design for quality improvement.	Quality management, critical thinking, analytical thinking
Demonstrate advanced knowledge of risk and safety engineering.	Risk management
Interpret and synthesize various methodologies and tools applicable in risk analysis and accident modelling.	Situational awareness, risk management
Critically review safety performance in a range of engineering operations.	Critical thinking, problem analysis
Apply risk-based design decision methods to industrial operations.	Qualitative decision making, quantitative decision making, risk management
Design risk-based safety measures for complex engineering operations.	Problem analysis, risk management
Analyze and explain the fundamental concepts and principles of supply chain management.	Problem analysis, supply chain management
Apply a range of quantitative techniques for effective supply chain performance analysis.	Quantitative decision making
Appraise the impact of e-commerce and other emerging initiatives in the field of supply chain management, both as an individual and as a part of a group	E-commerce, conceptual thinking
Work productively in teams of professional engineers and objectively evaluate the performance of the team and of your individual peers.	Communication, delegating, teamwork
Effectively and professionally communicate engineering concepts in multiple modes to a range of audiences.	Communication, sociability
Develop and deliver a professional engineering report, detailing the problem to be solved, the proposed problem solution, and critically evaluate the solution and the reasons why the solution was chosen or recommended.	Problem analysis, critical thinking, decisiveness
Examine and reflect on the socio-technical and other contexts in which engineering is practiced.	Critical thinking
Apply acquired analytical and theoretical knowledge to the design and implementation of engineering projects	Analytical thinking, conceptual thinking
Identify the responsibilities and deliverables of engineering managers from the project's initiation to successful completion.	Project management
Compare different project delivery methods, assess the associated risks, and follow standard procedures for risk mitigation.	Project management, risk management
Estimate project timelines and scheduling resources within required budgets.	Project management, scheduling
Evaluate progress and performance and take necessary measures for optimum output.	Analytical thinking, project management
Employ a wide range of engineering project management techniques and tools needed for successful project implementation. Identify any issues in engineering project management practices and provide solutions that enable successful completion of the	Project management, stakeholder management

project according to stakeholders' requirements	
Describe the management fundamentals with regard to consulting engineering practice and management	Consultation, project management
Demonstrate the ability to think critically, to solve problem, and to work in team	Teamwork, critical thinking, conceptual thinking, problem analysis
Apply the fundamental knowledge and theoretical frameworks related to entrepreneurial behavior in business management.	Entrepreneurship, commercial awareness
Develop comprehensive knowledge of business planning, financial management and technology management to develop successful ventures.	Financial management, business acumen, conceptual thinking
Identify and pursue business opportunities and create value for all stakeholders.	Stakeholder management, communication

University 3: Queensland University of Technology

https://www.qut.edu.au/courses/master-of-engineering-management#:~:text=Course%20Structure&text=60%20credit%20points%20of%20core,from%20a%20list%20of%20options

SKILLSETS OFFERED BY UNIVERSITY	ATTRIBUTE DERIVED
Problem identification, research design and planning, literature search and communications through reports and presentations are essential attributes of engineers in all the disciplines	Problem analysis, communication,
The students will be trained to develop a real-life ERP system based on actual data from industry.	Enterprise resource planning
The unit provides an overview of the project management methodologies, frameworks, processes, and key knowledge areas.	Project management

University 4: University of Wollongong

https://protectau.mimecast.com/s/g7c4C2xMo3szo154tntcOe?domain=courses.uow.edu.au

SKILLSETS OFFERED BY UNIVERSITY	ATTRIBUTE DERIVED
Understand and demonstrate some proficiency in the application of the strategy development process and use of strategic analysis tools.	Strategic management
Demonstrate the ability to think strategically.	Strategic decision making
Demonstrate an understanding of the importance of considering the economic, technological and people side of managing strategy for an engineering business.	Empathy, conceptual understanding, economics
Understand and demonstrate the importance of effective teamwork in developing a strategic plan and persuasive lobbying in winning key stakeholder support for the acceptance and implementation of a strategic plan.	Teamwork, strategic planning
Understand that in the real-world strategy rarely offers obvious answers but that gathering the right information and using this to persuade powerful stakeholders of the value of a specific course of action is integral to successful strategy acceptance and subsequent implementation.	Stakeholder management, communication, strategic planning
To provide experience and understanding of the innovation and design processes for engineering structures, components and systems.	Innovation, creative thinking, design understanding
To understand the relationships between design and the lifetime of the product.	Product management
To experience membership of a design team and to understand the importance of teamwork in successful design realization.	Teamwork, design understanding
To understand financial, regulatory and human issues impacting on engineering design.	Financial management
Analyze the role of logistics in ensuring swift and even flow of material through supply chains	Logical thinking, material knowledge
Demonstrate an advanced understanding of the strategic, tactical and operational decisions that determine the attributes and performance of logistics systems	Logical thinking, operational decision making
Appreciate the enabling role of information systems and technology in relation to the functions of logistics systems.	Technology, logistics
Explain the role of project management within the context of broader strategic plans.	Project management, strategic decision making
Involvement in the planning of engineering management research and the ability to analyze data that may be presented from an investigation.	Data analysis, research skills
Understand the data requirements for financial modelling and decision making	Financial management, quantitative decision making
Demonstrate a working knowledge of the identification of cost streams to the required level of accuracy for financial planning and project evaluation	Cost management, project management,
Demonstrate a working knowledge of basic financial modelling techniques for typical engineered asset management situations.	Asset management

University 5: La Trobe University

https://www.latrobe.edu.au/courses/master-of-engineering-management

SKILLSETS OFFERED BY UNIVERSITY	ATTRIBUTE DERIVED
Investigate and apply understanding of current and future key areas of innovation in Australia and worldwide.	Critical thinking, innovation
Analyze comprehensive market research and primary research data to derive realistic project and business objectives.	Market research, research skills
Conduct high level brainstorming methodology and selection methods to unravel numerous potential solutions to identified complex problems.	Brainstorming, problem analysis
Critically analyze and interpret business and economic environments to formulate business and marketing strategies	Marketing research, strategic thinking, critical thinking
Develop effective self-branding strategy, presentation and engagement using online tools	Branding, strategic thinking, presentation
Effectively prepare, present and evaluate short, engaging speeches for a non-technical audience, using advanced communication principles	Giving speeches, communication, presentation

Effectively plan, develop and evaluate well-structured, reflective and critical documents for a technical audience	Critical thinking, reflection
Examine the importance of basic accounting and finance principles.	Accounting, financial management
Prepare budgets, manage working capital, and make appropriate pricing and production decisions.	Budgeting, financial decision making
Value the securities issued by a firm to raise capital, determine the firms cost of capital, and apply appropriate capital investment decision-making techniques to make and justify recommendations.	Financial management, investment
Evaluate the utility of diverse organizational Behavior theory and concepts.	Communication, organizational behavior
Analyze workplace issues in organizational Behavior terms and recommend practical and evidence-based solutions.	Organizational behavior
Understand the economic way of decision-making and apply it in a number of areas of business and policy.	Financial decision making
Analyze and evaluate strategic behavior of competing economic agents and institutions in various market structures	Market research, strategic thinking
Apply and interpret concepts of descriptive statistics to real life data and interpretation of results	Data analysis, quantitative decision making, statistical knowledge
Apply probability theory in business and financial decision making	Financial decision making
Conduct estimating linear regression models and testing hypothesis to aid decision-making	Statistical knowledge, research skills
Communicate effectively to a professional audience, ability to present work in a professional manner	Communication, presentation
Evaluate business strategies for innovation in real-life business situations within sustainable value creation	Innovation, business strategies, sustainable solutions
Analyze and manage ethical and societal issues in the research context by demonstrating an appreciation of the importance of ethics and sustainability in engineering practice and research	Ethics, sustainable solutions, research skills
Employ advanced communication skills by reporting research findings through documentation and presentations	Documentation, communication, presentation
Determine the client's project goals, the stakeholders and the project risks, prepare project plans to meet project objectives and requirements, develop documentation to achieve project objectives within time, cost and quality parameters	Stakeholder management, project management, risk management
Establish risk management frameworks to ensure quality management systems are effective, adequate and updated.	Risk management, quality management
Select and integrate appropriate research methodologies to carry out engineering projects or advanced academic study.	Research skills
Organize teamwork, manage interdisciplinary collaboration, and assess own and other team member's contributions	Teamwork, collaboration
Apply systems thinking and approaches to analyze complex natural and human-made systems, and to design engineered solutions	Systems thinking, problem analysis
Develop risk management plans for engineering projects and systems in accordance with appropriate risk management standards	Risk management, strategic thinking
Analyze and propose solutions to typical managerial problems/opportunities using rational, analytical decision modeling.	Judgment, critical decision making

University 6: University of Technology Sydney

https://handbook.uts.edu.au/courses/c04275.html

SKILLSETS OFFERED BY UNIVERSITY	ATTRIBUTE DERIVED
Recognize and apply areas of knowledge and techniques appropriate for successful project management	Project management
Construct project related documentation while working in a team environment	Project management
Reflect and evaluate the impact of personal and professional decisions on prepared plans	Planning
Show a well-developed awareness of management behavior, the structure of organizations and the way decisions are made.	Organizational behavior
Explain the particular difficulties many technical people experience when faced with managerial decision-making	Critical decision-making
Analyze and propose solutions to typical managerial problems/opportunities using rational, analytical decision modeling.	Analytical thinking, problem-solving
Communicate and explain the dichotomies of decision-making in the presence of hazards and risk.	Communication
Demonstrate a knowledge of the psychology of judgment and the nature of individual decision-making and be able to explain the critical importance of psychological factors, personal values and social norms.	Judgment, critical decision-making
Recognize the advantages and drawbacks of group decision-making and be able to effectively manage individual decisions in their domain of expertise as well as more broad ranging group decisions.	Teamwork, critical thinking
Exhibit a sound knowledge of key current thinking regarding the sociology of strategic decisions.	Strategic decision-making
Incorporate the values of culture and history of Indigenous communities in risk analysis studies and the development of risk management plans	Risk management
Identify stakeholders, boundaries and uncertainties in engineering projects and systems	Stakeholder management
Assess, evaluate, prioritize, and treat risks in engineering projects and systems lifecycle	Risk management
Develop risk management plans for engineering projects and systems in accordance with appropriate risk management standards	Risk management, systems thinking
Apply systems thinking and approaches to analyze complex natural and human-made systems, and to design engineered solutions	Systems thinking
Organize teamwork, manage interdisciplinary collaboration, and assess own and other team member's contributions	Teamwork
Apply professional written and verbal communication skills to present research findings and recommendations to peers and broader audiences	Communication
Develop a professional project management plan to investigate a research topic	Project management, planning

APPENDIX – C: INTERVIEW QUESTIONS LIST

1. What is your current position? (Could you please describe your work, what do you do, your roles and responsibilities, company/organization name) How long have you been working here?
2. Before working in this position, what were your previous positions? (Since you are currently in a management role after a technical role, could you explain the changes in responsibilities you felt and the different kind of roles or training you had to take)
   Have you worked in any other companies? (Which company)
3. So, what is your educational background? (What engineering course did you pursue, did you do any management courses like MBA which has helped get this management role? Did you have to undergo any kind of trainings to be able to take up the management positions?)
4. For the ones who haven't undergone any kind of management degrees or training) Do you think not pursuing a management degree has somehow challenged you in taking proper responsibilities as manager or was it a smooth transition for you?
5. What are the different challenges you had to go through during your transition from an engineer (Technical) to a managerial position?
   In your experience what are the kind of changes you think we have to make?
6. "they say engineers specialize in technical skills but lack soft skills/professional skills like communication, negotiation and often need to re-skill or undergo separate training to be better in this management position" What is your opinion?
7. How has digital technology changes drastically affected the management in your organization, if so what are some of the critical challenges faced?
8. In your opinion as a manager with leadership responsibilities, what do you think enhances re-skilling to stay in control of tasks or the various digital technological developments nowadays?
9. According to Wikipedia, "Digital intelligence is defined as the ability to face the challenges and adapt to the demands of life in the digital world." So, my question for you is, how does being digitally intelligent impact your capacity as an engineering manager in this current era of innovation and technological advancements?
10. What qualities or attributes do you believe are necessary for competent managers, in your opinion?