

An Integrated Model of Project Managers' Competencies through Factor Analysis

Dr. Elmahdee Hashim, Dr. Aminah Binti Md Yusof, Dr. Khawla M Alamen
School Of Graduate Studies, UTM

Abstract: Any project manager to be qualified must possess core competencies. The required competencies must cover all aspects needed for successful projects to deal with engineering, coordination, and managerial issues. Despite there are many frameworks, they do not cover all competencies. For example, the PMCD framework focused on managerial competencies and lack of engineering competencies. Both managerial and engineering competencies are very important. Managerial competencies help in leading, manage, and control the project activities; however, engineering competencies help in understanding the engineering aspects and dealing with them. Therefore, this study tries to integrate two important frameworks which are PMCD and Engineering Canada Frameworks. Factor Analysis is used to categorize the competencies in the integrated model. A number of six factors or groups have been identified for the 21 competencies of the two frameworks.

Keywords:- Project Manager; Competencies; PMCD Framework; Engineering Canada Framework; Factor Analysis.

I. INTRODUCTION

Project management became essential in performing any project, especially for engineering projects. Indeed, any activities should have clear objects and can be considered as a project even with personal activities. However, engineering projects are more sensitive for cost, time, and quality. This fact arises the importance of possessing core competencies needed for project managers to perform their projects successfully.

Project-based organizations have become increasingly popular of late due to its effectiveness and competitiveness. One of the factors that influence project success is employing competent project managers. Nowadays, in a highly technological and high level of competitive environment, project managers play a critical role in projects' success. Their selection, assignment, and ongoing development are the critical key to a project's ultimate success. Pinto and Kharbanda (1995), argued that project management is a leader-intensive endeavor, and competent project managers can lead projects to success even in the face of substantial challenges. Additionally, Crawford (2000), pointed out that a competent project manager is a strong factor that affects project success or failure. Bedingfield and Thal (2008) pointed out that project success can be enhanced by selecting the most appropriate and competent project manager. Also, Cheng *et al.* (2005) indicated that there is a growing awareness of

the relationship between project managers' competencies and achieving project success. However, the process of attracting and developing qualified project managers are difficult and expensive (Hashim, Talib and Alamen, 2014).

In order to survive in a competitive market, organizations today are looking for competitive advantages. One of these competitive advantages is having a competent team leading by competent project managers (Bratton and Gold, 1999; Dainty, Cheng and Moore, 2004). Authors such as Karpin (1995) and Smith, Carson, and Alexander (1984) have assumed that if project teams are competent, they will perform their tasks effectively and this leads to successful projects and increase the competitive advantage of the organization. On the other hand, Pinto and Kharbanda (1995), pointed out that it is popular to project-based organizations to discover that they do not have a sufficient number of competent project managers who are the key factor behind the project success. The author added that despite the acknowledgment of senior managers about the way in which project managers acquire their skills, they are unsure what the best way to develop and provide well-trained project managers for the future.

A project manager must possess the core competencies that enable him to well manage the project and achieve its objectives and deliverables successfully. Recently, there has been a growing emphasis within researchers on the need to identify the core competencies of the project manager that improve his performance in order to meet the growing demand in the industry (Dainty, Cheng and Moore, 2004). Crawford (2000) stated that despite the project manager competencies are obviously a critical and vital factor for project success, it is still difficult to be quantified and based on the opinions of the project management practitioners. Also, Stevenson and Starkweather (2010) concluded that the project managers' competencies are the key factor that influences the eventual outcome of the project. Furthermore, the organizations' success depends on their competent employees (Brophy and Kiely, 2002). Additionally, a successful project manager is dependent on his competencies (Turner and Muller, 2006). Despite the existence of great frameworks developed by great people, they all complete each other because one framework may miss a competency that is in the other ones. Therefore, this study is an attempt to identify the core competencies needed for the project managers and to develop an integrated framework has a new view of project management. After the deep studying of the project management competencies in the literature, this study

integrated the most useful frameworks which are PMCD and Engineering Canada frameworks.

II. PROJECT MANAGERS' COMPETENCIES

Nowadays, there is an increasing demand for competent project managers because projects become more complex and more non-project-based organizations move into management by projects (Crawford, 1997). Ruuska and Vartiainen (2003) revealed that the project manager competencies are the key aspect of a project's success. Due to the consensus acknowledgment of the important role of the competent project manager, most organizations recognize the importance of developing their managers and employees to enhance their competitive capabilities (Bratton and Gold, 1999; Dainty, Cheng and Moore, 2004). Furthermore, Kerzner (1982) thinks that project management continues to become more challenging and emphasizes to pay special attention to the development of

the project managers to be able of coping with jobs that range from small to mega projects.

The literature has shown that most of the previous researches focus on skills which are one element of the competency, while; only a few researchers have focused on the competency itself. According to Cartwright and Yinger (2007), the major components of competencies are abilities, attitudes, skills, behavior, knowledge, and personality. Also, it is obvious that there is no consensus about one category which can represent and describe the project managers' competencies and their skills. This can be in contrast or aligned in some aspects with standers that include what project manager is expected to know, such as PMBOK Guide (2000), the IPMA's Competence Baseline (2006), and the APMBOK (2006); and what project manager is able to do, such as the occupational or performance-based competency standards of Australia and the United Kingdom. Table 1 shows some previously studied competencies of the project manager.

No.	Author	Studied Competencies/ Skills
1	Katz (1974)	Technical skills, Human skills, and Conceptual skills.
2	Bowenkamp and Klenier (1987)	Problem-solving, administration, supervision and team management, interpersonal relationship, personal qualities.
3	Pettersen (1991)	Problem-solving, administration, supervision and team management, interpersonal relationship, personal qualities.
4	Strohmeier (1992)	Team building; Conflicts; Communications; and Influence and motivation.
5	Goodwin (1993)	Problem-solving, interpersonal relationship, knowledge.
6	Anderson and Tucker (1994)	Administration, supervision and team management, interpersonal relationship, knowledge, experience.
7	Pinto and Kharbanda (1995)	Problem-solving, administration, supervision and team management, interpersonal relationship, personal qualities, knowledge, experience.
8	Grant, Baumgardner, and Shane (1997)	Knowledge, experience
9	Gushgari, Francis and Saklou (1997)	Communication; Listening; Project management; Decision making; Leadership and motivation; Problem-solving; Quality management; Organizing; Delegating; Planning; Result orientation; Financial management; Time management; Technical knowledge; Negotiation; Personal adaptability; Administration; Project acquisition; Creativity; and Risk-taking.
10	Crawford (1997)	Input competencies; Process competencies; and Output competencies.
11	Brugger, Gerrits, and Pruit (2000)	Problem-solving, administration, supervision and team management, interpersonal relationship, knowledge.
12	Crawford (2000)	Problem-solving, administration, supervision and team management, interpersonal relationship, knowledge
13	Edum and McCaer (2000)	Technical skills, managerial skills, financial skills, legal skills, communication skills, general skills, and IT skills.
14	Hauschildt (2000)	Problem-solving, supervision and team management, interpersonal relationship, personal qualities, knowledge.
15	Odusami (2002)	Problem-solving, administration, supervision and team management, interpersonal relationship, personal qualities.
16	Dainty, Cheng and Moore (2004)	Achievement orientation, initiative, information seeking, focus on client's needs, impact & influence, defectiveness, teamwork & co-operation, team leadership, analytical thinking, conceptual thinking, composure, and flexibility.
17	Mantel <i>et al.</i> (2005)	Communication, organizational, team building, leadership, coping, and technological skills.
18	Hyvari (2006)	Supervision and team management, knowledge.
19	Valencia (2007)	Leadership Ability, Communication Skill, Decision Making Skill, Administrative Skill, Coping Ability, Analytical Thinking, and Technical Competence.
20	Patanakul and Milosevic (2008)	Multiple-project managers' competencies; organizational experience; interdependency management; multitasking; simultaneous team management; and management of the inter-project process.
21	Crawford and Nahmias (2010)	Leadership, Team development/team selection, Stakeholder management, Communication, Decision-making and problem-solving, Planning (cost, time, risk, quality, scope), Governance, Contract management, Monitoring and controlling (cost, time, risk, quality, scope), Organization structure, Project definition, Administration, Transition management, Change control, and Closing.
22	Omidvar <i>et al.</i> (2011)	Job-competencies; Person-competencies; and Contextual competencies.

Table 1:- Studied Competencies in the Literature

Through the analysis of the studied competencies/skills from the literature, it can be concluded some important aspects and results as the following:

- The categorization of the project manager competencies is different from author or standard to another. Crawford (1997) has categorized them into three groups (input competencies, process competencies, and output competencies). PMCD Framework (2002) has categorized them as project management knowledge/performance competencies, and personal competencies. IPMA (2006) has categorized them into three dimensions (Technical competences, Behavioural competencies, and Contextual competences). While, Omidvar *et al.* (2011) have categorized them as personal-related competencies, job-related competencies, and contextual competencies.
- The naming or description of the competencies are varied, as some of them have been described as competencies, abilities, skills, or attitudes, e.g. Valencia (2007) has described them as attitudes.
- Most of the technical competency elements are similar to the project management knowledge-competency elements in the PMCD Framework, such as in IPMA (2006) and Edum and McCaer (2000). While this study defines the technical competencies that can reflect and represent the engineering aspects of the project.

Depending on the analysis results, this study adopted the project management knowledge competencies provided by PMCD Framework. The choice of the project management knowledge competencies is because these

competencies reflect all project management areas in the PMI PMBOK Guide which are Project Integration Management, Project Scope Management, Project Time Management, Project Cost Management, Project Quality Management, Project Human Resources Management, Project Communications Management, Project Risk Management, and Project Procurement Management. In the same way, Personal competencies have been adopted from the same framework because they reflect all personal characteristics needed for a project manager which are the achievement and action competence; helping and human service competence; impact and influence competence; managerial competence; cognitive competence; and personal effectiveness competence.

In order to represent the technical or engineering competencies, This study adopted the engineering competencies which are provided by Engineers Canada (2011) which are: applying engineering knowledge, methods and techniques competency; using engineering technology, tools and equipment competency; safeguarding public safety; recognizing the impacts of engineering on the environment, economy and society competency; managing engineering activities competency; and communicating engineering information competency. This choice is because that these competencies reflect the important parts of the engineering aspects of the project, as well as, they are very important not only for the project manager but also for any engineer. Fig. 1 illustrates a conceptual project manager competencies framework that is developed for this study.

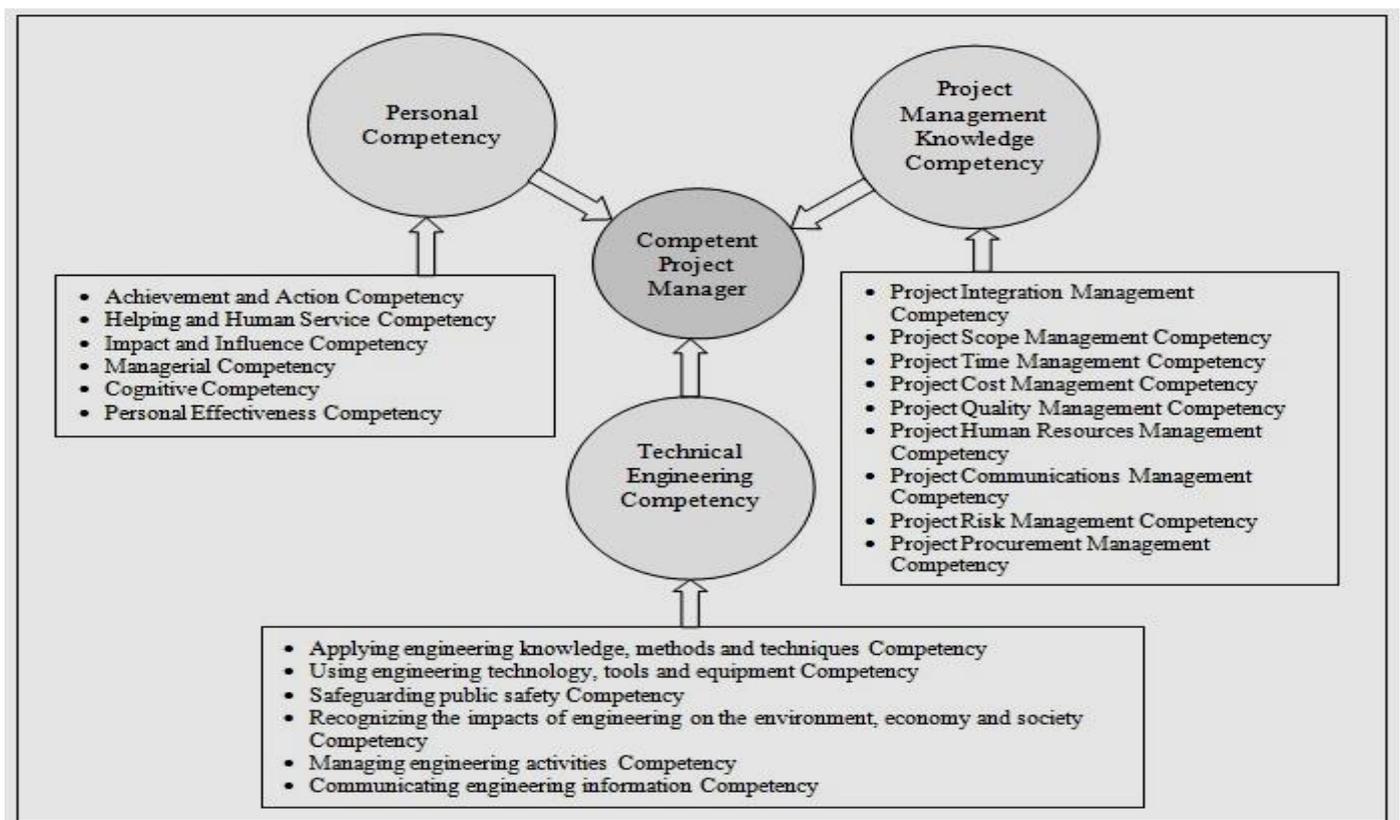


Fig 1:- Conceptual Framework

III. CONSTRUCTION INDUSTRY IN MALAYSIA

The Malaysian construction sector is closely related to the country's economic development because of its linkage with the other economic sectors. Although the declining global economic climate has affected the Malaysian economy, CIDB (2009) reported that the construction sector registered a solid growth of 5.7% in 2009 compared to 2.1% in 2008. This paradox is a result of various interacting forces i.e. the implementation of projects under the Nine Malaysian Plan (9MP) and the stability of construction materials prices. While the report showed that the new project investments had decreased. CIDB's record as at 31 December 2009 showed that projects with a total value of RM57.2 billion were awarded in 2009 compared to RM81.1 billion of projects awarded in 2008. The decrease in the value of projects was due to the decline in private investments, which was affected by the global economic crisis (CIDB, 2009).

In order to support a need for learning, information, and development for the construction industry, the Malaysian government has established the Construction Industry Development Board (CIDB) that represents a statutory board under the Ministry of Works. Also, this board aims to make the construction industry more dynamic enable it to be globally competitive. CIDB has categorized the construction companies into seven grades (from G1 to G7) depending on their capabilities and contributions to the industry. Each grade has specific limits in regard with the value of projects awarded (G1: not exceeding RM 200 thousand; G2: not exceeding RM 500 thousand; G3: not exceeding RM one million; G4: not exceeding RM 3 million; G5: not exceeding RM 5 million; G6: not exceeding RM 10 million; and G7: no limit). Also, each company has to be under the assessment each year to reactivate or upgrade its grade in CIDB (CIDB, 2012).

IV. METHODOLOGY

This descriptive study has been conducted in Malaysian construction companies. The target respondents are the project managers who manage construction projects of the construction companies as well as the senior managers who have experience in the project management and have executed construction projects in the past.

The questionnaire included 112 items that represent the 21 competencies of the conceptual framework as well as 12 questions for demographic information purpose. All the questionnaire items are developed through the competencies' descriptions of the theoretical frameworks and validated by experts. In order to reduce time and cost, this study used the online survey as a tool to distribute the research questionnaire.

In order to develop an integrated model to represent the project managers' competencies, factor analysis is applied. In this factor analysis, the principal component analysis is used to reduce numerous correlated competencies into fewer underlying factors. For more

accuracy and better interpretation, factors are rotated using the varimax method.

V. RESULTS AND DISCUSSION

The questionnaire has been validated and distributed to 265 construction companies. The data has been collected from 74 companies with 94 valid respondents during 4 months.

A. Demographic Analysis

50 companies were under grade 7, with 62 respondents (65.9%); 15 companies were under grade 6, with 23 respondents (24.4%); 8 companies were under grade 5, with 8 respondents; and only one company was under grade 4 with one respondent. However, companies under grades 1, 2, and 3 did not respond to the questionnaire. Among these companies, only 5 governmental companies responded with 5 respondents (6.7%), while the rest respondents were collected from private companies.

The descriptive analysis of the respondents in regard with professional experience years, project management experience years, position, and membership in professional associations the results showed that: Professional experience: 10 respondents have more than 20 years' experience (21.2%); 29 respondents have experience from 15 to 20 years (30.8%); 38 respondents have experience from 10 to 15 years (40.4%), and 17 respondents have experience from 5 to 10 years (18.1%). While the experiences of the respondents in managing projects: only 1 respondent has more than 20 years' experience (1.06%); 8 respondents have experience from 15 to 20 years (8.5%); 36 respondents have experience from 10 to 15 years (38.3%); 39 respondents have experience from 5 to 10 years (41.4%); and 10 respondents have less than 5 years' experience in managing projects (10.6%).

In the respect of respondents' position, 11 respondents were managers of project managers (11.7%); 60 respondents were project managers (63.8%); 11 respondents were subordinate managers (11.7%), and 12 respondents were functional managers (12.7%).

In the respect of memberships in the professional associations of project management: only one respondent was an ASME member (1.06%); 5 respondents were SME members (5.3%); only one respondent was a member of IEEE (1.06%); 65 respondents were members of PMI (69.14%); 4 respondents were members of ASNE (4.25%); while 18 of the respondents were not members of any association (19.14%) as shown in Table 2.

Member	Frequency	%	Valid %	Cumulative %
No	18	19.1	19.1	19.1
ASME	1	1.1	1.1	20.2
SME	5	5.3	5.3	25.5
IEEE	1	1.1	1.1	26.6
PMI	65	69.1	69.1	95.7
ASNE	4	4.3	4.3	100.0
Total	94	100.0	100.0	

Table 2:- Memberships in the Professional Associations

Factor analysis is a sophisticated statistical technique which aims to provide further insight among numerous correlated variables into a much fewer underlying factor (Field, 2005). In order to estimate the adequacy of the questionnaire data for factor analysis, KMO (Kaiser–Meyer–Olkin) test and Bartlett's test of sphericity were

conducted. KMO value represents the ratio of the squared correlation between variables to the squared partial correlation between variables (Field, 2005). The KMO value varies between 0 and 1. A value of 0 indicates that the sum of partial correlations is large relative to the sum of correlation, indicating diffusion in the pattern of correlation (hence, factor analysis is inappropriate). A value close to 1 indicates that patterns of correlation are relatively compact and factor analysis yield distinct and reliable factors (Feild, 2005). Values greater than .5 are barely acceptable, while values below .5 lead either to collect more data or to rethink which variables can be included (Kaiser, 1974). Furthermore, values between .5 and .7 are mediocre, values between .7 and .8 are good, values between .8 and .9 are great, and values above .9 are superb (Field, 2005). The KMO value of the 21 variables is nearly 0.7 (.693) which is considered good for this research.

A total of six factors were evolved as shown in Table. 3. These factors explained 61.4% of total variance.

Factors	Factor loading	% variance explained
Factor 1: Engineering knowledge		20.698
Communicate engineering information	.796	
Apply engineering knowledge, methods, and techniques	.775	
Manage engineering activities	.704	
Use engineering technology, tools, and equipment	.636	
Safeguard public safety	.526	
Recognize the impacts of engineering on the environment, economy, and society	.463	
Factor 2: control and coordination		12.970
Project Scope Management Competency	.716	
Project Procurement Management Competency	.637	
Project Communications Management Competency	.623	
Project Integration Management Competency	.597	
Project Quality Management Competency	.548	
Factor 3: constraints control		10.014
Project Cost Management Competency	.770	
Project Time Management Competency	.749	
Project Risk Management Competency	.675	
Factor 4: personal impact		7.222
Personal Effectiveness Competency	.767	
Project Human Resources Management Competency	.731	
Cognitive Competency	.492	
Impact and Influence Competency	.462	
Factor 5: helping and action		5.497
Helping and Human Service Competency	.839	
Achievement and Action Competency	.692	
Factor 6: general management		5.026
Managerial Competency	.790	
Total		61.427

Table 3:- Factor Analysis Result

B. Factor Analysis

➤ Factor 1: Engineering knowledge

The first factor explains 20.7% of the total variance of the linear component (factor) and contains six competencies. All the competencies in this factor were represented exactly as presented in Engineers Canada (2011) Framework which are "communicating engineering information competency", "applying engineering knowledge, methods and techniques competency", "managing engineering activities competency", "using engineering technology, tools and equipment competency", "safeguarding public safety competency", and "recognizing the impacts of engineering on the environment, economy, and society competency".

Communicating engineering information competency; applying engineering knowledge, methods and techniques competency; managing engineering activities competency; using engineering technology, tools and equipment competency are associated with the engineering activities of the project and they received a significance of .796, .775, .704, and .636 respectively (see Table 3.). A competent project manager should possess these competencies that allow him to deal with the engineering aspects of the project in a professional manner. These allow them to well understand the problems that may happen and apply sophisticated solutions with low cost by well using of the available technologies. This is in line with the respondents' education background in this study, all respondents are engineers.

Safeguarding public safety competency and recognizing the impacts of engineering on the environment, economy and society competency seem not very important for the project managers in Malaysian construction companies and they received a significance of .526 and .463 respectively (see Table 3.). While the second competency can be excluded from the factor analysis because its loading is less than 0.5 according to Feild (2005). The lower impact of these competencies may be because in most cases, project managers focus only on their tasks regardless of external aspects such as public safety, environment, and/or economy. But this may depend on national policies and culture.

➤ Factor 2: Control and Coordination

The second factor explains 12.97% of the total variance of the linear component (factor) and contains five competencies. The first competency is *project scope management competency* (with a factor loading of 0.716) enables the project manager to complete the project by including only the required work and to control scope changes. The second competency is *"project procurement management" competency* (with a factor loading of 0.637) enables the project manager to acquire goods and services needed for the project scope. The third competency is *"project communications management" competency* (with a factor loading of 0.623) enables the project manager to well collect and distribute the project information to the stakeholders. The high ability in communicating with the

stakeholders especially the clients with clarity can increase the trust level and open the opportunities for future projects. The fourth competency is *"project integration management" competency* (with a factor loading of 0.597) enables the project manager to well coordinate the various elements of the project. The fifth competency is *project quality management competency* (with a factor loading of 0.548) enables the project manager to apply the required processes that ensure the project will satisfy the needs for which it was undertaken.

➤ Factor 3: Constraints Control

The third factor explains 10.01% of the total variance of the linear component (factor) and contains three competencies. The first competency is *project cost management competency* (with a factor loading of 0.770) enables the project manager to apply the required processes that ensure that the project will be completed within the approved budget. The second competency is *project time management competency* (with a factor loading of 0.749) enables the project manager to apply the required processes that ensure that the project will be completed on time. The third factor is *project risk management competency* (with a factor loading of 0.675) enables the project manager to well identify and analyze the risks that can negatively effect on the project.

➤ Factor 4: Personal Impact

The fourth factor explains 7.22% of the total variance of the linear component (factor) and contains four competencies. The first competency is *personal effectiveness competency* (with a factor loading of 0.770) enables the project manager to be self-control, self-confidence, and flexible and to act in the way that promotes organizational goals or meet organizational needs. The second competency is *"project human resources management" competency* (with a factor loading of 0.731) enables the project manager to well lead the project team in a way that increases its productivity and performance. The third competency is *cognitive competency* and the fourth competency is *impact and influence competency* can be excluded because their factor loadings are less than 0.5 according to Feild (2005).

➤ Factor 5: Helping and Action

The fifth factor explains 5.497% of the total variance of the linear component (factor) and contains two competencies. The first competency is *helping and human service competency* (with a factor loading of 0.839) enables the project manager to be customer service oriented by discovering and meeting the customer or client needs. Also, it enables him to understand other people by hearing accurately the unspoken thoughts, feelings, and concerns of others. The second competency is *"achievement and action" competency* (with a factor loading of 0.692) enables the project manager to be achievement oriented; concerned in order, quality, and accuracy; initiative; and information seeker.

➤ *Factor 6: General Management*

The sixth factor explains 5.026% of the total variance of the linear component (factor) and contains only one competency. The only competency for this factor, managerial competency (with a factor loading of 0.790) enables the project manager to work cooperatively with others by being part of the team, to develop others by teaching them or foster the development, to lead the project team, and to use the positional power to make others comply with the orders.

VI. CONCLUSION

The resultant model of this study integrated a number of 21 competencies of two frameworks which are PMCD Framework (2002) Engineers Canada Framework (2011). It can be concluded that these competencies are very important to ensure project success. Focusing on only engineering or managerial competencies does not help the project manager on leading the project successfully and may arise many problems for the project. Therefore, the project managers must possess these competencies and make a balance between them.

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