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A construction project management knowledge model: The type and level of knowledge required

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Abstract

Construction project managers come from diverse backgrounds and may, therefore, lack the knowledge set currently required in order to be competent and effective in practice. The aim of this article is to establish the National Qualifications Framework (NQF) level of each type of knowledge area required for a competent and effective construction project manager in South Africa. These levels of knowledge are important, in order to develop a proposed construction project management knowledge model to be used by the construction industry. A mixed methods research design was used, including structured questionnaires (n = 40), interviews (n = 10), and a single case study. The questionnaire survey, using close-ended questions measured on a 5-point Likert scale, tests the importance of and rated the NQF qualification levels of each knowledge type fit for project managers in the built environment. The rating assisted in knowing to what knowledge depth project managers need to be educated and trained. Interviews were conducted with 10 construction professionals to obtain their views on the importance of industry-specific knowledge of a construction project manager and to critically review the form of knowledge considered essential. The case study of a building project to the value of R35 million was used to gain understanding of the impact that industry-specific knowledge, or the lack thereof, may have on the successful completion of a project. Results showed that qualifications to gain industry-specific knowledge should at least be on NQF level 6; a qualification on NQF level 7 is recommended to gain adequate project management knowledge (theory). These findings are important, as some construction project management courses in

South Africa are currently below NQF level 6. This may be contributing to industry not producing construction project managers with the required knowledge set. The proposed model outlines the adequate knowledge sets and level thereof that can be used when designing training and educational degrees for construction project managers. The proposed model could also be used in practice as a guideline for placing or promoting construction project managers.

Keywords: Construction project management, knowledge model, type of knowledge, NQF knowledge level, South Africa

Abstrak

Konstruksieprojekbestuurders kom van uiteenlopende agtergronde, en mag dus die kennisstel kort wat tans benodig word om vaardig en effektief in die praktyk te wees. Die doel van hierdie artikel is om die Nasionale Kwalifikasieraamwerk (NKR)-vlak van elke tipe kennisarea vas te stel wat benodig word vir 'n bevoegde en effektiewe bouprojekbestuurder in Suid-Afrika. Hierdie vlakke van kennis is belangrik om 'n voorgestelde konstruksieprojekbestuur-kennismodel te ontwikkel wat deur die konstruksiebedryf gebruik kan word. 'n Gemengde metodes navorsingsontwerp is gebruik, insluitend gestruktureerde vraelyste (n = 40), onderhoude (n = 10) en 'n enkele gevallestudie. Die vraelys-opname deur middel van geslote vrae het die belangrikheid van en gegradeerde NKR-vlakke van elke kennissoort geskik vir projekbestuurders in die beboude omgewing, gemeet op 'n 5-punt Likert-skaal. Die gradering het gehelp om te weet tot watter kennisdiepte projekbestuurders opgelei moet word. Onderhoude is gevoer met 10 konstruksiewerknemers om hul standpunte oor die belangrikheid van bedryfspesifieke kennis van 'n konstruksieprojekbestuurder te verkry en om die vorm van kennis wat noodsaaklik beskou word, krities te hersien. Die gevallestudie van 'n bouprojek ten bedrae van R35 miljoen is gebruik om begrip te kry van die impak wat bedryfspesifieke kennis, of die gebrek daarvan, op die sukses van 'n projek kan hê. Resultate het getoon dat kwalifikasies om bedryfskennis te verkry, ten minste op NKR-vlak 6 moet wees; 'n kwalifikasie op NKR-vlak 7 word aanbeveel om voldoende projekbestuurskennis (teorie) te verkry. Hierdie bevinding is belangrik aangesien sommige konstruksieprojekbestuurskursusse in Suid-Afrika tans laer as NKR-vlak 6 is. Dit kan bydra daartoe dat die industrie tans konstruksieprojekbestuurders sonder die vereiste kennisstel in diens neem. Die voorgestelde model beskryf die toereikende kennisstelle en vlak daarvan wat gebruik kan word by die ontwerp van opleidingskwalifikasies vir konstruksieprojekbestuurders. Die voorgestelde model kan ook in die praktyk gebruik word as riglyn om konstruksieprojekbestuurders te plaas of te bevorder.

Sleutelwoorde: Konstruksieprojekbestuur, kennismodel, NKR-kennisvlak, tipe kennis, Suid-Afrika

1. Introduction

The *PMI Pulse of the Profession* highlighted that the high cost of low performance resulted in organisations, globally, wasting US\$122 billion for every US\$1 billion spent on projects, due to poor project management. Organisations that use formal project management practices waste 13 times less money than organisations that do not (PMI, 2016).

The built environment is project driven, and to meet organisational aims and reach higher profits, these projects need to be completed as efficiently as possible (Rad & Levin, 2006: 1; Trebilcock, 2007: 40). In the built environment, project management is used to produce better projects, and speed up the operational process (Morrison & Brown, 2004: 73-74). To manage projects successfully, organisations use project managers with the necessary knowledge about techniques that are used to ensure successful management of projects (Burke, 2013: 1-5; Chordas, 2008: 66-69; Kerzner, 2013: 2-10; PMI, 2016).

Organisations in the built environment rely heavily on the proficiency of construction project managers (Orr, 2004: 1). Therefore, project managers cannot merely rely on experience, but they need, not only adequate knowledge, but also the correct knowledge set, in order to be competent and effective in managing projects (Craig, 2005: 42). As the market place is highly competitive, organisations in the built environment will benefit in knowing what type of knowledge construction project managers require and to what level it should be (Peterson, 2008: 38-42).

A literature review identified some knowledge management models for project management (Piraquive, García & Crespo, 2015; Yeong & Lim, 2010; Handzic & Durmic, 2010), but a specific model for project managers in the construction industry may not exist.

A proposed construction project management knowledge model may fill the void for a model that can be used by construction project managers as a possible enhancement tool for improved project management knowledge sets. A literature study clarified the type of knowledge project managers should have, as well as the level thereof based on the NQF scope of knowledge classification. This clarification was important to highlight some elements within the knowledge areas as well as the NQF level of knowledge classification that may contribute to the design of the proposed model.

In order to determine the elements needed to design the model, a mixed methods research study design was used to test the importance of NQF levels of knowledge for project managers in the built environment from not important to critically important. Interviews with construction professionals determined their views on the importance of industry-specific knowledge of a construction project manager. The case study of a building project was used to gain understanding of the impact that industry-specific knowledge and experience may have on the success of a project.

Based on the findings, the knowledge expected from project managers was grouped into NQF level 6 (technical knowledge) and NQF level 7 (project management knowledge theory), which together with knowledge gained through experience form the main basis of the proposed model.

2. Literature review

2.1 Type of knowledge

An effective project manager needs to have project management knowledge (Pacelli, 2004: 54; Sumner & Powell, 2013: 2; Udo & Koppensteiner, 2004); technical (industry) knowledge and experience (Kerzner, 2013: 9-1; Petterson, 1991: 99). A combination of these knowledge areas is essential, in order to effectively manage a project (Burger, Verster & Zulch, 2015: 69). To understand the importance of the type of knowledge within the proposed model, it is important to determine and define project management knowledge (theory), technical (industry) knowledge and experience that are considered in project management.

2.1.1 Project management knowledge (theory)

A successful project needs to be completed within time, cost and quality and according to the agreed upon scope. Some organisations fail to realise that having staff, time and money is not enough to ensure success. Some important factors to accomplish this are effective project planning, management, and control (Chordas, 2008: 66-69; Kerzner, 2013: 2-10). Having project management tools and techniques is important, in order to plan. Planning is important, in order to manage a project within time, cost, and quality parameters. By implication, integrated knowledge is required to have an understanding of, and an ability to apply and evaluate the key terms, concepts, facts, principles, rules and theories of project management to other fields, disciplines or practices (e.g., engineering) in the construction industry (Longman & Mullings, 2005: 5; Kerzner, 2013: 2-10). Project management is regulated by professional bodies, one of which is the Project Management Institute (PMI). The PMI has published a knowledge guide known as the PMBOK guide stipulating the key terms, concepts, facts, principles, and rules of project management areas.

The nine generic project management areas include integration, scope, time, cost, quality, human resources, communication, risk, and procurement. In addition to the nine PMBOK knowledge areas

that are generic, the PMI have identified four additional areas known as the *Construction Extension to the PMBOK* that are industry specific, namely safety management, environmental management, claims management, and financial management (PMI, 2015; Burger *et al.*, 2015: 53). The purpose of the *Construction Extension* is to improve the efficiency and effectiveness of the management of construction projects. The focus of this study is on NQF level qualifications. The 13 project management areas are only introduced and not discussed in this article.

2.1.2 Technical (industry) knowledge

A project manager must have detailed technical knowledge of the main areas of project management, in order to accurately understand and apply the key terms, concepts, facts, principles, rules, and theories of the technical industry requirements of the project so that business needs are addressed and satisfied (Cadle & Yeates, 2001: 358; Ashworth & Hogg, 2002: 381-384). Turk (2007: 25) states that project managers need to know what questions to ask and should be able to judge when they are not getting the full story. In order to do this, technical knowledge is required. This knowledge is also needed to evaluate technical concepts and solutions, assess risks and make trade-offs between cost, schedule and technical issues (Kerzner, 2013: 146-149). A blend of technical knowledge and project management knowledge is, therefore, required.

The following technical knowledge areas are required: construction science, finance and cost, construction processes, and design processes (Burger *et al.*, 2015: 22; SACPCMP, 2015). Each of these four areas contains knowledge subsections. Construction science includes understanding of structures, understanding of construction and building sciences, understanding construction and building finishes, and knowledge of building material. Finance and cost includes understanding financial processes and having knowledge of the cost of construction. Knowledge of construction processes includes site, plant and equipment, formwork systems, quality management, health and safety management, environmental management, organisational/management structures, general building sequences, general output and production factors, and basic knowledge of building trades. Knowledge of the design processes consists of sequence of design processes and time required for design processes.

The construction industry is unique, as it differs from, for example, the IT industry. Project management within the construction industry

requires a specialised form of management. A construction project manager requires technical competencies, in order to effectively execute the work s/he needs to do (SACPCMP, 2015: Online).

2.1.3 Experience

Petterson (1991: 99) mentions that project managers need a solid basic experience in the relevant field. This is also supported by Sears, Sears & Clough (2008: 15) who state that the project manager needs certain attributes, in order to be successful. This includes a considerable background of experience and expertise. Experience alone will not suffice. In order to progress in a career, project managers need the combination of both experience and knowledge (Craig, 2005: 42).

Construction project managers thus need a blend of project management knowledge, technical knowledge, and experience in the field, in order to contribute to successful project management. The correct knowledge set will contribute to effective communication and trust in a project. These organisational elements are crucial for efficient and successful project management (Burger *et al.*, 2015: 69).

2.2 Level of knowledge

In South Africa, all education and training qualifications need to be registered through the South African Qualifications Authority (SAQA) and given a certain National Qualifications Framework (NQF) rating scale level. These NQF rating scale level descriptors are used to indicate the type and level of knowledge required for a qualification from NQF level 1 to NQF level 10 (SAQA, 2015: Online). The lower level descriptors relate to artisan training and, from NQF level 5, the focus moves towards management type of knowledge. As the level of knowledge sets of project managers is tested, the focus of this study is on NQF level 5 to NQF level 9.

- NQF 5 (certificate).
- NQF 6 (diploma level).
- NQF 7 (first degree such as a BSc).
- NQF 8 (Honours level).
- NQF 9 (Master's level).

For education and training qualifications in Construction Project Management, various project management courses, presented by different institutions in South Africa have been registered and received a certain NQF level. These courses range from a NQF level 5 (certificate) to a NQF level 9 (Master's) (SAQA, 2015: Online). The

NQF rating level indicates that the knowledge presented in the course is on an adequate level as expected for that course. An institution can offer a level 5 certificate programme. However, the SACPCMP requires a minimum of a level 8 for registration. Any lower NQF qualification will mean that the individual will need additional work experience or be required to write an entrance examination, in order to be registered as a professional construction project manager (SACPCMP, 2015: online).

Table 1 shows the scope of knowledge that is required for the various NQF levels defined by SAQA.

Table 1: NQF levels

<i>NQF level</i>	<i>Qualification</i>	<i>Requirements</i>
5	Certificate	Knowledge of the main areas of one or more fields, disciplines or practices, including an understanding of the key terms, concepts, facts, principles, rules, and theories of that field.
6	Diploma	Detailed knowledge of the main areas of one or more fields, disciplines or practices, including an understanding of, and an ability to apply the key terms, concepts, facts, principles, rules, and theories of that field, discipline or practice.
7	First degree such as a BSc	Integrated knowledge of the main areas of one or more fields, disciplines or practices, including an understanding of, and an ability to apply and evaluate the key terms, concepts, facts, principles, rules, and theories of that field, discipline or practice. Knowledge of an area or areas of specialisation and how that knowledge relates to other fields, disciplines or practices.
8	Honours	Knowledge of, and engagement in an area at the forefront of a field, discipline or practice. Furthermore, there is an understanding of the theories, research methodologies, methods and techniques relevant to the field, discipline or practice, and an understanding of how to apply this knowledge in a particular context.
9	Master's	Specialist knowledge to enable engagement with, and critique of current research or practices. An advanced scholarship or research in a particular field, discipline or practice is present.

The above literature review introduces project management knowledge (theory), technical (industry) knowledge, and knowledge gained through experience in the field, as the three knowledge types considered to be important for construction project managers. Project management knowledge (theory) requires integrated knowledge of an area of specialisation. Table 1 shows that NQF level 7, defined by SAQA, demands integrated knowledge of an area or areas of specialisation and how that knowledge relates to

other fields, disciplines or practices. Therefore, it can be suggested that the project manager's knowledge, as an expert in project management, should be at an NQF level 7.

Technical (industry) knowledge requires detailed knowledge that can be applied to more than one field in the construction management industry. The NQF guide of knowledge classification in Table 1 shows clearly that, for construction project management qualifications, the NQF level should at least be on level 6, as detailed knowledge needs to be applied from more than one field.

The SACPCMP (2015: Online) requires a minimum of a level 8 to be registered as a professional construction project manager.

3. Research

This study addressed the importance of NQF qualification levels of knowledge for project managers as well as the importance of gaining knowledge through experience for construction project managers in the built environment. The validity and reliability of a study is important (Creswell, 2009: 202-203). It was, therefore, decided to use a mixed methods study design, in which qualitative and quantitative data are collected in parallel, analysed separately, and then merged (Creswell, 2005). In this study, a questionnaire survey (n = 40) was used to test the project management knowledge theory, which specifies that a sufficient level of construction project management knowledge will have a positive effect on project completion by construction managers in the built environment. The interviews (n = 10) and single case study explored the impact and the importance of industry-specific knowledge for construction project managers in the built environment. The reason for collecting both quantitative and qualitative data is to elaborate on specific findings from the questionnaire survey (quantitative data), such as similar opinions regarding the importance of NQF levels of knowledge as well as the importance of industry-specific knowledge suggested by the interview and case study (qualitative data) respondents' groups (Creswell, 2005; Creswell & Plano-Clark, 2007).

3.1 Sampling method and size

A combined list of 87 built environment professionals was obtained from the personal business contact list of the researcher as well as from colleagues regarded by the researcher as professionals in the built industry. The list was stratified between those professionals involved in quantity surveying (17), project management (33),

engineering (18), building contracting (8), architects (4), valuers (1), and built environment academics (6), which represent the sample size of the questionnaire survey.

For the interview survey, using the original business contact list, the researcher selected 10 experienced senior project management professionals who work/worked for over 10 years on large buildings projects (R100 million and more) within the built environment in South Africa. These professionals have qualifications on an NQF level 6.

According to the SACPCMP's (2016: 24) annual report, there are approximately 1,585 professional construction project managers registered in South Africa. Using the sample size table recommended by Krejcie & Morgan (1970: 608), where a sample of 278 for a population of 1,000 is recommended, the sample sizes appear to be small, but the validity of the information supplied was inherent in their wealth of experience on the subject matter and the number of years they have spent in the construction industry.

A single case study of a building project to the value of R35 million was selected for the study. The reason for selecting the case study was the failure of the project, due to the limited previous built environment industry knowledge shown by the project manager who worked on the project. The project manager appointed on the project was registered as project manager and worked as a consultant for an engineering firm. He has a BCom qualification without any qualifications in the built environment. He has a few years' work experience.

3.2 Data collection

Leedy & Ormrod's (2010: 194) list of guidelines for compiling questionnaires was followed. A structured questionnaire was distributed electronically via email to a total randomly selected sample of 87 construction-related professionals in South Africa. Responses were returned within a two-month period. The project management knowledge topics used in the questionnaire were extracted from reviews of the literature. Some questions were based on the PMBOK knowledge areas, while others were based on the technical knowledge areas for project managers in the built environment introduced by the SACPCMP. This resulted in the formulation of a questionnaire divided into two sections, namely respondent's profile, and questions to determine whether the respondents think that it is important for a project manager to have industry-specific knowledge and to discover what form of knowledge they regard as essential for a project manager. Elements from the following main areas were

tested: Experience in the built environment, project management knowledge, technical knowledge, and qualifications. To reduce the respondent's bias, closed ended questions were preferred (Akintoye & Main, 2007: 601).

After the location city and addresses of the organisations were determined, interviews were planned, a date was set to meet, and the individual interviews were conducted with 10 professionals from built environment organisations in South Africa. Interviewees were asked to give their views on the importance of industry-specific knowledge of a construction project manager and to review the form of knowledge considered essential. Topics discussed included important knowledge types, industry-related knowledge required, and required qualification. Feedback from the qualitative research afforded an opportunity for respondents to elaborate on opinions, including experiences. All these discussions were recorded and used as the interview data. The interviews were conducted within two weeks.

For the case study, the quantity surveyor working on the project was questioned on his assessment of problems faced on the project. The quantity surveyor reported on specific incidences where the project manager's lack of industry-specific knowledge as well as project-management knowledge affected the project. All the discussions and emails exchanged were noted. It was also determined that the data would be interpreted using specific categories including industry-related knowledge and project-management knowledge. This cross-sectional study was carried out only once (Schoonraad, 2003: 139).

3.3 Response rate

Forty completed questionnaires were returned, resulting in a response rate of 45%. According to Moyo & Crafford (2010: 68), contemporary built environment survey response rates range between 7% and 40%, in general. All of the ten interviewees invited to participate in the study took part in the interview discussions.

3.4 Data analysis and interpretation of findings towards the proposed model

For the questionnaire survey, a 5-point Likert scale was used to obtain the opinions of the respondents and to analyse the results. Likert scales need a minimum of two categories and a maximum of eight or nine (Neuman, 1997: 159; Leedy & Ormrod, 2010: 189). For the purpose of analysis and interpretation, the scale measurement between 1 and 5 was used. Likert-type or frequency scales are designed to

measure attitudes or opinions. In this research, these ordinal scales measure levels of not important/very important. The scales were 1 = 'not important', 2 = 'fairly important', 3 = 'important', 4 = 'very important', and 5 = 'critically important'. The data were captured using the SPSS program, upon which the findings were reviewed against the foregoing literature review. This was used in order to make deductions and increase the understanding of the required knowledge for project management in the built environment. In the quantitative research, the raw data was coded prior to starting the analysis. The codes were then entered into a statistical computer program SPSS and usable statistics were compiled.

All discussions during the interviews were recorded and used as the interview data. Using *Microsoft Excel 2003®*, the raw data was analysed and organised into conceptual themes under the categories important knowledge types, industry-related knowledge required, and required qualification for construction project managers. These categories were tabulated.

Using qualitative analysis, the research case study was discussed and the data organised into specific categories. The category industry-related knowledge was coded: Knowledge of construction science; Knowledge of financial cost factors; Knowledge of design processes, and Knowledge of construction processes. The category project management knowledge was coded: Integration, Scope, Trust, Communication, Time, and Cost. These categories and codes were tabulated.

3.5 Limitations

This study is limited to construction project managers within South Africa. In terms of the guidelines stipulating type of knowledge that project managers should have, this study focused on the nine PMBOK knowledge areas from the PMI PMBOK guide 4th edition 2008 and did not include the 5th edition, as the study was conducted prior to the release of the 5th edition. Therefore, the study was limited to the nine PMBOK knowledge areas and did not include stakeholder management as the tenth area.

4. Results

The findings from the analysis and interpretation of the data collected for this study are shown in Tables 2 to 13. Tables 2 and 3 – the respondents' profile; Tables 4 and 5 – the type of knowledge needed for project managers; Table 6 – the importance of having

project management knowledge (theory); Table 7 – the case study results of why the project failed, due to lack of project management knowledge; Table 8 – the importance of having technical (industry) management knowledge in the built environment; Table 9 – the interview and case study responses on the industry-related knowledge required for construction project managers; Tables 10 and 11 – the importance of gaining knowledge through experience, and Tables 12 and 13 – the level of knowledge (qualifications) required for project managers in the built environment.

4.1 Respondents' profile

The first part of the interview survey and questionnaire survey contained questions on the demographic profile of the respondents who are in the best position to comment on the knowledge set that project managers should possess. Table 2 shows the professions of the respondents and Table 3 shows the years of experience in a profession as well as the respondent's NQF qualification level.

Table 2: Professions of respondents

<i>Profession of respondents</i>	<i>Questionnaire: Number of respondents in the correlating profession in column 1</i>	<i>%</i>	<i>Interview: Number of respondents in the correlating profession in column 1</i>	<i>%</i>
Quantity surveying	3	7.5	2	20
Project management	21	52.5	3	30
Engineering	10	25	3	30
Building contracting	3	7.5	2	20
Architects	1	2.5	0	0
Valuers	1	2.5	0	0
Built environment academics	1	2.5	0	0
Total	40		10	

Table 3: Respondents' NQF qualification level and years of experience in profession

<i>Profession</i>	<i>Years of experience in profession</i>			<i>Total</i>	<i>NQF qualification level of respondents in the profession</i>							<i>Total</i>
	<i>5-10</i>	<i>10-20</i>	<i>20+</i>		<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	
<i>Questionnaire respondents</i>												
Quantity surveying	1	0	2	3	0	0	0	0	0	2	1	3

Profession	Years of experience in profession			Total	NQF qualification level of respondents in the profession							Total
	5-10	10-20	20+		4	5	6	7	8	9	10	
Questionnaire respondents												
Project management	6	7	8	21	0	0	15	6	0	0	0	21
Engineering	2	4	4	10	0	0	0	10	0	0	0	10
Building contracting	1	2	0	3	1	0	2	0	0	0	0	3
Architects	0	1	0	1	0	0	0	1	0	0	0	1
Valuers	0	0	1	1	0	0	1	0	0	0	0	1
Built environment academics	0	0	1	1	0	0	0	0	0	0	1	1
Total	10	14	16	40	1	0	18	17	0	2	1	40
%	25	35	40		2.5	0	45	42.5	0	5	2.5	
Interview survey respondents	5-10	10-20	20+	Total	4	5	6	7	8	9	10	Total
Quantity surveying	0	1	1	2	0	0	0	0	2	0	0	2
Project management	0	2	1	3	0	0	0	0	3	0	0	3
Engineering	0	1	2	3	0	0	0	0	3	0	0	3
Building contracting	0	2	0	2	0	0	0	0	3	0	0	2
Total	0	6	4	10	0	0	0	0	10	0	0	10
%		60	40						100			

Indicating first the questionnaire results and then the interview results, the majority of the responses (52.5%; 30%) and (25%; 30%) were received from project managers and engineers. The results show that (35%; 50%) of the professionals have over 10 years' experience in their professions, of whom 40% from both respondents' groups have 20 years or more experience. The interview survey respondents all had NQF level 8 qualifications and the questionnaire respondents' NQF level of qualifications varied: 2.5% had NQF level 4; 45%, NQF level 6; 42%, NQF level 7; 5%, NQF 9, and 2.5%, NQF 10.

4.2 Type of knowledge needed

Based on the scale measurement used regarding mean scores, where 1 = 'not important', 2 = 'fairly important', 3 = 'important', 4 = 'very important', and 5 = 'critically important', the results in Table 4 show the mean scores for the importance levels of the

type of knowledge which a construction project manager should have, as perceived by the respondents who participated in the questionnaire survey. Table 5 shows the tabulated responses from the interview survey.

Table 4: Questionnaire responses: Importance of knowledge types

Knowledge area	Questionnaire responses	1 = Not important 5 = Critically important						Average rating
		1	2	3	4	5	Total	
Work experience	Number of respondents	1	5	15	14	5	40	4.35
	Percentage of total	2.5	12.5	37.5	35	12.5	100	
Project management knowledge	Number of respondents	1	5	15	14	5	40	3.85
	Percentage of total	2.5	12.5	37.5	35	12.5	100	
Technical knowledge	Number of respondents	2	2	8	17	11	10	3.83
	Percentage of total	5	5	20	42.5	27.5	100	

Table 5: Interview responses: Important knowledge types

Important knowledge	Industry-specific knowledge is essential. Knowledge of project management, the built environment and knowledge gained through experience are essential. Need project management knowledge plus industry-specific knowledge. Need to have knowledge and experience within the built environment.
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The results in Table 4 show that Knowledge through work experience ($M_s = 4.35$) was rated very important; Project management knowledge ($M_s = 3.85$) and Technical (industry) knowledge ($M_s = 3.83$) were rated important. Tabulated responses in Table 5 show that all ten interviewees indicated that a construction project manager needs technical (industry) knowledge, project management (theory) knowledge, and experience.

4.2.1 Project management knowledge

The generic project management knowledge areas listed in the PMI as well as the additional extension to the Construction PMBOK areas were tested. Table 6 shows the weighted mean score averages for

the 13 areas ranked according to the importance, as perceived by the respondents who participated in the questionnaire survey.

Table 6: Questionnaire responses: Importance of project management knowledge

PMBOK Project management knowledge	Response (N = 40)					Average mean score	Rank
	1 = not important 5 = critically important						
	1	2	3	4	5		
Project time management	0	0	7	22	11	4.10	1
Project cost management	0	0	11	16	13	4.05	2
Claims management (construction extension)	0	0	11	17	12	4.03	3
Project risk management	0	2	9	15	14	4.02	4
Project scope management	0	0	11	18	11	4.00	5
Financial management (construction extension)	2	0	9	17	12	3.93	6
Project human resources management	1	2	11	14	13	3.87	7
Project quality management	0	0	10	17	11	3.83	8
Project integration management	0	1	11	17	10	3.82	9
Project communication management	1	2	12	15	10	3.79	10
Occupational health and safety (construction extension)	1	3	12	15	9	3.70	11
Project procurement management	1	6	10	16	7	3.55	12
Environmental management (construction extension)	3	4	14	12	7	3.40	13
Total average						3.85	

Areas that were rated very important, with mean scores of 4 and above, will be included in the proposed model. These areas are: Project time management (4.10); project cost management (4.05); project claims management (4.03); project risk management (4.02), and project scope management (4.00).

Areas that were rated as important will be included in the proposed model. These areas are: Project financial management (3.93); project human resources management (3.87); project quality management (3.83); project integration knowledge (3.82); project communication management (3.79); project occupation health

and safety (3.70); project procurement management (3.55), and project environmental management (3.40).

With an Ms of 3.85, respondents view it important that project managers should have project management knowledge (theory). To gain theoretical project management knowledge, integrated knowledge and specialisation of the field is needed. A qualification on NQF level 7 (first degree such as a BSc) allows for integrated knowledge and specialisation of a field, discipline or practice.

Table 7 shows the tabulated responses from the case study of why the project failed, due to lack of project management knowledge.

Table 7: Case study results: Project management knowledge

<i>Project management knowledge</i>	<i>Reasons why the project failed</i>
Integration	The project manager lacked integrated knowledge There was inefficient management of the project For example, the waterline had to be moved, and would amount to R500,000. The project manager did not understand the implications and actions involved in moving the line as the project manager did not have knowledge about costing and construction processes
Scope	The project manager could not check the project work of the consultants, as the project manager did not have the technical knowledge of the work required to do construction-related tasks, and he could, therefore, not determine whether it was complete or not The project manager did not know this, due to the fact that he did not have knowledge of the scope of work
Trust	Lack of knowledge and inability to answer the client's questions led to mistrust in the project manager He did not instil trust among project team members, so they did not trust his expertise as project manager
Communication	Lack of knowledge led to miscommunication during the project He did not understand what the team members were saying and the implications of what they were saying He did not know what questions to ask and, therefore, asked the wrong questions
Time	There were time delays, due to miscommunication Due to his inadequate knowledge, he had to enquire about a lot of information that should have been part of his knowledge base
Cost	Time delays, as the result of insufficient knowledge, contributed to project cost increase The project manager did not understand the industry standard quantity surveying costing, as the project manager did not have knowledge about costing He could not justify the cost and the reason for the cost

The quantity surveyor who worked on the project is convinced that a large contributing factor in the eventual termination of the project was the project manager's lack of project management knowledge.

4.2.2 Technical (industry) knowledge

Technical knowledge areas, as listed by the SACPCMP, were tested in terms of their importance in the built environment. Table 8 shows the mean scores for the importance levels of project manager technical (industry) management knowledge, as perceived by the respondents from the questionnaire survey.

Table 8: Questionnaire responses: Importance of technical (industry) management knowledge in the built environment

SACPCMP technical knowledge areas	Response (N = 40)					Average mean score	Rank
	1 = not important 5 = critically important						
	1	2	3	4	5		
Knowledge of financial cost factors	0	0	4	19	17	3.94	1
Knowledge of design processes	0	0	10	17	11	3.83	2
Knowledge of construction processes	0	2	11	17	9	3.80	3
Knowledge of construction science	0	4	12	16	8	3.72	4
Average						3.83	

Rated as important, the following technical knowledge areas were identified as knowledge areas to be included in the proposed model: Knowledge of financial cost factors (Ms = 3.94); Knowledge of design processes (Ms = 3.83); Knowledge of construction processes (Ms = 3.80), and Knowledge of construction science (Ms = 3.72). With a weighted average of 3.83, supported by the results from the interviews and case study tabulated in Table 9, the findings show that having technical (industry) knowledge is important.

Table 9: Interview and case study responses: Industry-related knowledge required

<i>Industry-related knowledge required</i>	<i>Interview responses</i>	<i>Case study results: why the project failed</i>
Knowledge of construction science	<p>Industry knowledge is most important</p> <p>Should know the essentials of the industry</p> <p>Needs to understand the processes relevant in the industry to understand what is going to be developed and built</p> <p>Needs project management knowledge plus industry-specific knowledge</p>	<p>Lacked knowledge in the fields of construction science and construction processes</p> <p>For example, the project manager did not know what bending schedules were. His lack of industry-specific knowledge caused frustration among project team members and negatively affected the project</p>
Knowledge of construction processes	<p>Needs above average knowledge about the industry and an understanding of how various elements fit together</p> <p>Has to know and understand the process and systems</p> <p>Needs a different level of required knowledge</p> <p>Experience is one of the essential knowledge components</p>	<p>The project manager did not understand the construction processes that had to take place. For example, the waterline had to be moved to a lower level. The project manager did not understand why it should be lower</p>
Knowledge of design processes	<p>Has to understand the processes involved in the industry</p> <p>Has to be familiar with the steps and processes</p> <p>Has to have knowledge of the roles and responsibilities of the parties involved in a building project</p>	<p>The project manager did not understand what the team members were saying and the implications of what they were saying. For example, the 300 trees that were to be planted on site cost substantially more than expected and took longer. The project manager did not know that the costs and time involved were more than merely the purchase price per tree and the planting thereof</p>
Knowledge of financial cost factors	<p>Has to understand the processes involved in cost and finances</p>	<p>The project manager did not have knowledge about costing. For example, the waterline had to be moved; this would amount to R500,000. The project manager did not understand why it costs so much</p>

The case study indicated that the project manager lacked knowledge. The consultants working on the project agreed that the project manager lacked knowledge in the fields of construction science, construction processes, design processes, and finance. Therefore, the project failed to be completed.

4.2.3 Knowledge through experience

Respondents rated the importance of gaining project management knowledge through working within the built environment. With a weighted average of 4.35, the questionnaire findings in Table 10 show that the respondents view experience in the built environment as a crucial knowledge element for a project manager.

Table 10: Questionnaire responses: Importance of experience in the built environment

Responses	1 = Not important 5 = Critically important					
	1	2	3	4	5	Total
Number of respondents	0	1	1	21	17	40
Percentage of total	0	2.5	2.5	52.5	42.5	100
Average rating	4.35					

Of the 40 respondents, 38 rated the importance of experience as either 4 or 5, with 52.5% regarding it as very important, and 42.5% as critically important. A total of 95% indicated experience as being either very important or critically important. Table 11 shows the coded interview responses supporting this finding.

Table 11: Interview responses: Knowledge through experience

Important knowledge types	<p>Generic project management qualification without industry-specific knowledge will not suffice</p> <p>Needs project management knowledge plus industry-specific knowledge</p> <p>Needs to have knowledge and experience in the built environment</p>
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4.3 Level of knowledge (qualification)

To determine what the minimum level of qualification for construction project managers should be, respondents rated the NQF level of qualifications they deemed important on a 5-point Likert scale. Table 12 shows the Ms and rank of the NQF level of qualification

which respondents from the questionnaire survey deemed important for a project manager in the built environment.

Table 12: Questionnaire responses: NQF knowledge level required for a built environment project manager

NQF level	(N)	Response and (%)					Average mean score	Rank
		1 = not important 5 = critically important						
		1	2	3	4	5		
5	32	24	8	0	0	0	1.25	5
	%	100	0	0	0	0		
6	32	5	4	10	4	9	3.25	2
	%	15.6	12.5	31.3	12.5	28.1		
7	36	2	2	4	16	12	3.94	1
	%	5.6	5.6	11.1	44.4	33.3		
8	35	7	3	16	7	2	2.83	3
	%	20	8.6	45.7	20	5.7		
9	36	14	12	5	3	2	2.08	4
	%	38.9	33.3	13.9	8.3	5.6		

With a mean score of 1.25, no respondents viewed a qualification on NQF level 5 as important for project managers. NQF level 6, with a mean score of 3.25 was viewed as an important level of qualification which project managers in the built environment should have. With an MS of 3.94, NQF level 7 is rated the most important level of qualification which a project manager in the built environment should have. Only 11.2% stated that it is not important (5.6%), or only fairly important (5.6%), compared to 77.7% who stated that an NQF level 7 is very important (44.4%) and critically important (33.3%). The results show an MS below average for NQF level 8 (2.83) and NQF level 9 (2.08), indicating that respondents overall did not view these levels of qualification as important.

Table 13 shows the coded interview responses of the NQF level required for project managers.

Table 13: Interview responses: NQF knowledge level required qualification for project managers

Required qualification	<p>Generic project management qualification (NQF level 6) without industry-specific knowledge will not suffice</p> <p>Needs NQF level 7 qualification in the built environment, such as a degree in engineering, quantity surveying, or architecture</p>
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The majority of the respondents indicated an NQF level 7 qualification as adequate for project management knowledge (theory). Rated as important, and very important, NQF level 6 and NQF level 7, respectively, will be included in the proposed model.

In Table 1, SAQA describes NQF level 6 as 'detailed knowledge of the main areas of one or more fields, disciplines or practices, including an understanding of, and an ability to apply the key terms, concepts, facts, principles, rules, and theories of that field, discipline or practice'. Rated as important in Table 12, this study suggests that a project manager in the built environment should have technical industry-specific knowledge equivalent to NQF level 6. This implies that s/he needs to have detailed knowledge and understanding of areas such as construction science, design processes, finance and cost, and construction processes, which will be included in the proposed model.

Rated as important in Table 6, with an MS of 3.85, project managers need project management knowledge (theory). This type of knowledge should be on a higher level than technical knowledge, because project managers need to be specialists in their primary field of work, namely project management. The level of project management knowledge needs to be detailed knowledge of that area of specialisation. This implies that construction project managers need to have specialised knowledge and understanding of the 13 project management areas introduced in this study. Rated as very important in Table 12, this study suggests that, for a project manager to gain this specialised level of knowledge, qualifications equivalent to NQF level 7 (First degree such as a BSc), as detailed in Table 1, are suggested and will be included in the proposed model.

5. Proposed model for construction project management knowledge

With the literature and empirical reviews as foundation, a model is proposed that is viewed as an integrated system with effective construction project management knowledge as fundamental core, since the research demonstrated that efficient knowledge through work experience, qualified project management knowledge (theory), and technical (industry) knowledge support effective construction project management.

5.1 Construction project management knowledge model

Figure 1 illustrates the model for construction project management knowledge. The model is viewed as an expanding circle with technical (industry) knowledge centre to project management knowledge (theory) and work experience. Knowledge influences all activities related to project management. The efficiency of knowledge is again influenced by the level of knowledge (qualification), indicated in Figure 1 as NQF level 6 and NQF level 7. The model consists of effective construction project management knowledge as the foundation with three circles around this core. The first circle constitutes NQF level 6 knowledge (technical knowledge); the second circle, knowledge through industry experience, and the third circle, NQF level 7 of knowledge (project management knowledge theory) that a construction project manager should have.

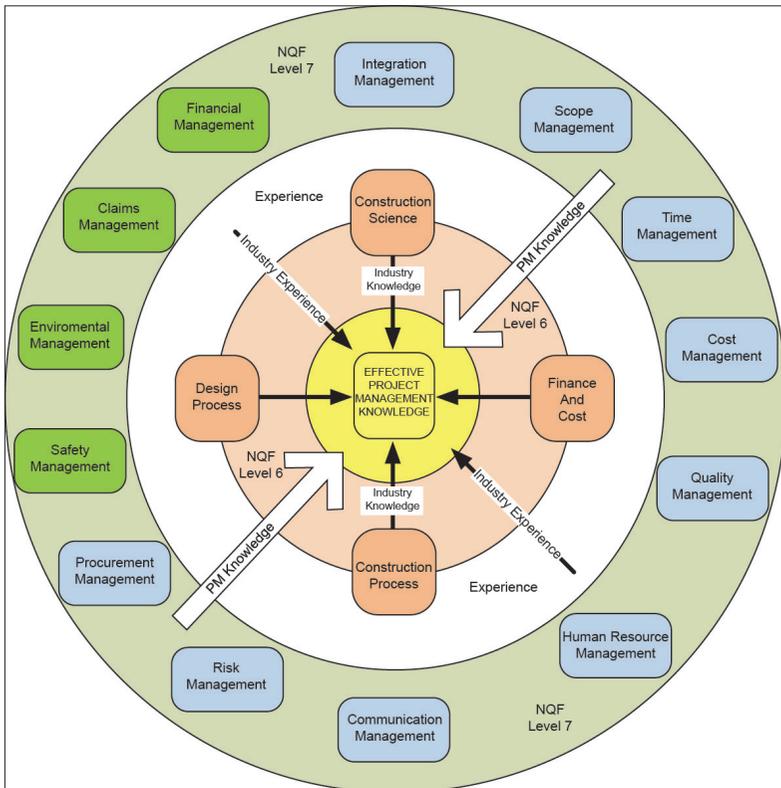


Figure 1: The construction project management knowledge model

5.1.1 NQF level 6 knowledge (technical knowledge)

The first circle, NQF level 6, following the core foundation circle, is shown as a circle where construction science, finance and cost, construction processes, and design processes are overlapping to the second circle. This overlapping is sensible, as some of the technical knowledge in this circle is closely linked to the second circle (knowledge through industry experience). The circle shows industry knowledge closely linked to and overlapping to the core circle. An NQF level 6 qualification (Diploma) will assist construction project managers to have detailed technical knowledge, including an understanding of, and an ability to apply the key terms, concepts, facts, principles, rules, and theories of construction science, finance and cost, construction processes, and design processes within the built environment. A construction project manager cannot be without this technical industry knowledge. It is fundamental. However, the second circle, that is knowledge through experience, is also needed, in order to develop an in-depth understanding of the knowledge gained through the first circle.

When the technical knowledge is on at least a NQF level 6 qualification, industry knowledge can be strengthened and enhanced and will assist the construction project manager to have a better overall knowledge set of construction science, finance and cost, construction processes, and design processes.

5.1.2 Knowledge through industry experience

The second circle, Experience, shows the work experience within the industry. The arrows flowing from the second circle over the first circle to the core, illustrate the importance of gaining knowledge through experience to ensure effective construction project management. Experience in industry is essential to contribute to effective project management. However, experience on its own, without the first and third circles, will not sufficiently contribute to effective project management. This set of knowledge supports and strengthens technical knowledge in the second circle and effective construction project management knowledge in the core circle.

5.1.3 NQF level 7 (project management knowledge theory)

The third circle, NQF level 7, shows the level of qualification for project management knowledge areas in a sequence supported by the literature reviewed, but in combinations; this is sensible, as some of the project management knowledge areas are sequential and closely linked. The nine generic project management areas within

the circle are indicated in blue: Integration management, scope management, time management, cost management, quality management, human resources management, communication management, risk management, and procurement management. The four construction-specific project management areas indicated in green are: Safety management, environmental management, claims management, and financial management.

The third level incorporates the nine project management areas that are necessary for any project to be managed, as well as the four construction-specific areas. All these areas are important and influence each other. If communication management does not take place, all the areas are affected. There may be an increased risk, the project may have scope creep, be of a lower quality, at a higher cost with little integration between all the areas. If time, cost or quality are influenced, this may have an effect on each other. A project that is not completed within time may undergo a cost and quality adjustment.

However, the third circle does not stand alone. The 13 areas in circle three are affected by circles one and two. Lacking industry knowledge and experience may quite likely impact on project management elements in circle one. The aim of a project is to complete it on time, within cost and according to an expected quality. Without the combined knowledge of all three, the achievement of effective project management may be affected.

A qualification on NQF level 7 (First degree such as a BSc) will assist the project manager to have integrated knowledge of the main areas of project management, including an understanding of, and an ability to apply and evaluate the key terms, concepts, facts, principles, rules, and theories of project management. It should also assist project managers to gain specialised knowledge on project management theory so that they can have an understanding of how project management relates to other fields, disciplines or practices such as engineering, and so on.

When project management knowledge theory is on at least a NQF level 7 qualification, project management knowledge can be strengthened and enhanced and will assist the construction project manager to have better knowledge of project management knowledge theory. The arrows flowing from the third circle over the second and first circles to the core illustrate the importance of having a qualification on NQF level 7 for project management knowledge, in order to ensure effective construction project management. This set of knowledge supports and strengthens work experience within

the industry in the third circle; technical knowledge in the second circle, and effective construction project management knowledge in the core circle.

It is proposed that, if all areas of construction project management knowledge, from project management knowledge theory to technical knowledge and work experience are in position to ensure the gaining of efficient knowledge, the result will be a project manager that possesses efficient knowledge to execute effective construction project management.

6. Conclusion and recommendation

Appropriate literature elicited a range of structured questions that were used to obtain quantitative and qualitative data from the survey and interview participants. Analysis of the data with literature and the results from the surveys determined the elements of a proposed model and showed that the knowledge expected from project managers can be grouped into technical knowledge (construction science, finance and cost, construction processes, and design processes within the built environment), and knowledge through industry experience and project management knowledge theory (the nine generic project management areas include integration management, scope management, time management, cost management, quality management, human resources management, communication management, risk management, and procurement management; the four construction-specific project management areas include safety management, environmental management, claims management, and financial management).

The research results show that knowledge is fundamental to the development of effective construction project management, in order to produce successful projects. The model includes two NQF levels of qualification knowledge sets, which, used in combination with knowledge gain through industry experience, are proposed to assist construction project managers in developing their knowledge sets, and through improved levels of knowledge, ensuring the successful execution of projects.

Implementation and use of the proposed model relies on the willingness of construction project managers relative to understanding the importance of such a model. It is, therefore, recommended that the interrelated knowledge sets included in the model are of utmost importance. These include 'engaging people', which will encourage construction project managers to take ownership in an

attempt to introduce and implement this proposed construction project management knowledge model in their firms.

This research does not consider the model as a complete means to an end. Further research is needed, in order to develop an instrument to measure the level of an individual's or group's knowledge levels to improve their construction project management knowledge sets.

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