Project management skills for engineers: industry perceptions and implications for engineering project management course

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Abstract:

It is well established that projects play an important part in all engineering sectors and successful projects require effective project management (PM). For professional engineers in Australia, PM forms part of a standard competency specified by Engineers Australia. It has also become a standard component of engineering programs offered at most Australian universities. Nonetheless, there are not enough studies on specific project management skills, which engineering graduates are expected to learn and effectively apply in a project work environment, to help deliver a better targeted and more relevant project management course. The main aim of this research is thus to identify essential PM knowledge areas that engineering graduates require in their early career, with the outcomes expected to provide implications on the design of engineering project management (EPM) courses. The research was achieved through an online survey, which seeks input from industry practitioners and was partly developed using the details of PM knowledge areas provided in the Guide to the Project Management Body of Knowledge. The results from the survey of 30 practitioners showed that project scope management, project time management and project cost management were the three most critical areas and perceived as the areas where graduate engineers may require more improvement. The results further highlighted that such PM knowledge areas should require more emphasis within EPM courses taught to undergraduate engineering students.

Introduction

Projects are perceived to be a means through which modern societies achieve social and economic ends to generate new values (Winch, 2010). The significance of good project management (PM) in delivering engineering projects to fulfil predetermined objectives has been well established (Smith, 2008). Because of the significance of PM, industrialists and engineering institutions have called for the inclusion of PM in higher education degree programs (Smith, 2008). In developing PM courses, a number of factors would be taken into consideration, such as study discipline, year level, teaching resources, class size, preferences of the course developers/designers and feedback from the industry. Given that one of the key roles of the universities is to produce engineering graduates who are ready to work in the industry, engaging industry practitioners as part of an engineering course/curriculum

development has become more relevant. Within Information Systems (IS) and Information Technology (IT) education, industry involvement in developing IS/IT curricula/courses has been prevalent, as evident in past research studies (e.g. Gonzenbach, 1998; Carbone & Gholston, 2004). However, research that provides sufficient information to guide the development of appropriate engineering project management (EPM) courses based on industry input within the Australian context has been very limited.

Given the above knowledge gap, this research aimed to seek input from engineering practitioners regarding the current project management skills of engineering graduates as well as the specific areas that should be emphasised in EPM courses offered at Australian universities.

Key Project Management Skills

It is well documented that engineers are expected to possess soft skills such as PM in addition to specific technical skills (Pulko & Parikh, 2003). According to Engineers Australia's Stage 1 Competency, "*Professional Engineers* are required to take responsibility for engineering projects and programs in the most far-reaching sense" (Engineers Australia, 2011). As part of such responsibility, although not all engineers are expected to take on a role as project manager, they are invariably expected to have the ability to personally conduct and manage an engineering project, or as a member of a team to conduct such a project, and to demonstrate a key contribution to the team effort and the success of the outcome (Engineers Australia, 2011). In Australia, the need for management studies (including PM) to be included in undergraduate engineering level was first identified through a survey conducted in 1972 and in many subsequent studies as reported by Palmer (2002). Current engineering education programs tend to therefore incorporate courses that equip engineering graduates with management skills necessary for the actual project work environment. The use of a modern teaching approach such as the Project-Based Learning (PBL) technique reflects universities' endeavours to train engineering graduates by engaging them in a project-like environment. Such technique attempts to mimic professional situations in either exploring a project or a problem with more than one way to either implement the project or solve the problem (Nepal & Stewart, 2010; Stewart, 2007)

While the need for PM knowledge is clearly documented in the Engineers Australia's competency standard, no further information is provided regarding specific project management skills or knowledge areas that professional engineers are expected to master. As the nature of PM encompasses a broad range of skills, a desktop research conducted by the authors into the structures of PM courses offered in undergraduate engineering programs at Australian universities showed a substantial degree of variation in terms of the contents included in those courses. Numerous PM textbooks have been published but similarly their structures and contents are, to some extent, different.

Although various perspectives on PM contents exist as mentioned above, a number of standards have been developed to provide a basic list of common skills required to develop a suitable PM competency, such as the National Competency Standards for Project Management by the Australian Institute of Project Management. Many of these standards are nonetheless based on the standard developed by the Project Management Institute (PMI) namely *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*. This document lists nine key project management areas as presented in details in Table 1. Because the PMBOK Guide is the most widely referenced standard for project management competency, it was used as a basis for developing a questionnaire survey utilised for the purpose of this research study. The following section further elaborates the details of the research method.

Methodology

Questionnaire Survey

The present study utilised an online survey research method to seek opinions regarding the PM skills required of engineering graduates from professionals employed in Australian engineering organisations. The developed questionnaire is divided into three main sections. The first section sought to obtain background information of the respondents (e.g. age, years of experience and position). Based on PMBOK's knowledge areas presented above, the second section asked the

respondents to rate the PM knowledge areas and to assess the overall PM skills of graduate engineers currently working in their organisations. The third section requested the respondents to assign a level of emphasis on each PM knowledge area if they were asked to develop a PM course. This section also included an open-ended question for the respondents to provide additional comments.

Table 1 Project Management Knowledge Areas (PMI, 2008)

PM Knowledge Area	Details	Key Skills
1.Project Integration Management	The processes and activities needed to identify, define, combine, unify, and coordinate the various processes and project management activities	Project plan development, execution and control
2. Project Scope Management	The processes required to ensure that the project includes all the work required to complete the project successfully	Define, create and verify project scope
3. Project Time Management	The processes required to manage timely completion of the project	Estimating activity duration and resources, Schedule development and control
4.Project Cost Management	The processes involved in estimating, budgeting, and controlling costs so that the project can be completed within the approved budget	Cost estimating, budgeting and control
5. Project Quality Management	The processes and activities of the performing organisation that determine quality policies, objectives, and responsibilities so that the project will satisfy the needs for which it was undertaken	Quality planning, assurance and control
6. Project Human Resource Management	The processes that organize, manage, and lead the project team	Acquire, develop and manage project team
7. Project Communications Management	The processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval, and ultimate disposition of project information	Stakeholders management, communication planning, performance reporting
8. Project Risk Management	The processes of conducting risk management planning, identification, analysis, response planning, and monitoring and control on a project	Risk identification and analysis, risk response development and control
9. Project Procurement Management	The management of processes necessary to purchase or acquire products, services, or results needed from outside the project team	Procurement planning and administration, contract administration and close-out

Sample

The sampling frame was obtained from a list of engineering organisations' representatives who registered as industry partners with the Industry Affiliates Program (IAP) at Griffith School of Engineering, Griffith University (where the authors are based at). This work integrated learning (WIL) program provides final year students the opportunity to develop work-ready skills through the completion of an industry-based project. Being active industry partners, this group of professionals would most likely have reasonable experience working with, or supervising, graduate/student/cadet engineers, hence would be at the best position to assess their current PM skills and provide other useful comments. In total, 65 industry partners were identified to form a sampling frame. Each of these partners was sent a personalised email consisting of statements describing the survey purpose and the link to the online questionnaire.

Results and Discussion

Background of respondents

Of the 65 emails sent, 30 industry partners (representing 30 engineering organisations) completed the questionnaire, equating to a 46% response rate. The majority of the respondents hold senior positions (76%), whereas the remaining are experienced (17%) and junior (7%) staff members. About 80% reported that they have more than five years of experience working in an engineering project environment. More than half (53%) reported that they have sometimes worked with or supervised graduate engineers and 33% reported to have done this on a regular basis. These respondents also represent organisations that are mostly private (70%) providing engineering consultancy (60%), engineering contractor (18%), manufacturing (11%) and other (11%) services. The respondents' fields of engineering expertise are diverse, including civil/structural (24%), water/environmental (21%), electronics and electrical (18%), mining (10%), mechanical (10%), manufacturing and process (8%), chemical (4%) and others (5%). The majority of these organisations are actively involved in engineering projects (86%), with 60% operating internationally, 23% regionally and 17% nationally.

PM skills of graduate engineers

The second section of the survey was focused on the importance of each PM knowledge area and the PM skills of graduate engineers as perceived by the respondents. A five-point Likert scale was used to measure both the perceived importance (1= 'not important', 5='very important') and perceived skills (1='very poor' and 5='very good'). Table 2 presents the mean values of both the perceived importance and perceived skills along with their ranking. The table also shows the differences between the mean scores of the perceived importance and those of the perceived skills. These differences are also illustrated in Figure 1. For ranking purpose, a normalised mean difference was also calculated for each PM knowledge area by dividing the mean difference of that knowledge area by the total sum of the mean differences of all the nine knowledge areas.

Table 2 Perceived importance of PM Knowledge areas and PM Skills of graduate engineers

PM Knowledge Area	Perceived Importance	Rank	Perceived Skills	Rank	Mean Difference	Normalised Mean Difference	Rank
1. Project Integration Management	3.53	5	3.07	3	0.47	9%	5
2. Project Scope Management	3.83	2	2.90	4	0.93	18%	1
3. Project Time Management	3.97	1	3.07	3	0.90	18%	1
4. Project Cost Management	3.67	4	2.87	5	0.80	16%	2
5. Project Quality Management.	3.77	3	3.20	1	0.57	11%	4
6. Project Human Resource Management	2.80	7	2.73	6	0.07	1%	6
7. Project Communication Management	3.77	3	3.13	2	0.63	12%	3
8. Project Risk Management	3.50	6	2.70	8	0.80	16%	2
9. Project Procurement Management	2.90	8	2.83	7	0.07	1%	6

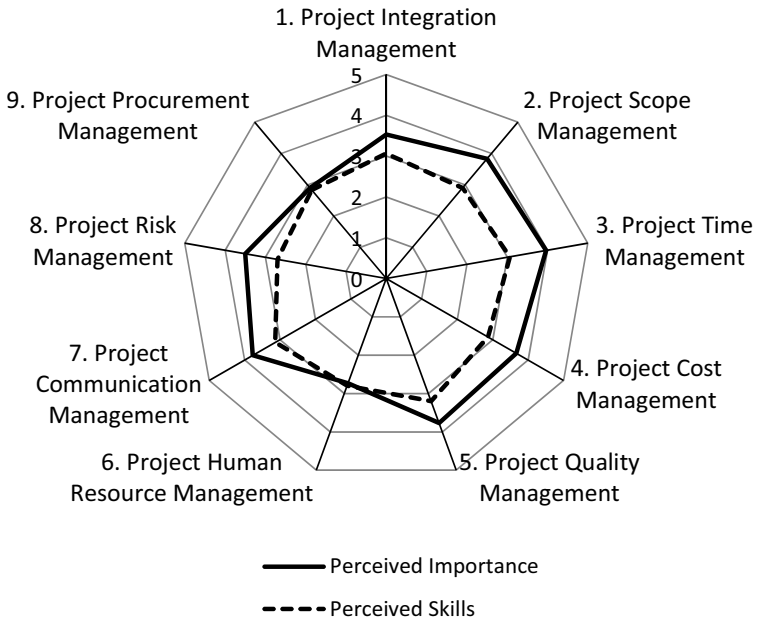

Figure 1: Perceived importance and perceived skills comparison

According to Table 2, it can be seen that the respondents perceived project time and scope management as the two most important areas that graduate engineers should have and human resource and procurement as the two least important areas. The overall level of perceived PM skills of the graduate engineers is generally average, with the two best areas being project quality and communication management. The table also shows the mean difference, which refers to the 'performance gap' between the perceived levels of PM skills of graduate engineers and the perceived importance for each of the PM knowledge areas. As evident in Table 2 and Figure 1, the perceived PM skills are all lower than their perceived importance. The largest gaps are in the areas of project scope (18%), time (18%), cost (16%) and risk (16%) management. It can be inferred that these are the areas where graduate engineers may require improvement with respect to the benchmark levels of importance perceived by the respondents.

Perceived emphasis on PM content areas

In the last section of the survey, respondents were asked to assign a percentage weight on each PM knowledge area (i.e. level of emphasis) if they were to develop a PM course. Table 3 presents the average levels of emphasis for all the nine PM knowledge areas along with the ranking. For comparison purpose, the normalised mean difference and ranking taken from Table 2 are also included. It can be seen from the table that the ranking of PM knowledge areas' emphasis is generally consistent with that of the performance gaps identified in the preceding section. This implies that the emphasis the respondents placed on each PM knowledge area corresponds to the gap identified in each knowledge area.

Table 3 Perceived emphasis of PM knowledge areas

PM Knowledge Area	Average Emphasis (%)	Rank	Normalised Mean Difference (%)*	Rank*
1. Project Integration Management	12%	3	9%	5
2. Project Scope Management	15%	1	18%	1
3. Project Time Management	15%	1	18%	1
4. Project Cost Management	13%	2	16%	2
5. Project Quality Management.	11%	4	11%	4
6. Project Human Resource Management	7%	6	1%	7
7. Project Communication Management	11%	4	12%	3
8. Project Risk Management	9%	5	16%	2
9. Project Procurement Management	7%	6	1%	6

*Values taken from Table 2

In addition, it is worth highlighting that the three highest ranked PM knowledge areas in both the perceived emphasis and the performance gap are identical – project scope management, project time management and project cost management. This suggests that these three areas are critical and should be emphasised in an EPM course. In particular, the qualitative feedback provided by the respondents mainly concentrates around these areas, as reflected by the following comments from five different respondents:

> *"Not enough emphasis on commercial realities, i.e. organisations exist to make money and you need commercial skills or at least an awareness of them"*
>
> *"Scoping the project is critical. That is, determining the client's needs and expectations then managing them through regular communication."*
>
> *"Managing Time on a Project is the most fundamentally important requirement to our business. Losing one day on the project is worth a lot more than losing one excavator or crane. Graduates have difficulties producing a fully resourced four or eight week look ahead schedule, let alone updating and checking against baselines."*
>
> *"The most important facets of PM that graduates will need to deal with is managing time, scope and reporting progress. All other areas come later in ones' career which gives one ample time to undertake internal/external training to gain experience."*
>
> *"A good project definition phase including an agreed root cause followed by an agreed and understood scope & aims is probably the most important aspect in project management. Most projects stall or fail due to poor planning and understanding up front."*

Respondents also acknowledged the fact that specific PM skills require development through direct professional experience and cannot be effectively taught during undergraduate studies. Indeed, professional competency in PM is attained by the combination of knowledge acquired during studies/training and skills developed through experience and the application of such acquired knowledge (Edum-Fotwe and McCaffer, 2000). Hence, PM knowledge areas critical for graduate engineers such as those identified above should be more emphasised when teaching EPM to engineering students.

Conclusion

PM has become one of the main components of standard undergraduate engineering programs offered at most Australian universities. It is also one of the key abilities of a professional engineer as stipulated by Engineers Australia's Stage 1 Competency Standard. However, details regarding specific PM knowledge areas that engineers, especially at graduate or junior levels, should possess are largely unavailable. Such limitations also mean that the structuring of an existing EPM course would be based on a less informed decision. To cope with this limitation, the herein presented research was conducted to provide a better understanding of the critical PM areas based on the input from industry practitioners. The results from a survey of 30 practitioners showed that project scope management, project time management and project cost management are the three most important skills for graduate engineers involved in engineering projects. These are also the areas where graduate engineers require further improvement. Finally, the results highlight that such PM knowledge areas would require more emphasis when teaching EPM to engineering students.

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