Prioritising project management competences across the software project life cycle

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The final, published version in International Journal of Managing Projects in Business, 10.1108/IJMPB-11-2017-0145, 2019 will be available at:

https://dx.doi.org/10.1108/IJMPB-11-2017-0145

emerald PUBLISHING

International Journal of Managing Projects in Bu

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Journal:	*International Journal of Managing Projects in Business*
Manuscript ID	IJMPB-11-2017-0145.R1
Manuscript Type:	Research Paper
Keywords:	Project management competence, Competence prioritisation, Software project, Project management life cycle

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Article classification: Research paper

Structured Abstract

Purpose: This paper investigates the relative importance of project management competences across the different stages of a software project life cycle to identify competence development gaps and opportunities.

Design/method/approach: A deductive and quantitative approach was adopted to address our research questions with a web-based survey for data collection.

Findings: After reviewing the context of competences and project management competences, the importance of the project management competences overall and for specific stages in the project life cycle was analysed. The result highlights that functional and meta-competences are perceived to be the most important competence dimensions for software project practitioners.

Originality/value: This study makes three contributions. First, it consolidates PM competences into a set of 20 within four competence dimensions. Second, it prioritises these competences across the software project life cycle. Third, it identifies the significance of the inter-relationship between project management competences and project life cycle to reveal project management competence development gaps and opportunities.

Keywords

Project management competence; competence prioritisation; software project; project management life cycle

Introduction

This paper investigates the relative importance of project management (PM) competences across the different stages of a software project life cycle to identify competence development gaps and opportunities.

This is of particular relevance: despite the steady development of research since the 1990s into the importance of PM competences for the successful delivery of projects (Morris and Hough, 1987; Heywood *et al*., 1992; Crawford, 2003; Cheng *et al*., 2005; Crawford, 2005; Morris, 2013). There has been limited research on PM competence prioritisation across the project life cycle (Buchanan, 1991; Stevenson and Starkweather, 2010).

More specifically, research has identified PM competences (Crawford, 2000, 2002); proposed competence development frameworks (Suikki *et al*., 2006; Takey and Monteiro, 2015); prioritised competences for specific types of projects (Edum-Fotwe and McCaffer, 2000; Seppänen, 2002; Crawford and Nahmias, 2010; Skulmoski and Hartman, 2010; Li *et al.*, 2011; Palacios-Marques *et al.*, 2013), and for specific project stages (Havila *et al.*, 2013; Gomes *et al.*, 2012; Ahadzie *et al.*, 2014).

However, studies on PM competences tend to focus on the early stages of a project with limited consideration of competences needed at different stages (Havila *et al.*, 2013). In addition, Stevenson and Starkweather (2010) identify the need to determine the link between specific competences and project stages.

This paper therefore focuses on two different but connected aspects of PM competences. First, we identify the main PM competences from existing literature and establish their perceived level of importance in managing software projects. Second, we explore PM competence prioritisation across the software project life cycle.

This research therefore contributes to developing the body of knowledge in software PM competences by recognising and linking relevant competences to specific project life cycle stages.

Following this introduction, the paper defines terms and identifies the PM competences from existing literature. We describe the methodological approach employed. We then present and discuss the findings. Finally, we conclude with some implications for PM development and practice.

Managerial Competence and Projects

Managerial competences are an important part of any organisation. The identification and development of these can contribute to the achievement of an organisation's strategic goals.

The concept of competence is well discussed in two complementary bodies of literature. First, in the human resource management and development literature discussing managerial capability (Stamp, 1981; Cave and Wilkinson, 1992); and second, in the literature discussing individual managerial competence (Boyatzis, 1982, 2008; Cave and Mckeown, 1993; Woodruffe, 1993; Mirabile, 1997; Sandberg, 2001; Le Deist and Winterton, 2005; Königová *et al.*, 2012).

While there remains an ongoing debate about definitions of competence (Le Deist and Winterton 2005; Königová *et al.*, 2012), overall, this body of work focuses on the individual manager and the knowledge, skills, attributes, traits, behaviours and abilities required to perform a certain role, job or function effectively and is concerned with how to develop these.

In this paper, we draw on the work of Le Deist and Winterton (2005) who develop a holistic typology of competence. This brings together the distinct approaches to competence definitions and usages, such as: a behavioural approach in the USA; a functional approach in

the UK; and a multi-dimensional and holistic approach in France, Germany and Austria. Le Deist and Winterton's (2005) competence typology consists of four dimensions:

1. Cognitive competence refers to knowledge and understanding, reinforced by theory and tacit knowledge gained through experience. Le Deist and Winterton refer to this as 'know-what' and 'know-why'.
2. Functional competence refers to the skills and abilities an individual should possess when working in a specific area. Le Deist and Winterton refer to this as 'know-how'.
3. Social competence refers to behaviours and attitudes which are characteristic of an individual and are usually associated with exceptional performance. It considers the way individuals create, build and maintain relationships, and interface with others. Le Deist and Winterton refer to this as 'know-how to behave'.
4. Meta-competence refers to the ability to acquire and learn new competences, and includes reflection and self-awareness. We can refer to this as 'know thyself'.

This multi-dimensional conceptualisation provides a holistic understanding of the term competence and provides a foundation for thinking about training and development in different professions. But perhaps because of the different international approaches mentioned above, studies in managerial competence in project management have in fact been extraordinarily wide ranging.

Broadly this research identifies competences (Crawford, 2000, 2002; Fong and Chan, 2004; Cheng *et al.*, 2005; Gillard and Price, 2005; Partington *et al.*, 2005; Brill *et al.*, 2006; Ahsan *et al.*, 2013); develops competence frameworks (Suikki *et al.*, 2006; Takey and Monteiro, 2015); identifies competences for a specific type of project (Edum-Fotwe and McCaffer, 2000; Seppanen, 2002; Crawford and Nahmias, 2010; Skulmoski and Hartman, 2010; Li *et al.*, 2011; Palacios-Marques *et al.*, 2013); and identifies competences for a specific project

stage (Gomes *et al.*, 2012; Havila *et al.*, 2013; Ahadzie *et al.*, 2014). These studies generally provide a list of knowledge areas, skills, and/or abilities required to manage projects.

For instance, Crawford (2000) identifies 24 competences for project managers; Fong and Chang (2004 cited in Suikki *et al.*, 2006) identify five key capabilities required for effective project management work; Gillard and Price (2005) identify 10 competences; Partington *et al.* (2005) identify 17 key attributes of programme management; and Stevenson and Starkweather (2010) identify core and critical competences for IT project managers.

However, three limitations of this body of research can be identified. First, as Nijhuis *et al.* (2015) state there does not seem to be a common agreement on a set of project management competences; nor does there seem to be an agreement on which competences are most important; Crawford (2005) and Cheng *et al.* (2005) are two exceptions to this. Second, the research has tended to focus on the early and middle stages of managing projects or been generic; Skulmoski and Hartman's (2010) project phase investigation is an exception. Third, there seems to be an assumption in the literature that these competences are equally important throughout the project life cycle.

This is important as the nature and dynamics of projects require a range of managerial competences to be deployed to accomplish the required tasks as the project progresses. Recognising the relationship between competences and life cycle stages could advance the efficiency of PM resource allocation and managerial efficiency (Stevenson and Starkweather, 2010) as well as identify opportunities for PM development (Silvius, 2009; Ekrot *et al.*, 2016). Silvius and Batenburg's (2009) study begins to identify these opportunities by providing insights into the expected future development in PM competences in 2027. By developing four future scenarios of Europe (i.e. levels of international cooperation and public/private responsibilities), the importance of 46 PM competences were tested based on responses from

project managers and practitioners (Silvius, 2009). The result contributes to our better understanding of PM competence variations in a macro perspective (in a different era), but it does not focus on micro variations in a project life cycle (in a different project stage). Thus, more understanding of PM competences across the software project life cycle is needed.

Therefore, this research will address the following research questions (RQ):

- RQ1. What is the perceived level of importance of existing project management competences for managing software projects?
- RQ2. What is the level of prioritisation of PM competences across the software project life cycle?

Project Management Competence Typology and Description

We follow the suggestions of Durach *et al.* (2017) to begin to address RQ1 and identify the PM competences. We determined to review existing literature that explicitly studied and identified individual PM competences aligned to Le Deist and Winterton's (2005) competency typology dimensions and across a range of projects such as IT/IS, engineering, R&D and manufacturing.

To retrieve a sample of potentially relevant literature we conducted a key word search for managerial competence in projects (competen*+ project*+ manag*) on three search engines (Science Direct, Web of Science and ProQuest). We used a backward approach, limiting our search to 12 years (2017-2005) in the first instance. This stage provided a baseline sample of 64 publications. We then consolidated the database and reviewed the abstracts for relevance of content, in other words, did the studies identify PM competences along the competence typology dimensions (Le Deist and Winterton, 2005).

This resulted in 19 publications identified as pertinent. Two independent searches were undertaken and compared for consistency. Alongside this process, we also used cross-referencing to identify relevant publications published before 2005. In addition, we included in the review project management bodies of knowledge (APM, 2012; PMI, 2013) and competence frameworks (IPMA, 2006; PMI, 2007; APM, 2008) which capture and represent the required knowledge and understanding (cognitive dimension) in project management. In total, we reviewed 31 sources of literature. It is to this literature that we turn next.

We used as a baseline Crawford's (2000, 2005) study as the majority of the post 2005 publications make reference to this work. Crawford (2000, 2002) identifies 24 PM competences as a result of a systematic review. Crawford (2005) provides an integrated model of project management competence which aligns with Le Deist and Winterton's (2005) competence typology along three (cognitive, functional, social) of the four competence dimensions. We therefore used the cognitive, functional, social and meta-competence dimensions and definitions as high level coding dimensions and synthesised 20 PM competences (identified in **bold**, and summarised in table 1).

[insert Table 1 about here]

Within a cognitive competence ('know-that' and 'know-why') dimension, studies (Andersen, 2008; Thomas and Mengel, 2008; Stevenson and Starkweather, 2010; Starkweather and Stevenson, 2011) have found several elements that are central to the development of PM competence: knowledge acquired through **educational background** in project management (Stevenson and Starkweather, 2010; Andoh-Baidoo *et al.*, 2011); relevant **training and certification** programmes such as PMP or PRINCE2 (Thomas and Mengel, 2008; Stevenson and Starkweather, 2010; Starkweather and Stevenson, 2011); and a working history in terms of **prior project experience** in relevant projects (Anderson, 1992; Hölzle, 2010; Stevenson

and Starkweather, 2010; Taylor and Woelfer, 2010). Knowledge and understanding about major **PM process knowledge**, as captured in the various project management bodies of knowledge (APM, 2012; IPMA, 2006; PMI, 2013) have been used in competence studies (Crawford, 2000; El-Sabaa, 2001; Cicmil, 2006; Brière *et al.*, 2015) and therefore can be considered collectively as a cognitive competence.

For example, research has identified the importance of knowledge and understanding in resource and **planning** management including time, cost and human resources for project productivity (Anderson, 1992; Wateridge, 1997; Crawford, 2000; El-Sabaa, 2001; Muzio *et al.*, 2007; Müller and Turner, 2010a, 2010b, 2010c; Brière *et al.*, 2015). In addition, various authors (Anderson, 1992; Wateridge, 1997; Jurison, 1999; Crawford, 2000; El-Sabba, 2001; Stevenson and Starkweather, 2010; Starkweather and Stevenson, 2011) have highlighted **technical knowledge**; that is, having technological knowledge and understanding relating to software and systems as a key competence.

Within a functional competence ('know-how') dimension we find a range of studies highlighting the relevance of competence in **managing risk and uncertainty**: in other words, the knowledge and ability to deal with ambiguity, uncertainty, threats and change; to solve problems; and to control escalation (Wateridge, 1997; Crawford, 2000; El-Sabaa, 2001; Opfer *et al.*, 2002; Muzio *et al.*, 2007; Thomas and Mengel, 2008; Stevenson and Starkweather, 2010; Fisher, 2011; Starkweather and Stevenson, 2011; Li *et al.*, 2011). Bander and Giber (1995) and Cheng *et al.* (2005) have identified what we call **informative power**, the knowledge and ability to seek and understand relevant information as a competence of superior PMs alongside **negotiation skills** (Jurison, 1999; Crawford, 2000; Cheng *et al.*, 2005; Cicmil, 2006; Andersen, 2008; Skulmoski and Hartman, 2010).

Competence in **decision making** has been conceptualised (Wateridge, 1997; Crawford, 2000; Cheng *et al.*, 2005; Cicmil, 2006) as knowledge, skills and ability for critical judgment; conceptual thinking; intuitive insight; and timely decision making.

Assembling the project team is concerned with the ability to understand the organisational context (strategy, structure) and how this affects the project for staffing, team building and support (Anderson, 1992; Bander and Gilber, 1995; Wateridge, 1997; Crawford, 2000; Opfer *et al.*, 2002; Cheng *et al.*, 2005; Cicmil, 2006; Andersen, 2008; Stevenson and Starkweather, 2010; Starkweather and Stevenson, 2011; Fisher, 2011).

Strategic directiveness refers to the skills and ability to provide strategic direction, providing goals and definition (Crawford, 2000; Opfer *et al.*, 2002; Cheng *et al.*, 2005; Geoghegan and Dulewicz, 2008).

Within the social competence ('know-how to behave') dimension we find that **leading** competence, which relates to personal empowerment, delegation, rewarding and interpersonal understanding, has been widely noted in the literature (Anderson, 1992; Wateridge, 1997; Jurison, 1999; Crawford, 2000; El-Sabaa, 2001; Opfer *et al.*, 2002; Cheng *et al.*, 2005; Andersen, 2008; Geoghegan and Dulewicz, 2008; Thomas and Mengel, 2008; Taylor and Woelfer, 2009; Müller and Turner, 2010a, 2010b, 2010c; Stevenson and Starkweather, 2010; Skulmoski and Hartman, 2010; Fisher, 2011; Gomes *et al.*, 2012; Pauget and Wald, 2013; Zhang *et al.*, 2013; Galvin *et al.*, 2014; Brière *et al.*, 2015).

Competence in **managing stakeholders** including customers has been identified in a few studies (Crawford, 2000; El-Sabaa, 2001; Cheng *et al.*, 2005; Zhang *et al.*, 2013). **Communicating**, the importance of being able to manage relevant organisational and inter-organisational connections, to build, maintain and manage relationships, has been particularly emphasised in the literature and is closely aligned with managing stakeholders (Wateridge,

1997; Jurison, 1999; Crawford, 2000; El-Sabaa, 2001; Opfer *et al.*, 2002; Henderson, 2004; Andersen, 2008; Silvius, 2009; Müller and Turner, 2010a, 2010b, 2010c; Stevenson and Starkweather, 2010; Skulmoski and Hartman, 2010; Fisher, 2011; Pauget and Wald, 2013; Dillon and Taylor, 2015).

Contextual awareness has also been identified as a key competence in the literature. For example, **cultural and social awareness** refers to understanding the culture of organisations (internal and external), cultural variance and fit (Cicmil, 2006; Stevenson and Starkweather, 2010; Fisher, 2011; Zhang *et al.*, 2013). Research has also highlighted a number of attitudes or behaviours: these include **Conscientiousness**, the ability and observed behaviour of promoting managerial transparency (Geoghen and Dulewicz, 2008; Müller and Turner, 2010a, 2010b); **emotional resilience,** the ability to manage emotions and display energetic attitudes (Opfer *et al.*, 2002; Cheng *et al.*, 2005; Cicmil, 2006; Anderson, 2008; Geoghegan and Dulweicz, 2008; Müller and Tuner, 2010a, 2010b; Fisher, 2011); and **self-inspiration,** the personal attitudes and behaviours of self motivation, and self-confidence (Bander and Giber, 1995; El-Sabaa, 2001; Opfer *et al.*, 2002; Cheng *et al.*, 2005; Geoghegan and Dulewicz, 2008; Clarke, 2010; Müller and Turner 2010a, 2010b).

Finally, within the meta-competence ('know-thyself') we find **managing self-knowledge** has also been identified as an important competence (Söderlund *et al.*, 2008; Müller and Turner, 2010a, 2010b, 2010c; Huang *et al.*, 2015). This is the ability to reflect on experience, recognise the lessons learned, and to apply them as the project progresses through its life-cycle and in future projects.

The review of this literature indicates that research on PM competences has been an important area of research focus over the past 17 years. We note that there is no common

agreement on a single set of PM competences (Nijhuis, 2015), nor is there clarity about PM competence importance across the project life cycle.

This wide-ranging body of literature has enabled us to consolidate and synthesise 20 PM competences across four competence dimensions (Le Deist and Winterton, 2005). This offers a more holistic approach to PM competence research and provides a foundation to address RQ1 and RQ2.

Research Method

We consolidate 20 PM competences across 4 competence dimensions in a 'theoretical' manner. Based on this, we aim to find out the 'empirical' evidence of the relative importance of PM competencies across the project life cycle. To fulfil the purpose of this study, a deductive and quantitative approach was adopted. We echo Crawford's argument that only a limited number of PM studies - mostly qualitative - have addressed the area of PM competence (Crawford, 2005). In regard to data collection, a survey method was used to collect project practitioners' perceptions who have had valuable extensive experiences (Erickson and Gutierrez, 2002) and the insights of members of the community of PM practice (Fisher, 2011); "the knowledge of practitioners and of research specialists must grow together in new ways" (Erickson and Gutierrez, 2002, pp. 23). Thus, we methodologically follow the significance of securing a synergised balance between the knowledge of practitioners and researchers.

Data Collection

We designed a web-based survey as our data collection instrument. The survey design consisted of two components. First, we used the 20 competences identified through the literature review. Second, eight software project life cycle stages (initiation; requirement analysis; planning; prototyping; analysis and design; implementation; test and transition; and

closing) were identified by reviewing life cycle models, standards and PM guides (Bennatan, 1995; IEEE Standard, 1997; IEEE/EIA, 1998; Royce, 1998; Jurison, 1999; OGC, 2009; Favaro, 2010; PMI, 2013). The survey had three sections (see appendix 1).

The first section aimed to address RQ1; to establish and validate the level of importance of each competence. To ensure a common understanding of terms we provided the definitions of the 20 competences and then asked participants to rate their level of importance on a six-point Likert scale from 1 (not at all important) to 6 (essential). This scale was adopted to minimise common method biases in terms of scale format (Podsakoff *et al*., 2003), and to reduce an error of central tendency (Blumberg *et al*., 2008).

The second section aimed to address RQ2 to identify and prioritise the five most important competences at each stage of the software project life cycle. To ensure a common understanding of project life cycle stages we provided information about key management activities at each life cycle stage. We then asked participants to select and rank the five most important competences at each stage of the software project life cycle.

The third section aimed to collect basic demographic information about the participants. The survey was designed to take no more than 15 minutes.

The survey was piloted to ensure clarity and coherence. Two software project managers, each with 20-year experience in the discipline, completed the survey and provided feedback on the content and structure. The survey was amended to clarify the definition of 'activity' in relation to each life cycle stage, and its structure and format to provide more coherence. The pilot participants reviewed the revised survey before the final version of the survey was administered.

Participants

The survey was administered during a two-month period to software project managers and practitioners with a minimum of one year of work experience. The web-based survey was distributed in two ways. First, the survey was sent as a web link via e-mail to more than 100 software project managers through one of the author's professional networks. Second, the survey web link was posted on the Project Management Institute's (PMI) project manager community pages and the discussion boards on PM communities. To increase the number of responses, reminders were sent and posted twice. Of the 82 responses received, 57 (22 female, 35 male) were fully completed, and these were the responses that we analysed. Anonymity of participants and their responses was maintained.

Over three-fifths of participants (63.1%) had software project experience of more than seven years; almost half (49%) were from South Korea; just under a third (30%) from the UK; and roughly a tenth each from India (10.5%) and from other countries (10.5%). Most participants (79%) had experience in managing software projects in the IT/IS industries and financial sectors, and nearly one third of participants were also in the area of telecommunication and the public sector. Over half of the participants (54.3%) are in a project manager role, while the remaining (45.7%) are in a practitioner role (analyst, consultant, system/software architect, programmer). Finally, a quarter of the participants have PM certification (e.g. PMP, PRINCE2, PROJECT+).

Perceived Importance of Project Management Competences (RQ1)

Figure 1 plots the average importance ratings of PM competences by participants for section 1 of the questionnaire. By and large, four competences received highest average scores of 5 or more. These are: 'managing risk & uncertainty' (5.23), 'planning' (5.12), 'leading' (5.05) and 'decision making' (5.04). While 'training and certification' and 'education background' were scored the lowest, receiving average scores between 3.00 and 4.00.

Aligned with the literature review, the twenty competences that were identified are categorised by four competence dimensions: cognitive, functional, social and meta competences. Among the four competence dimensions, functional competences tended to receive a higher score (average score = 4.87) compared to the other three competence dimensions. Functional competences include two of the top scoring competences such as 'managing risk & uncertainty' and 'decision making'.

The meta-competence dimension scored the second highest among the four dimensions (average score 4.74). Social competences scored the third highest among the four dimensions (average score = 4.63). With the 'leading' competence recording the highest score (5.05) in this dimension. Cognitive competences scored the third highest (average score = 4.31); these cover technical knowledge, PM process knowledge, training and certification, prior projects experience, educational background and planning competences. The competences in this dimension show wider variations relatively than competences in other dimensions.

[insert Figure 1 about here]

Relative Importance of Competences across the Project Life Cycle (RQ2)

Table 2 shows the relative importance of PM competences across the project life cycle stages. Participants identified and rank ordered (1-5) the most important competences for each project life cycle stage: initiation, requirements analysis, planning, prototyping, analysis and design, implementation, test and transition, and closing.

Analysis by Life Cycle Stages

Looking across the project life cycle, due to technological similarities across software projects, prior relevant project experience as well as long-term judicious thinking about how the project aims will be achieved is considered significant in the early stages. During the requirements analysis stage three competences were considered the most important:

'managing stakeholders', 'planning', and 'communicating'. Here the project managers build lines of communication and facilitate communication with the client and other stakeholders to capture and create a clear and comprehensive requirements statement.

During the planning stage, 'planning' and 'decision making' continue to be within the top competences; 'PM process knowledge' is also a high priority competence at this stage. Due to the specific characteristics of software projects, participants considered technical proficiency ('technical knowledge') as the most important competence for the next four stages: prototyping, analysis and design, implementation, and test and transition.

'PM process knowledge' and 'prior projects experience' are considered within the top three important competences of software PM during the prototyping stage. This can be due to the special features of prototyping activities, such as the role of input data in the success of prototyping process based on previous experience. 'Managing risk & uncertainty' are ranked second during the implementation and test and transition stages and third during the closing stage, as this is where the performance gaps between the previous stages start to become evident. During the closing stage of a project the relative priorities of competences change, so that 'negotiation' and 'managing stakeholders' are ranked among the top two competences.

[insert Table 2 about here]

Analysis by Competence Dimensions

To assess the relative importance of PM competences, we took the importance rating score (1-5 given by the survey participants) for each competence across the software project life cycle; then, the score was converted into a percentage. Figure 2 captures this where the X-axis represents the eight life cycle stages, and the values on the Y-axis represent the relative importance in percentage. Therefore, the higher the percentage score, the higher the relative importance of PM competence at a certain life cycle stage.

The cognitive competence dimension, relating as it does to acquiring PM knowledge and experience: technical knowledge, PM process knowledge, training and certification, prior projects experience, education background and planning. The 'technical knowledge' score increases by almost 50% between the planning and prototyping stage, and then decreases to between 50-60% for the following stages up to the test and transition stage. By contrast the knowledge about planning was considered more important than the other three competences during the first three stages of the project life cycle (initiation, requirements analysis and planning), peaking at planning (70%) and then declining to around 20% in the following two stages (prototyping and analysis and design) before tailing off in the last two stages (test and transition and closing).

The relative importance of 'PM Process knowledge' in the life cycle ranges from 10% to 40%, peaking during the planning and prototyping stages. The relative importance of 'prior projects experience' was recognised as significantly more important than the other two aspects (education background, and training and certification) across the project life cycle.

Previous project experience was considered as the most important at 45% during the initiation stage, with its importance decreasing to a range of between 23-34% up to the implementation stage, and further decreasing to under 20% in the last two stages of transition and testing and closing. 'Education background' and 'training and certification' show a continuous score below 6% across the whole project life cycle, that is relatively less important than other competences.

The second dimension (linked to decision making, strategic directiveness, managing risk & uncertainty, assembling the team, negotiating and informative power competences) can be considered as functional competences. The relative importance of decision-making competence fluctuates greatly across the software project life cycle. It peaks at between 30-

40% during the initiation, planning, analysis and design, and test and transition and closing (10-20%).

Another two competences, 'strategic directiveness' and 'managing risk & uncertainty', show the opposite tendency. 'Managing risk & uncertainty's score of around 10% during the initiation stage gradually increases during the following stages up to the test and transition stage, peaking at just under 50%, and then dropping slightly to just under 40% at the closing stage. 'Strategic directiveness' high score of 27% during the initiation stage slightly decreases during the three stages, and then shows a stable trend between 13-17% in the last stages.

'Assembling the team' has a marked variation during the planning stage (at around 20%) and its relative importance slightly decreases in the following stages. 'Negotiating' competence, at 45%, was recognised as being particularly important at the closing stage. 'Informative power's relative importance was perceived as being at its highest both at the early stages (requirements analysis) and middle stages; between the prototyping and implementation.

Third, the social competence dimension covers seven competences, and four of them show a relatively stable trend. The importance of 'leading' was rated more consistently (at 5-12%) across the project life cycle, increasing in perceived importance to between 15-27% at the last three stages. 'Managing stakeholders' is regarded as important during the initiation stage (31%), peaks at requirements analysis (47%) and then again at the closing stage (37%).

Competence in 'communicating', which is highly relevant for interactive relationships, generally tends to be perceived as of higher priority during the last stage of the software project life-cycle. The importance of 'communicating' increases to around 30% during the requirement analysis and closing stages.

Among the four other stable competences (cultural/social awareness, conscientiousness, emotional resilience and self-inspiration), 'conscientiousness' recorded exceptionally the high score of 11% at the closing stage. By contrast, 'cultural/social awareness' competence received higher scores during the early stages, initiation and requirement analysis. 'Cultural and social awareness' scored less than 8% across the whole life-cycle, but received relatively higher scores during the initiation and requirement analysis stages.

The fourth dimension, associated with 'managing self-knowledge' competence, can be seen as meta-competence. 'Managing self-knowledge' competence fluctuates below 20% across the software project life-cycle, decreasing during the planning and analysis and design stages and increasing during the prototyping and test and transition stages.

[insert Figure 2 about here]

Project Management Competence Development Opportunities

Through the analysis of twenty PM competences in four competence dimensions, competence development opportunities can be identified with clear evidence from the results. This section discusses three PM competence 'development opportunities' based on the analysis of cognitive, functional, social and meta competences.

As the first development opportunity, a considerable awareness by software project practitioners regarding the value of **PM education, training and certification** was found. The importance results of cognitive competences highlight a gap between the distinguishable level of importance between PM knowledge itself and a means of acquiring the PM knowledge. The questionnaire results show that the importance level of competences in terms of knowledge about software technology (technical knowledge), PM process (PM process knowledge) and planning was scored relatively higher than other cognitive and meta competences. In particular, possessing technical knowledge (cognitive) and managing

relevant self-knowledge (meta) were regarded as critical during the prototyping, test and transition stages due to the unusual nature of the software project life-cycle.

Compared to PM knowledge itself, however, the means of obtaining knowledge were rated significantly low across the project life-cycle such as training, certification and education background.

The gap between the perceived higher importance of PM knowledge and the lower importance of PM training seems paradoxical: PM education/training programmes are mainly composed of PM knowledge. This finding mirrors those identified by previous studies that there is a gap between PM training and practice (Wateridge, 1997; Thomas and Mengel, 2008; Egginton, 2010, 2012). Our practitioners perceive 'practice' in managing software projects as more significant than 'theory'. This should not come as a surprise and reflects the findings of Ramazani and Jergeas (2015), whose qualitative study points out that PM education and training systems need to be improved to prepare project managers on their journey from good to great. Furthermore, instead of the theoretical training and education, previous project experience was perceived to have more relevance to the tasks across the software project life cycle. Software project managers and practitioners in particular have more concern for the level of project relevance during the early project stage to maximise their management performance by drawing on previous PM experience. This finding echoes that of Stevenson and Starkweather (2010) with regard to IT projects more generally. Therefore, recognition of the value-added PM training, education and certification in a more substantive and practical way can be one of the competence development opportunities emphasised in this study.

The second competence development opportunity is related to the importance of continuous **risk management competence**. From the importance results of functional competences, we found that the relative importance of the 'managing risk & uncertainty' competence

significantly and consistently increases during the middle and last stages of software project. This is in contrast to what academic literature indicates. Theoretically, it is generally acknowledged that project risks are high at the early stage due to a high level of uncertainty and decrease as we progress through the lifecycle (Atkinson *et al.*, 2006; APM, 2012; PMI, 2013). However, responses from the participants gave us a different viewpoint. This interesting result from our empirical data indicates more understanding about how risks are managed across the life cycle in the sector or a misunderstanding in practice of the difference between the concepts of risk, problems and issues: this also leads to the need of negotiation skill for customer acceptance and satisfaction. 'Negotiating' competence also scored very high at the closing stage. This may imply that responding to the escalated risks through the early and middle stages or new risks during the systems test and transition stage is critical for the successful closing of project. Moreover, practitioners may consider negotiation competence during the last stage as one of critical abilities to minimise the project risks. Thus, this second opportunity refers to a need of developing on-going risk management competences in the long-term approach throughout the software project life-cycle.

Third, the importance of social and meta-competences can be another competence development opportunity. One noticeable finding is that there is a real need to diversify the concept of **PM leadership**. Normally, the existing context of PM leadership has tended to focus heavily on developing cognitive and functional competences (PMI, 2007, 2013; APM, 2012). However, the empirical evidence in this study emphasises the necessity of widening the context of leadership including social and meta aspects. Hence, and similarly to the first opportunity, the educational contents regarding PM leadership or executive management need to address more diverse PM competence development opportunities.

The relative importance of other social competences also shows a high dependency on certain life-cycle stages. Our empirical results indicate that the early and close-out stages of a

software project require the deployment of key competences, particularly with regard to the social aspects (e.g. managing stakeholders, communicating and leading), and this goes some way to addressing the critique by Havila *et al*. (2013) of previous research on project competence for focusing only on the early and middle stages of managing projects.

We also found that consensus with senior managers and many project stakeholders should be finalised based on a certain level of satisfaction and agreement (managing stakeholders); again, this reflects findings from other research (e.g. Henderson, 2004, 2008; Havila *et al.,* 2013).

Conclusion

The aim of this study was to analyse the perceived relative importance of PM competences across the life cycle in a software project environment.

The two research questions addressed were: 1) what is the perceived level of importance of existing project management competences for managing software projects? and 2) what is the level of prioritisation of PM competences across the software project life cycle?

To answer these questions, previous literature addressing individual competences for managing projects was extensively reviewed; twenty PM competences were identified. Survey responses from 57 software project managers and practitioners were collected, and the perceived level of importance of each of the 20 competences was identified. A relative importance analysis was also carried out.

As a result, we identified current PM competence development gaps and opportunities (i.e. perceived gaps from software project practitioners' expectations regarding PM education, training and certification, risk management strategy in the long-term approach, diversification of PM leadership).

This study makes original contributions. First, a set of 20 PM competences within four competence categories was identified and they were prioritised based on their relative importance across the life cycle stages. This draws our attention to the significance of inter-relationship between PM competences and project life cycle.

Moreover, perceived PM competence deployment gaps were highlighted to suggest possible competence development opportunities. For instance, a theoretical understanding of PM knowledge was rated as one of the most important competences to managing software projects; the completion of relevant education and training was identified as the least important one. This appears to be something of a paradox, since the main contents of PM education and training usually comprise theories, and abstract or conceptual ideas.

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Appendix 1. Sample Questionnaire Items

Section	Topic and Question	Response Range	Note
1. (Q1-Q20)	Importance of Competences Please read and familiarise yourself with the meaning of each project management competence. Please rate the importance of each competence in managing software projects.	6-point scale: - Not at all important - Less important - Important - Very important - Extremely important - Essential	Along with the questions, the definitions of each competence were provided.
2. (Q21-Q28)	Competence Prioritisation Read and familiarise yourself with the eight Stages of software project life cycle and related key management activities. For each stage, select and rank order top five competences from 20 competences (i.e. Rank 1 is the most important competence in your own recognition).	Short-answer questions: - Rank 1 - Rank 2 - Rank 3 - Rank 4 - Rank 5	Along with the question, the definitions and a sample set of key management activities of each life cycle stage were provided.
3. (Q29-Q36)	Demographics 29. What is your gender? 30. Which category below includes your age? 31. How long have you been experienced in software/IT projects? 32. Have you been certified in a project management license or training? 33. State the country you currently work in as a software/IT project manager. 34. In which industry have you carried out software/IT projects? (multiple) 35. What types of projects have you experienced the most? 36. What is your current role in software projects?	Short-answer questions	Demographic information

Prioritising Project Management Competences across the Software Project Life Cycle

Tables

Table 1. Twenty project management competences in four competence dimensions

Dimensions	Cognitive	Functional	Social	Meta
Project management competences	• Technical Knowledge • PM Process Knowledge • Training and Certification • Prior Projects Experience • Education Background • Planning	• Decision Making • Strategic Directiveness • Managing Risk and Uncertainty • Assembling the Team • Negotiating • Informative Power	• Leading • Managing Stakeholders • Communicating • Cultural/Social Awareness • Conscientiousness • Emotional Resilience • Self-inspiration	• Managing Self-knowledge

Table 2. Relative importance of top-five project management competences across the life cycle

Rank	Initiation	Requirement Analysis	Planning	Prototyping	Analysis and Design	Implementation	Test and Transition	Closing
#1	Prior Projects Experience	Managing Stakeholders	Planning	Technical Knowledge	Technical Knowledge	Technical Knowledge	Technical Knowledge	Negotiating
#2	Decision Making	Planning	PM Process Knowledge	PM Process Knowledge	Decision Making	Managing Risk & Uncertainty	Managing Risk & Uncertainty	Managing Stakeholders
#3	Planning	Communicating	Decision Making	Prior Projects Experience	Prior Projects Experience	PM Process Knowledge	PM Process Knowledge	Managing Risk & Uncertainty
#4	Managing Stakeholders	PM Process Knowledge	Managing Risk & Uncertainty	Informative Power	Managing Risk & Uncertainty	Prior Projects Experience	Managing Stakeholders	Communicating
#5	Strategic Directiveness	Prior Projects Experience	Prior Projects Experience	Managing Risk & Uncertainty	PM Process Knowledge	Leading	Managing Self-knowledge	Leading

Prioritising Project Management Competences across the Software Project Life Cycle

Figures

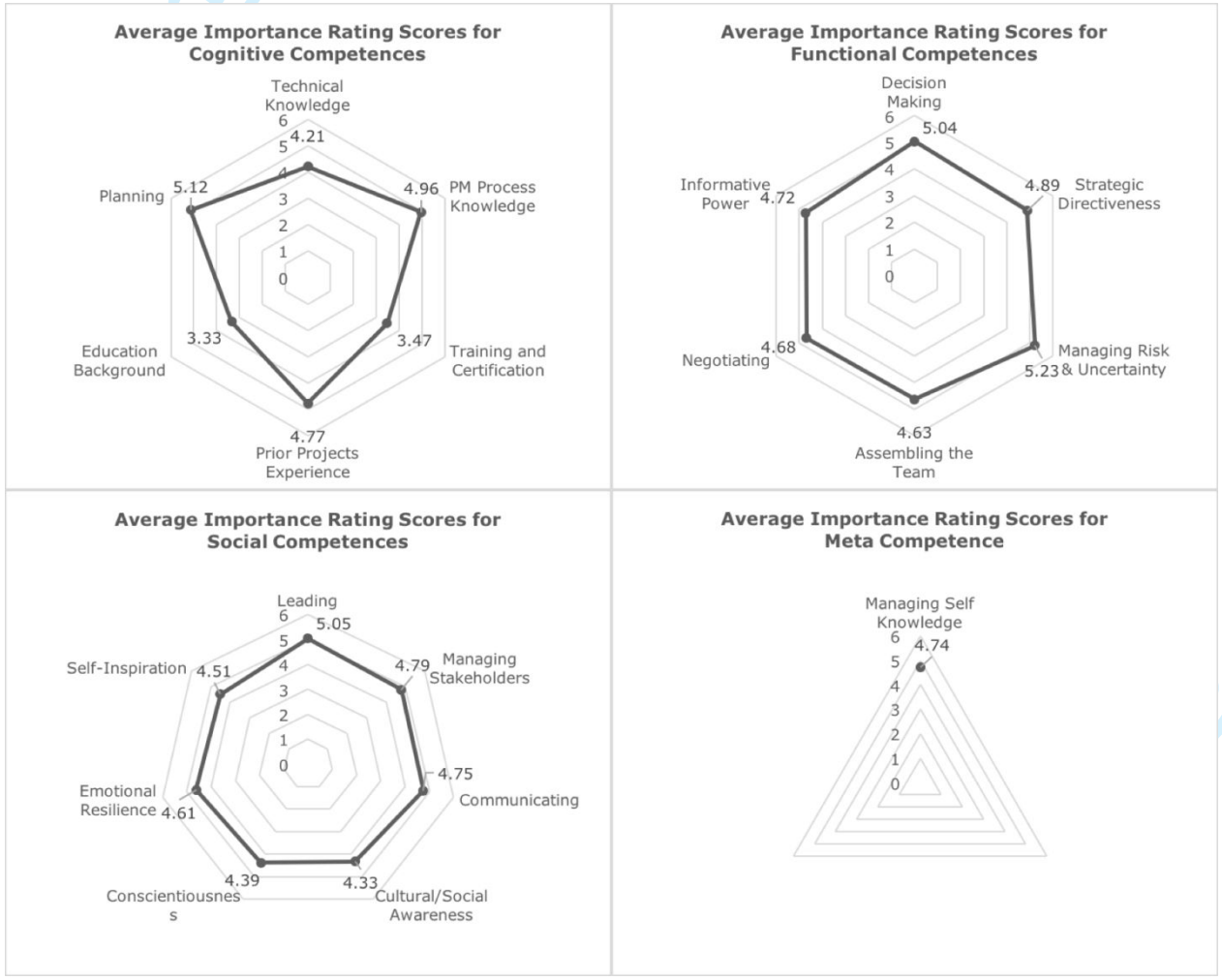

Figure 1. Importance rating scores of project management competences

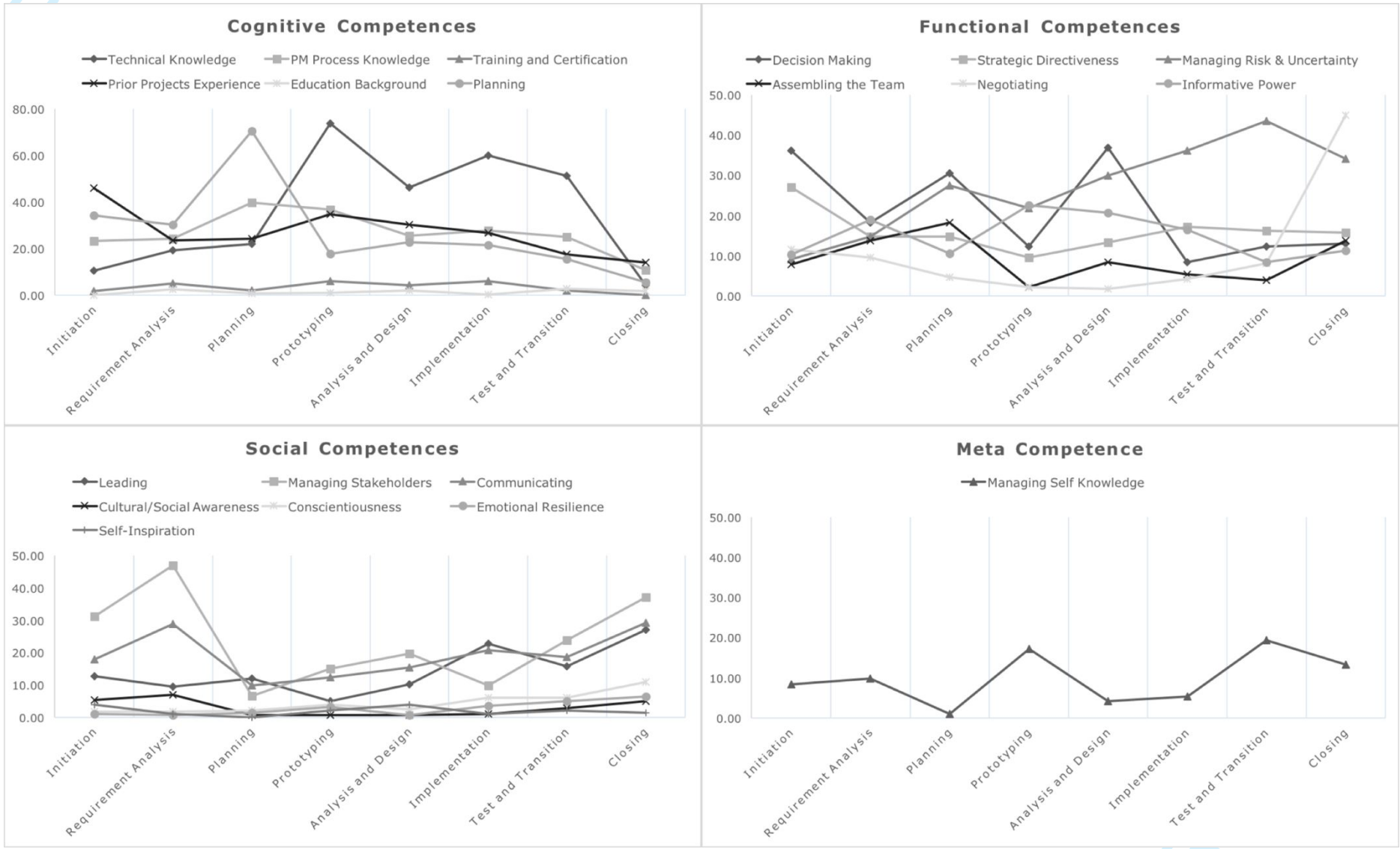

Figure 2. Relative importance of project management competences across the software project life cycle