

AN ONTOLOGY-BASED KNOWLEDGE MANAGEMENT FRAMEWORK FOR PERFORMANCE IMPROVEMENT OF CONSTRUCTION PROJECT MANAGERS

V. Paul Christopher Charlesraj
Ph.D Scholar

Satyanarayana N. Kalidindi
Professor

Building Technology and Construction Management Division
Department of Civil Engineering
Indian Institute of Technology Madras
Chennai 600036 India
paul@iitm.ac.in satyakn@iitm.ac.in

Abstract: 'Knowledge Management' (KM) is a promising business management concept that is gaining wide acceptance and is being implemented in various sectors to achieve improved level of performance and competence. Project management competence is one of the most significant criteria upon which the project performance is dependent on. Further, effective project management relies on the project manager's competency and authority. Construction Project Managers (CPManagers) play a key role in the success of a construction project. Assessment and improvement of the Skill, Knowledge, and Competency (SKC) levels of CPManagers will be valuable to CPManagers as well as the organisation. Selection and allocation of suitable CPManagers to projects is a challenging issue. An ontology-based KM framework for performance improvement of CPManagers has been proposed. Ontology of SKC of CPManagers, Construction Projects, and KM Tools constitute the knowledge component. Various elements of competence that are required for CPManagers have been identified.

Keywords: *Project manager, Performance improvement, Knowledge management, Ontology.*

1. INTRODUCTION

With the construction industry becoming more information and knowledge intensive, it has become essential for construction organisations to manage the knowledge embedded in the construction business processes to remain competitive. 'Knowledge Management' (KM) is a promising business management concept that is gaining wide acceptance and is being implemented in various sectors to achieve improved level of performance.

Project management competence is one of the most significant criteria upon which the project performance is dependent on. Further, effective project management relies on the project manager's competency and authority. Construction Project Managers (CPManagers) play a key role in the success of a construction project. They are one of the important knowledge resources in a construction organisation. Assessment and improvement of the Skill, Knowledge, and Competency (SKC) levels of CPManagers will be valuable to CPManagers as well as the organisation.

Selection and allocation of suitable CPManagers to projects is a challenging issue. The SKC of a perfect CPManager for a given project has to be defined based on project characteristics and environmental variables. The CPManagers having SKC close to the defined target level also have to be identified. This requires a systematic procedure for the assessment of SKC levels of available CPManagers. A hybrid approach that combines the assessment of personal qualities (input-oriented;

macro-level; person-oriented) as well as the functional analysis (output-oriented; micro-level; task-oriented) is appropriate for the realistic assessment. The objective of this paper is to present the proposed conceptual model, which is an ontology-based KM framework for performance improvement of CPManagers.

2. LITERATURE REVIEW

A brief review of literature related to the role of CPManagers in the performance of construction projects, competency development of project managers, KM in construction, and ontologies in KM systems is presented in this section.

2.1 Construction Project Performance – Role of CPManagers

Various attempts have been made by researchers to identify critical success factors (CSF) in construction. A review related to CSFs in construction revealed that a number of variables influencing project success can be grouped under five main categories, viz., human-related factors, project-related factors, project procedures, project management actions, and external environment [1]. To achieve a successful project delivery the project manager should fulfill a number of roles including those of facilitator, coordinator, motivator, and politician. However, the review of literature suggests that attention paid to the development of appropriate performance measures for project managers is marginal [2].

2.2 Competency Development of Project Managers

There are two main approaches for the assessment of competency of managers, one originated from USA and the other from UK [3],[4]. The former approach deals with the personal qualities of the managers that means input-oriented and a macro level approach. The UK-originated approach is task-oriented (output-oriented) involving functional analysis at micro level. Both the approaches are complementary to each other. The Project Management Institute (PMI) has come up with a generic framework for competency development of project managers [5]. Several factors influencing the performance of CPManagers were reported [2],[6],[7],[8]. There is a need for a holistic approach for the performance framework of project managers [9].

2.3 KM in Construction

The applicability and usefulness of KM in construction has been researched in strategic management of construction [10], general construction project management [11],[12], knowledge discovery from construction databases [13] and corporate memory for construction [14].

2.4 Ontologies and KM Systems

Ontology is an explicit specification of a conceptualisation [15]. Maedche et al. [16] proposed integrated enterprise-KM architecture for implementing an Ontology-based KM System (OKMS). Distributed ontology

architecture for KM in highway construction has been proposed by El-Diraby & Kashif [17].

The research efforts in the field of KM in construction are limited. With KM showing promise to improve the organisational performance and limited attention paid to the development of appropriate system for performance measure of CPManagers, there is a need for investigating the role of KM in the performance improvement of the CPManagers.

3. FRAMEWORK DESCRIPTION

The concept map that illustrates the proposed ontology-based KM framework for performance improvement of CPManagers is presented in Figure 1. The ontology of SKC of CPManagers, Construction Projects, and KM Tools constitute the knowledge component. These ontologies represent the body of knowledge in their respective domains. They also turn out to be the standard vocabulary that makes possible a common understanding among the personnel in the organisation, which prevent ambiguity.

The objective is to identify the CPManager with right SKC for the project at hand. It involves the assessment of the SKC of the available CPManagers as well as defining the target SKC to successfully manage the project in hand. By mapping the current SKC level to the target SKC (which has been arrived at based on the project specifications,

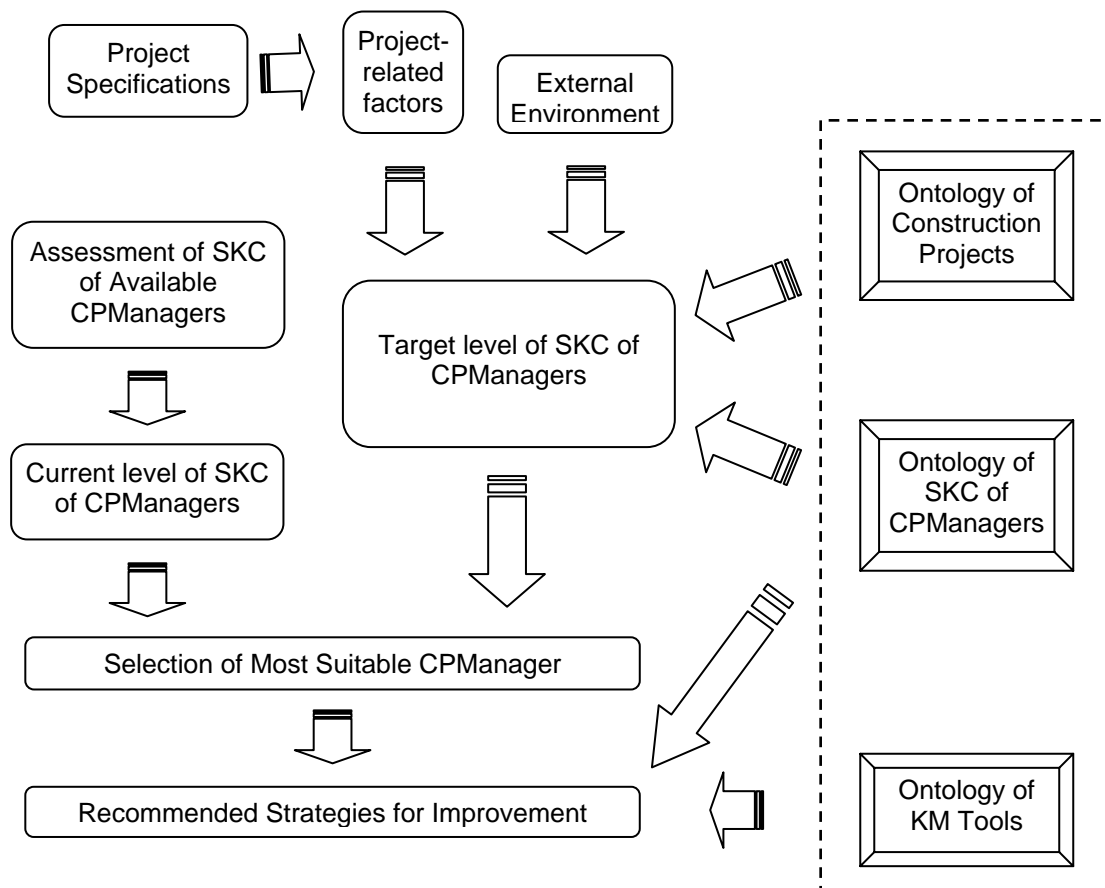


Figure 1. Concept Map of Proposed Framework

external environment and the ontology of SKC of CPManagers) one can select the CPManager with the best possible combinations of SKC required to successfully complete the project. As it is near impossible to identify the ideal CPManager for a given project, it is possible to enhance the SKC level of the best CPManager among those available through KM.

3.1 Elements of Competence for CPManagers

The elements of competence required for CPManagers have been identified using the PMI's framework for competency development of project managers [5] as the basis. To be recognized as fully competent, an individual would need to be evaluated successfully against each of the following three dimensions:

- a) *Project Management Knowledge* - The knowledge and understanding that a project manager bring to a project or project-related activity (The knowledge component of competence)
- b) *Project Management Performance* - The ability of individual project managers to perform project management activities to the levels of performance expected
- c) *Personal Competency* - The core personality characteristics underlying a person's capability to do a project or project activity.

Project management competence elements (61 nos. given in Appendix A) have been identified and organized into nine units of competence, which are nine knowledge areas of project management as defined in PMBOK (Project Management Body of Knowledge) [18]. The nine project management knowledge areas are:

- (i) Project Integration Management
- (ii) Project Scope Management
- (iii) Project Time Management
- (iv) Project Cost Management
- (v) Project Quality Management
- (vi) Project Human Resources Management
- (vii) Project Communications Management
- (viii) Project Risk Management
- (ix) Project Procurement Management

They are also grouped under five clusters of competence based on the five project management process groups (viz. Initiating, Planning, Executing, Controlling and Closing).

Personal competence elements (40 nos. given in Appendix B) have been identified and grouped under six units of competence, namely, (i) Achievement and Action, (ii) Helping and Human Service, (iii) Impact and Influence, (iv) Managerial, (v) Cognitive, and (vi) Personal Effectiveness. They are also organized under 2 to 4 clusters per unit.

Each of these competency elements have been identified with a set of attributes, namely, ElementID, Unit of Competence, Cluster of Competence, Performance Criteria, and Assessment Guidelines. A snapshot of the structure of a

competency element is shown in Figure 2 as implemented in Protégé [19].

3.2 Ontology of KM Tools

Similarly, a list of KM tools has been identified. They are classified as KM Technologies and KM Techniques based on the use of Information & Communication Technology (ICT). ICT-based tools are classified as KM Technologies and the non-ICT-based tools as KM Techniques. The KM sub-processes (Locate, Capture, Represent, Share, and Create), where these tools are applicable and the knowledge domains (Transfer, Ownership and Conversion) they belong to were identified. A knowledge mapping of current-desired state of these three domains, Transfer (Internal/External), Ownership (Individual/Group) and Conversion (Implicit/Explicit) has been done. This mapping will be helpful in deciding on the strategies for improving current SKC level to target level. The ontology of the KM Tools has been implemented using Protégé [19]. The class hierarchy of the KM Tools ontology can be found in Figure 3.

The ontology of the KM Tools defines and describes various KM tools that can be adopted in different contexts to achieve specific KM objectives. It forms the knowledgebase of the proposed KMS prototype along with the ontology of SKC of CPManagers. It has been proposed to define the target level of SKC of CPManagers by considering the current project characteristics and the external environment. The factors to be considered have been identified. The ontology of SKC of CPManagers will facilitate this process.

3.3 Competency Assessment of CPManagers

An approach for the 360 degree evaluation and assessment of project management as well as personal competency of CPManagers is being developed. It is being developed as a hybrid approach of USA and UK-based approaches as discussed in the literature review.

It has been proposed to define the target level of SKC of CPManagers by considering the current project characteristics and the external environment. The factors to be considered have been identified. The ontology of SKC of CPManagers and ontology of Construction Projects will facilitate this process. An algorithm is to be proposed for recommending KM strategies for improvement of performance of CPManagers based on current & target level of competence with the aid of ontology of SKC and KM tools.

The implementation of the proposed ontology-based KM framework is an ongoing project. A pilot survey shall be conducted to refine and finalise the elements of competence. Behaviourial Event Interviews shall be conducted for the assessment of SKC of CPManagers. The entire framework will be tested using case study approach.

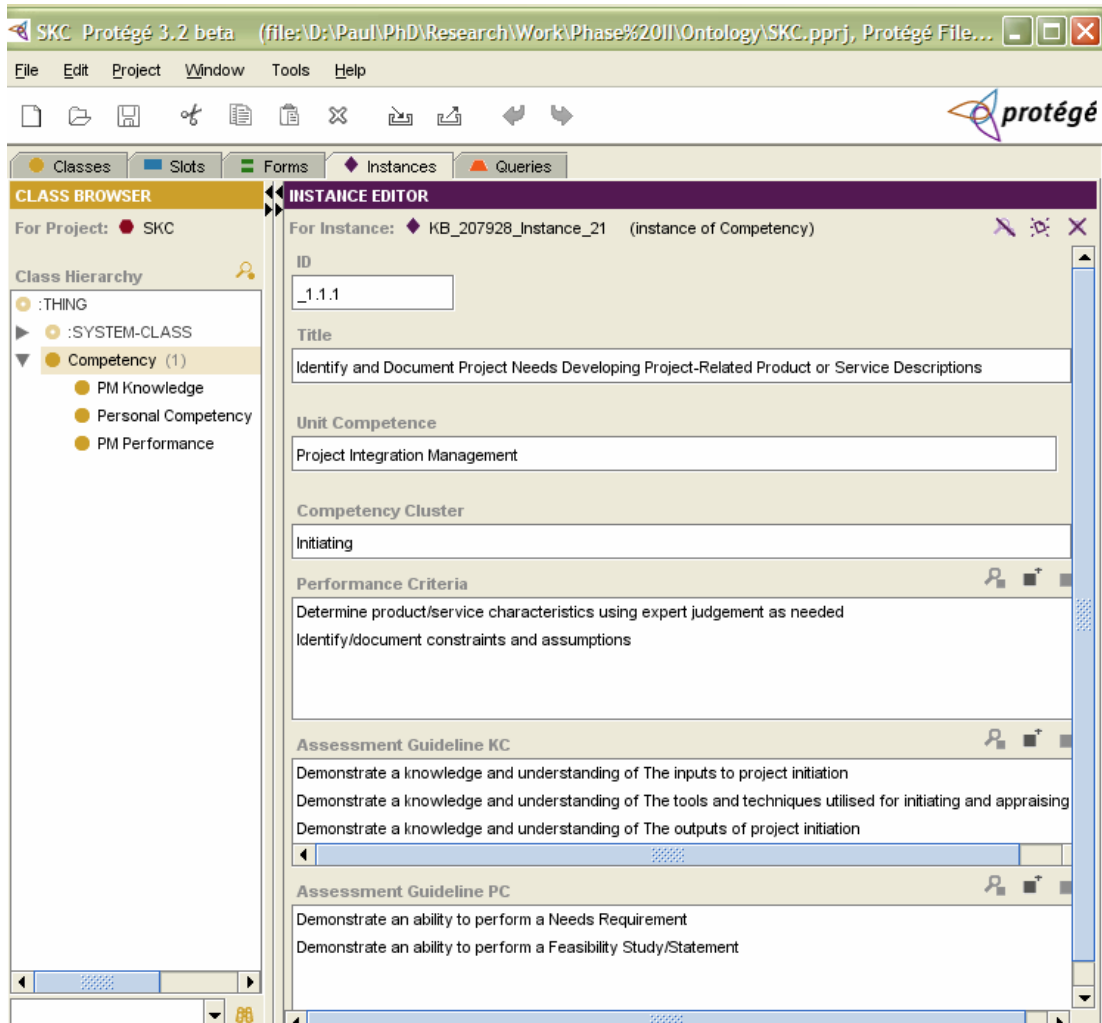


Figure 2 Sample Element of Competence

4. SUMMARY

Selection and allocation of suitable CPManagers to projects is a challenging issue. An ontology-based KM framework has been presented for the performance improvement of CPManagers. Implementation of this framework in a construction organisation can improve the effectiveness & efficiency of the CPManagers and also it provides a solid platform for recruitment, training, self-learning and personal career development of CPManagers.

REFERENCES

- [1] Chan, A. P. C., Scott, D. and Chan, P. L. (2004). "Factors affecting the success of a construction project." *ASCE Journal of Construction Engineering and Management*, 130(1), 153-155.
- [2] Dainty, A. R. J., Cheng, M. and Moore, D. R. (2003). "Redefining performance measures for construction project managers: an empirical evaluation." *Construction Management and Economics*, 21(2), 209-218.
- [3] Cheng, M., Dainty, A. R. J. and Moore, D. R. (2003). "The differing faces of managerial competency in Britain and America." *The Journal of Management Development*, 22(6), 527-537.
- [4] Dainty, A. R. J., Cheng, M. and Moore, D. R. (2005). "Competency-based model for predicting construction project managers' performance." *ASCE Journal of Management in Engineering*, 21(1), 2-9.
- [5] PMI (Project Management Institute) (2002). "Project management competency development framework." *Project Management Institute*, Pennsylvania, USA.
- [6] Dainty, A. R. J., Cheng, M. and Moore, D. R. (2004). "A competency-based performance model for construction project managers." *Construction Management and Economics*, 22(8), 877-886.
- [7] Egbu, C. O. (1999). "Skills, knowledge and competencies for managing construction refurbishing works." *Construction Management and Economics*, 17(1), 29-43.
- [8] Edum-Fotwe, F. T. and McCaffer, R. (2000). "Developing project management competency: perspectives from the construction industry."

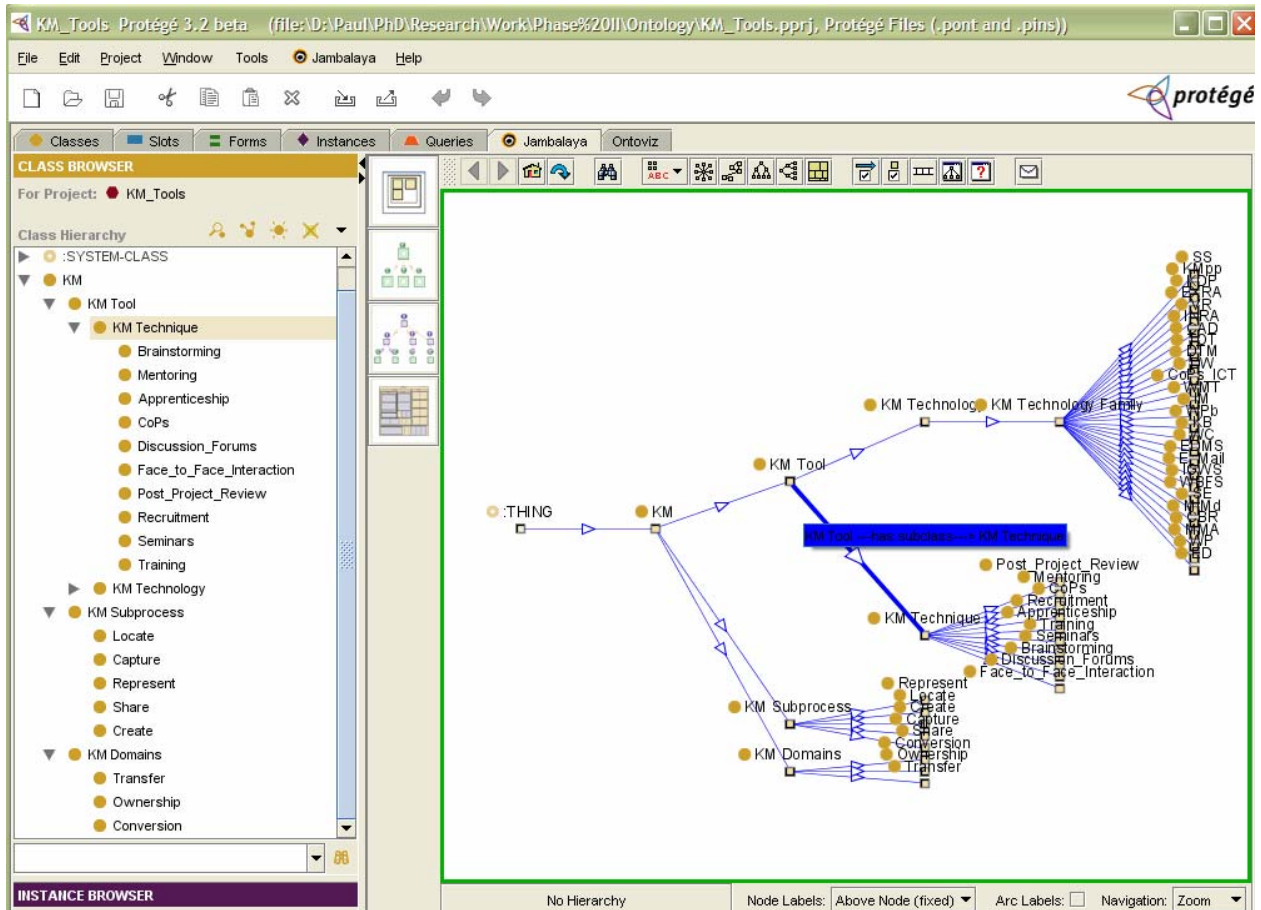


Figure 3 Class Hierarchy in KM Tools Ontology

International Journal of Project Management, 18, 111-124.

- [9] Cheng, M.-I., Dainty, A.R.J., and Moore, D.R. (2005). "Towards a multidimensional competency-based managerial performance framework: A hybrid approach." *Journal of Managerial Psychology*, 20 (5), 380-396.
- [10] Carrillo, P. M., Robinson, H. S., Anumba, C. J. and Al-Ghassani, A. M. (2003). "IMPaKT: A framework for linking knowledge management to business performance." *Electronic Journal of Knowledge Management*, 1(1), 1-12.
- [11] Whelton, M., Ballard, G., and Tommelein, I. D. (2002). "A knowledge management framework for project definition." *Electronic Journal of Information Technology in Construction, ITCON*, 7, 197-212.
- [12] Wetherill, M., Rezgui, Y., Lima, C., and Zarli, A. (2002). "Knowledge management for the construction industry: The e-COGNOS project." *Electronic Journal of Information Technology in Construction, ITCON*, 7, 183-196.
- [13] O'Brien, W. J., Issa, R. R. A. Hammer, J., Schmalz, M. S., Geunes, J. and Bai, S. X. (2002). "SEEK: Accomplishing enterprise information integration across heterogeneous sources." *Electronic Journal of Information Technology in Construction, ITCON*, 7, 101-124.
- [14] Ribeiro, F. L. (2000). "Toward a technology for corporate memories in construction." *Proceedings of the International conference of CIB W78 on Construction Information Technology 2000*, Reykjavik, Iceland, 28-30 June.
- [15] Gruber, T. (1993). "A translation approach to portable ontologies." *Knowledge Acquisition*, 5(2), 199-220.
- [16] Maedche, A., Motik, B., Stojanovic, L., Studer, R. and Volz, R. (2003). "Ontologies for enterprise knowledge management." *IEEE Intelligent Systems*, 18(2), 26-33.
- [17] El-Diraby, and Kashif, K. F. (2005). "Distributed ontology architecture for knowledge management in highway construction." *ASCE Journal of Construction Engineering and Management*, 131(5), 591-603.
- [18] PMI (Project Management Institute) (2000). "A Guide to the Project Management Body of Knowledge (PMBOK Guide) - 2000 edition." *Project Management Institute*, Pennsylvania, USA.
- [19] The Protégé (2006). "The Protégé; Ontology Editor and Knowledge Acquisition System." <<http://protege.stanford.edu>>, last visited 24 Feb 2006.

Appendix A

Elements of Project Management Competence

1. Identify and document project needs developing project-related product or service descriptions
2. Perform an initial project feasibility study and analysis
3. Conduct project plan development
4. Conduct project plan execution
5. Conduct integrated change control
6. Conduct project closure with regard to integration
7. Prepare project charter
8. Conduct scope planning
9. Conduct scope definition
10. Execute scope
11. Conduct scope verification
12. Conduct scope change control
13. Conduct Project closure with regard to scope
14. Preliminary planning activities
15. Conduct activity definition
16. Conduct activity sequencing
17. Conduct activity duration estimation
18. Conduct schedule development
19. Implement project schedule
20. Conduct schedule control
21. Conduct project closure with regard to time
22. High-level budget development preparation
23. Conduct resource planning
24. Conduct cost estimating
25. Conduct cost budgeting
26. Execute cost baseline
27. Conduct cost control
28. Conduct project closure with regard to cost
29. Determine quality requirements
30. Conduct quality planning
31. Conduct quality assurance
32. Conduct quality control
33. Conduct project closure with regard to quality
34. Conduct organisational definition
35. Conduct organisational planning
36. Conduct staff acquisition
37. Conduct team development
38. Manage HR
39. Conduct project closure with regard to HRM
40. Preliminary communications planning
41. Conduct communications planning
42. Conduct information distribution
43. Conduct project performance reporting
44. Conduct administrative closeout
45. Conduct preliminary risk planning
46. Develop risk management plan
47. Conduct risk identification
48. Conduct qualitative risk analysis
49. Conduct quantitative risk analysis
50. Conduct risk response planning
51. Execute risk response plan
52. Conduct risk monitoring and control
53. Conduct project closure with regard to RM
54. Preliminary procurement planning
55. Conduct procurement planning
56. Conduct solicitation process
57. Conduct solicitation

58. Conduct source selection/contract development
59. Conduct contract administration
60. Manage and review contract performance
61. Conduct contract closeout

Appendix B*Elements of Personal Competence*

1. Operates with intensity to achieve project goals
2. Motivates project stakeholders in a positive way
3. Provides new solutions in planning and developing strategies
4. Operates with individual integrity and personal professionalism
5. Manages projects in an ordered, accurate way
6. Provides accurate and truthful information
7. Takes initiative when required
8. Takes accountability for and delivers project
9. Seeks new opportunities
10. Strives for best practice
11. Ensures information used to manage project is complete and accurate
12. Represents the client inside the project
13. Takes initiatives to provide excellent client service
14. Strives to understand all project stakeholders' thoughts, feelings, and concerns
15. Listens and responds to others
16. Takes appropriate actions to influence others
17. Influences across projects and organisations
18. Understands and influences project team members
19. Understands the organisation
20. Understands the project
21. Builds and maintains suitable relationships with project stakeholders
22. Establishes and maintains at the right level inside and outside the organisations
23. Builds team orientation within the project
24. Molds core project stakeholders into a team
25. Undertakes team-building activities
26. Builds a project culture where personal development is encouraged
27. Develops project members to effectively build project culture
28. Demonstrates leadership of the project
29. Leads the project team
30. Uses assertiveness when necessary
31. Manages the complete project
32. Understands at a suitable level all issues associated with the project
33. Facilitates solutions across all issues related to the project
34. Sees the project in a holistic way
35. Maintains self-control
36. Creates an environment of confidence
37. Accepts failure positively
38. Changes to meet the needs of the project
39. Changes at the require pace
40. Demonstrates commitment to the project