Understanding Applications of Project Planning and Scheduling in Construction Projects

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Abstract

Construction project life-cycle processes must be managed in a more effective and predictable way to meet project stakeholders' needs. However, there is increasing concern about whether know-how effectively improves understanding of underlying theories of project management processes for construction organizations and their project managers. Project planning and scheduling are considered as key and challenging tools in controlling and monitoring project performance, but many worldwide construction projects appear to give insufficient attention to effective management and definition of project planning, including preplanning stages. Indeed, some planning issues have been completely overlooked, resulting in unsuccessful project performance. There is a lack of knowledge of, and understanding about, the significance of applications of project planning and scheduling theory in construction projects. Thus, improving such knowledge should be incorporated with new management strategies or tools to improve organizational learning and integration in the context of project planning and scheduling. This implies a need to assess project stakeholders' understanding on the application of project planning and scheduling theories to practice.

The main aim was to study and describe project stakeholders' perspectives regarding a set of identified criteria comprising aspects assumed to be significant in successful project planning and scheduling. The main research question was developed as follows: *What level of understanding do project stakeholders have about the application of project planning and scheduling theories in practices of construction projects?* This key question is divided into a number of specific questions concerned with various aspects of project planning and scheduling. Three different questionnaire surveys were considered and designed in order to collect and analyse data relevant to the empirical studies presented and discussed under the scope of this thesis. The study context is Oman. The thesis is based on a summary of five appended papers, of which four represent empirical survey studies. The results form the basis of discussions and reflections, and the four key factors identified are: (1) highlighting management tools needed to improve organizational knowledge and understanding of project planning theories and methods; (2) paying particular consideration to the significant factors (enablers and barriers) impacting project planning and scheduling; (3) identifying project management roles and organizational behaviour in planning and scheduling; and (4) increasing project stakeholders' awareness of front-end planning for a more successful project execution.

Key words: Project planning, project scheduling, front-end planning, construction projects, project stakeholder perspectives, Oman.

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August 2015, Lund
Hammad AlNasseri

Dedication

I would like to dedicate this doctoral thesis to the soul of my beloved and well-known uncle, Khalifa Mubarak AlNasseri (1916-2015), the family big father of wisdom and kindness, who died while I have been in Sweden. May Allah (God) rests your soul in peace and makes your grave a beautiful paradise… Ameen. I will miss you a lot for the rest of my life.

I also dedicate this work to the souls of all persons that I knew who passed away while I was in Sweden.

Abstract

Construction project life-cycle processes must be managed in a more effective and predictable way to meet project stakeholder needs. However, there is increasing concern about whether know-how effectively improves understanding of underlying theories of project management processes for construction organizations and their project managers. Project planning and scheduling are considered as key and challenging tools in controlling and monitoring project performance, but many worldwide construction projects appear to give insufficient attention to effective management and definition of project planning, including preplanning stages. Indeed, some planning issues have been completely overlooked, resulting in unsatisfactory project performance. There is a lack of knowledge of, and understanding about, the significance of applications of project planning and scheduling theory in construction projects. Thus, improving such knowledge should be incorporated with new management strategies or tools to improve organizational learning and integration in the context of project planning and scheduling. This implies a need to assess project stakeholders' understanding on the application of project planning and scheduling theories to practice.

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planning and scheduling. Three different questionnaire surveys were considered and designed in order to collect and analyse data relevant to the empirical studies presented and discussed under the scope of this thesis. The study context is Oman.

The thesis is based on a summary of five appended papers, of which four represent empirical survey studies. The results form the basis of discussions and reflections, and the four key factors identified are: (1) highlighting management tools needed to improve organizational knowledge and understanding of project planning theories and methods; (2) paying particular attention to the significant factors (enablers and barriers) impacting project planning and scheduling; (3) identifying project management roles and organizational behaviour in planning and scheduling; and (4) increasing project stakeholders' awareness of front-end planning for a more successful project execution.

Keywords: Project planning, project scheduling, front-end planning, construction projects, project stakeholder perspectives, Oman.

Papers

This research is based on the following five research papers (Appendix A), which are referred to in the text by their Roman numerals. The papers are appended at the end of this thesis.

Paper I **AlNasseri, H. A.,** Widén, K., & Aulin, R. 2014. Taxonomy of Planning and Scheduling Methods for a More Efficient Use in Construction Project Management. **Journal of Engineering, Design and Technology, 14 (2), Forthcoming.**

Paper II **AlNasseri, H. A.** & Aulin, R. 2015. Assessing understanding of planning and scheduling theory and practice in construction projects. **Engineering Management Journal, 27 (2), 58-72.**

Paper III **AlNasseri, H. A.** & Aulin, R. 2015. Enablers and barriers to project planning and scheduling based on construction projects in Oman. **Submitted and accepted for publication** with the **Journal of Construction in Developing Countries**.

Paper IV **AlNasseri, H. A.** & Aulin, R. 2015. Understanding project management roles and organizational behaviour in planning and scheduling based on Oman construction projects**. Journal of Construction in Developing Countries**, **21 (1), Forthcoming.**

Paper V **AlNasseri, H. A.** & Aulin, R. 2015. Understanding the application of front-end planning (FEP) in construction projects. **Submitted and under review** with the **Journal of Construction Innovation.**

The contribution to the papers

In the appended Papers (I to V), the first named author made the major contribution, including the design and conduct of the study, the collection and analysis of data, as well as the writing of the papers. Co-author(s) contributed with comments and guidance throughout the development and revision stages of the papers.

Other related research publications not appended in the thesis:

1. **Al Nasseri, H.,** Widén, K. & Aulin, R. 2013. Towards a Taxonomy of Planning and Scheduling Methods in the Context of Construction Management. 7th Nordic Conference on Construction Economics and Organization, 11-14 June, Trondheim, Norway.

2. **AlNasseri, H.,** Alnuaimi, A. & Aulin, R. 2015. Towards improving management roles and organizational behaviour in planning and scheduling: A perspective from Oman construction projects. Third International Conference on Advances in Civil, Structural and Mechanical Engineering, 26-27 May, Birmingham, UK.

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INTRODUCTION

1.1 Background

The purpose of construction project management is to plan, coordinate and control the application of project objectives in the most effective way according to stakeholders' needs (Harris and McCaffer, 2013). It involves many processes and sub-processes and includes the definition of project scope, cost estimating, roles and responsibilities of the project team, project stakeholder management, as well as the utilization of planning and control methods and tools. These require knowledge of the fundamentals of project management in order to develop successful project plans and schedules (Heagney, 2011), which are necessary for the delivery of the project to time, cost and quality objectives (Babu and Suresh, 1996; Whitty and Maylor, 2009). Where there is a lack of knowledge, the application of project management concepts will result in incomplete project plans (or poor planning) and, hence, loss of project performance (Ahern et al., 2014). A lack of knowledge about the application of theories in practice can be considered a major reason for poor project planning (Ahern et al., 2014). From a conceptual view, Kerzner (2009) pointed out that planning and scheduling and their related fundamentals should be properly defined to ensure their successful application in practice. A more recent view by Baldwin and Bordoli (2014) is that project planning needs

to be reconsidered as a key part of, or a creative activity in, determining the overall success of a project rather than as a preliminary function used for developing project schedules and resource plans. Baldwin and Bordoli also argue that the results of planning should be fully integrated and communicated to project stakeholders who are, for the purpose of this research, the key players in a construction project, i.e. owners (or clients), project managers, designers (or consultants) and contractors. Furthermore, Baldwin and Bordoli (2014) recognize the need to maximize the efficiency of project execution with respect to time, cost and quality aspects. In support, Alias et al. (2014) argue that current practices of project management in construction industry fail to ensure project success in terms of good planning and quality achievement. These authors attributed this failure to a lack of assessment of critical factors impacting such practices from the perspectives of project stakeholders.

The context of this research is Oman construction projects in respect of which a number of construction studies have aimed to identify factors impacting the performance of projects in terms of schedule delays and cost overruns (Alnuaimi et al., 2009; Ballal et al., 2007). Such occurrences are not confined to Oman, but appear to be a fairly common problem in construction where much research has been concerned with the assessment of factors (e.g. schedule delays, cost overruns and risks) considered as either success or failure criteria with regard to project performance (Ahadzie et al., 2008; Ijaola and Iyagba, 2012; Le-Hoai et al., 2008). These studies, along with similar studies discussed in this thesis, have examined project management factors related to situations where project stakeholders modified the original scope. A typical consequence of the inadequate consideration of such factors has resulted in contractual disputes with respect to schedule deviations and cost overruns. Many of such disputes can also be attributed to inadequate consideration and definition of

the factors affecting the development and control of project planning and scheduling at the front-end stage of a project.

From the perspective of mega industrial projects, the significance and impact of project planning on a project is also claimed by Merrow (2011), who concluded that poor scope definition in the early planning stages led to schedule slippage and cost overruns. Merrow indicated that such situations resulted from inappropriate initiation and preplanning (front-end planning), leading to poor definition of the project scope: *"[…] the requirement to make major changes in the objectives, scope, precise location, or any other major elements after the start of the detailed definition phase can result in an unmanageable project." (Merrow, 2011, p.56).* According to Merrow, front-end planning is a preplanning stage where project stakeholders should be confident that they are making the most effective decisions regarding the definition of project scope as the basis for more detailed planning.

In summarizing the above views, project managers and other stakeholders should effectively understand how to close the gap between planning and scheduling theories and their practices. This needs more thorough project planning and scheduling, which could be achieved through a competent team where learning is fostered at both the organizational and project levels. Special attention should also be paid to the definition of preplanning stages (or front-end planning) of a project for a more effective design and, hence, successful project execution. These issues do, however, need further examination from the perspectives of both project stakeholders and their construction organizations.

1.2 Statement of the problem

From a project management perspective, it has been argued that a successful project should fulfil the following criteria (Kerzner, 2009): (1) completed within the as-planned time and cost; (2) implemented at the specified levels of project performance; (3) delivered according to project stakeholder needs and expectations; and (4) completed within the defined and agreed scope. According to Alias et al. (2014), successful construction projects basically rely on successful practices of project management in regard to planning, implementation and cost, time and quality achievements. In reality, however, there are shortcomings as is manifest in schedule deviations and cost overruns (Altoryman, 2014; González et al., 2014; Hussein and Klakegg, 2014; Kumaraswamy and Chan, 1998). Such shortcomings result from improper identification of risks in project planning in the early stages of the project (Hussein and Klakegg, 2014). This supports the significance of successful planning and scheduling to a project.

The significance of project planning in construction has therefore been recognized, but it has not been explicitly addressed by researchers. Winch and Kelsey (2005) acknowledged that construction planning is more likely to be used as a tool for making rapid decisions based on observed views rather than detailed analyses of real requirements and the concerns of project stakeholders. A decade later, no specific investigations of the effectiveness of the application of project planning and scheduling have taken place in the construction industry. This seems to be a questionable issue that needs a more rigorous assessment from the perspectives of both project stakeholders and projects. However, the analysis of project stakeholders' perspectives should be complemented by an understanding of their roles and behaviour in a project.

More recently, a study by Yang et al. (2014) revealed that the assessment of project stakeholder attributes and behaviour in construction projects still needs attention in practice.

The application of project planning and scheduling can be also affected by risk factors in a project which, if not properly addressed, can act as barriers to the effective implementation and control of project plans and schedules. Wallace et al. (2004) stated that: *"[…] poor planning and control often leads to unrealistic schedules and budgets and a lack of visible milestones to assess whether the project is producing the intended deliverables. Without accurate estimates project managers do not know what resources to commit to a development effort. The net result is often excessive schedule pressures or unrealistic schedules that can increase project risk." (Wallace et al., 2004, p.117, Table 1).* From a project management perspective, Alias et al. (2014) reveal that the understanding of critical success factors impacting practices of the project management concept in construction projects are more useful in decision-making support, especially at the earlier stages of a project. For instance, a study carried out on Canadian megaprojects by Gharaibeh (2013) revealed that problems of cost overruns contributed to unsatisfactory outcomes for project stakeholders despite the use and integration of new schedule and cost control techniques. Gharaibeh examined the major reasons behind cost overruns in two case projects and found that unclear project scope (with uncertainty), inaccurate initial estimates of project cost up front, lack of contingency resources and misunderstanding of scope by contractors were considered as major issues.

The literature review also analysed a number of studies within the geographical boundary of this research, the Gulf region, and the findings from these studies showed that many construction projects have been affected by time and cost

overruns. However, there is currently no clear indication that this problem is a major consequence of a lack of understanding or poor definition of project planning and scheduling in practice. For example, in a survey on the schedule performance of Saudi construction projects, Assaf and Al-Hejji (2006) reported that 45 out of 76 projects investigated were delayed by more than 30% beyond the originally scheduled completion date. Another study revealed that more than 50% of the sample of construction projects in UAE experienced varying degrees of schedule deviations and cost overruns (Faridi and El-Sayegh, 2006). In Qatar, over 85% of construction projects were subject to time and cost overruns as a result of factors such as poor design and deficiencies in schedule and cost estimates (Jurf and Beheiry, 2012). The Bahrain construction industry has faced the same problems, with projects delayed due to critical factors such as inadequate planning and scheduling (Altoryman, 2014). In Oman, a number of construction projects were also found to be subject to schedule delays by more than 40% beyond their original schedule plans (Alnuaimi and Al Mohsin, 2013). These studies within the Gulf region indicated that insufficient planning and poor scheduling of project activities, ineffective design stages, improper coordination between project stakeholders and lack of knowledge about project requirements are amongst the most critical factors causing schedule deviations and cost overruns.

Considering the above views from the literature, a question concerning the level of understanding of current practice of project planning and scheduling seems relevant: are planning and scheduling theories properly understood and effectively applied in practice? Once again, the measurement of project performance should consider more specific aspects and management issues concerned with requirements, definitions and the application of project planning and scheduling. This is important in order to manage a more realistic

plan and integrated schedule. In other words, the application of project planning and scheduling based on the knowledge and perspectives of project stakeholders is an important area that needs further assessment. Project stakeholders are identified in this research as owners, project managers, designers and contractors. Such assessments are important for improving and supporting the understanding of the application of project planning theories and scheduling concepts in practice to ensure successful project performance. In other words, the transfer of a project from planning (theoretical plans) to implementation (physical actions) without understanding planning theories, including scheduling concepts and related matters, can result in the poor performance of a project.

Proper application of project planning and scheduling should incorporate aspects such as understanding of, or familiarity with, project planning and scheduling methods and tools, knowledge about underlying theories and concepts of planning and scheduling, and the ability to pre-plan the project, i.e. front-end planning. In addition, identifying the shortcomings in the current practice of project planning and scheduling requires the assessment of project stakeholder roles and behaviour in the project planning context.

1.3 Research aim, questions and objectives

The research aims to examine the extent to which project stakeholders understand the application of the aforementioned issues related to project planning and scheduling in construction projects. To achieve this aim, the following five research questions (RQs) have been postulated.

RQ1: Could a taxonomy be created as a support tool for planning and scheduling methods and tools?

RQ2: Do project stakeholders sufficiently understand the application of planning and scheduling fundamentals to practice?

RQ3: In project planning and scheduling, how can barriers be mitigated and enablers promoted?

RQ4: How can project management roles and organizational behaviour be managed effectively in planning and scheduling?

RQ5: To what extent do project stakeholders understand the application of front-end planning in a project?

Research questions RQ2 to RQ5 were pursued from the perspectives of project stakeholders in the context of construction projects in Oman. In order to answer these questions, the following five objectives were set.

1. To provide a taxonomy for planning and scheduling methods and tools.
2. To evaluate the current level of understanding of applications of project planning and scheduling fundamentals in practice.
3. To identify and evaluate significant enablers and barriers to planning and scheduling.
4. To identify and evaluate project management roles and organizational behaviour in planning and scheduling practices.
5. To evaluate project stakeholders' understanding of the application of front-end planning (FEP).

1.4 Research delimitations

This research has been confined to the assessment of project stakeholder perspectives on a set of aspects related to project planning and scheduling in the context of construction projects in Oman. However, project planning and scheduling is a broad field and involves important aspects which are not included in the scope of this research such as quality, communication and cost management. The research is based on analyses of the phenomena from the perspective of project stakeholders who are, by definition, closely involved in the project, i.e. owners, project managers, designers and contactors and their teams, rather than all categories of stakeholders. The research set out to provide descriptive or profiling views about the research problems they reflect, relating to planning and scheduling on construction projects in Oman.

1.5 Thesis structure

Chapter 1: Provides an overview of the research, with regard to project planning and scheduling. This is followed by a brief description of the research context, statement of the problem, research questions and related objectives as well as delimitations, and finally presents the thesis structure.

Chapter 2: Provides a theoretical background to the research. It offers an overview of the research theory investigated, followed by an introduction to project planning and scheduling and its significance to construction projects. This is followed by topics concerned with knowledge requirements in project planning and scheduling. The final part of this chapter focuses on front-end planning, which appears to be an under-explored research area.

Chapter 3: Presents an overview of the research philosophy and design, a description of the theoretical aspects of quantitative approaches, research methods and the data collection strategy.

Chapter 4: This chapter summarizes the findings from the research (appended Papers) listed in Table 1.1 and it also briefly discusses the contributions arising from each individual study.

Chapter 5: The chapter presents a short discussion of results and the overall conclusions drawn from the research, as well as the main contributions and recommendations for further research.

Table 1.1 Overview of the appended papers.

Research papers	**Research objectives**	**Research methods**	**Paper status**
Paper I: Taxonomy of planning and scheduling methods for a more efficient use in construction project management	To provide a taxonomy for planning and scheduling methods and tools **(# 1)**	Qualitative approach (critical literature review)	Submitted and accepted for publication
Paper II: Assessing understanding of planning and scheduling theory and practice in construction projects	To evaluate the current level of understanding of applications of project planning and scheduling fundamentals in practice **(# 2)**	Quantitative method (questionnaire survey)	Published
Paper III: Enablers and barriers to planning and scheduling based on construction projects in Oman	To identify and evaluate significant enablers and barriers to planning and scheduling **(# 3)**	Quantitative method (questionnaire survey)	Submitted and accepted for publication
Paper IV: Understanding project management roles and organizational behaviour in planning and scheduling based on Oman construction projects	To identify and evaluate project management roles and organizational behaviour in planning and scheduling practices **(# 4)**	Quantitative method (questionnaire survey)	Submitted and accepted for publication
Paper V: Understanding the application of front-end planning (FEP) in construction projects	To evaluate project stakeholders' understanding of the application of front-end planning (FEP) **(# 5)**	Quantitative method (questionnaire survey)	Submitted and under review

THEORIES AND CONCEPTS OF PROJECT PLANNING AND SCHEDULING

'It is within this context of planning and scheduling in the twenty-first century that we need to consider the fundamentals of planning and scheduling'. (Baldwin and Bordoli, 2014, p.7)

2.1 Introduction

The extant theory relevant to this research was approached and investigated, with the aim of understanding and identifying shortcomings in the application of project planning and scheduling in practices within the context of construction projects. This work covered: (1) the related areas or aspects of project planning and scheduling, namely project planning and scheduling fundamentals; (2) the factors impacting project planning and scheduling; (3) management roles and behaviour (or attitudes) of project stakeholders in planning and scheduling; and (4) front-end planning.

2.2 Project planning and scheduling: definitions and objectives

The definition of project planning has been considered across broad front by both construction researchers and practitioners (Baldwin and Bordoli, 2014). For example, project planning is defined as a set of established processes used

to make a decision on what tasks must be performed to achieve the project's set objectives within schedule and cost (Pierce, 2013). The author further stated that planning involves the development of realistic schedules and cost estimates, the assignment and coordination of resources, as well as taking account of the views of project stakeholders. Project planning can also be regarded as an iterative process or procedure utilized to define project scope, develop and refine project objectives and set the course of actions to run a project according to specified standards of quality (Faniran et al., 1998). Baldwin and Bordoli (2014) state that regardless of the definition chosen for project planning, it has the objective of achieving a number of common factors including the production of realistic schedules and costs, the completion of a project to defined standards of quality, design criteria, project resources, health and safety, and meeting project stakeholders' expectations.

From the perspective of the study reported in this thesis, project planning can be viewed as a systematic procedure involving the complete definition of the scope of preplanning stages, the identification of significant factors affecting project planning performance and control, as well as the identification of roles and behaviours of project stakeholders involved in the development and implementation of project planning.

Depending on the observer or author, scheduling is regarded as either an integral part of, or output from, project planning. A schedule is a representation of project activities identified by the work breakdown structure (WBS), as part of the definition of the project scope (Baldwin and Bordoli, 2014). In addition, the concept of project scheduling deals with the logical sequencing of activities and the addition of activity durations. It includes

related concepts such as resource loading and tracking progress during project execution (Yang, 2007).

More recently, it has been argued that planning and scheduling should be recognized as two separate, but closely related, activities that should not be performed concurrently in practice (Baldwin and Bordoli, 2014). According to Baldwin and Bordoli (2014, p.9): *"[…] planning may be an iterative process but the tasks of planning and scheduling should not be attempted concurrently. Planning should precede scheduling. Scheduling should never precede planning. It is not a good practice to plan whilst scheduling. It is not a good practice to schedule whilst planning. Planning and scheduling therefore requires timing, organization and discipline. On larger projects, where planning and scheduling will be separate tasks undertaken by different people, it is easier to differentiate between the two tasks, and the tendency to confuse the roles of planning and scheduling is less likely to arise."*

On the basis of the distinction between planning and scheduling as two separate tasks, Baldwin and Bordoli (2014) simplified the objective of planning and scheduling as follows: *"the main objective of planning is to ensure that things happen successfully. This requires objectives to be established, tasks to be identified and progress to be monitored. The project schedule provides the basis for measuring progress, the basis for regular review and an updating of the plan" (Baldwin and Bordoli, 2014, p.13).* From project management perspective, project planning and scheduling involve interrelated inputs and detailed deliverables that are to be implemented according to their assigned objectives. These objectives should be effectively defined and controlled early in planning and during execution for successful project performance. Figure 2.1 presents an overall view of planning and scheduling inputs and related functions (objectives) of each assigned input (or project activity).

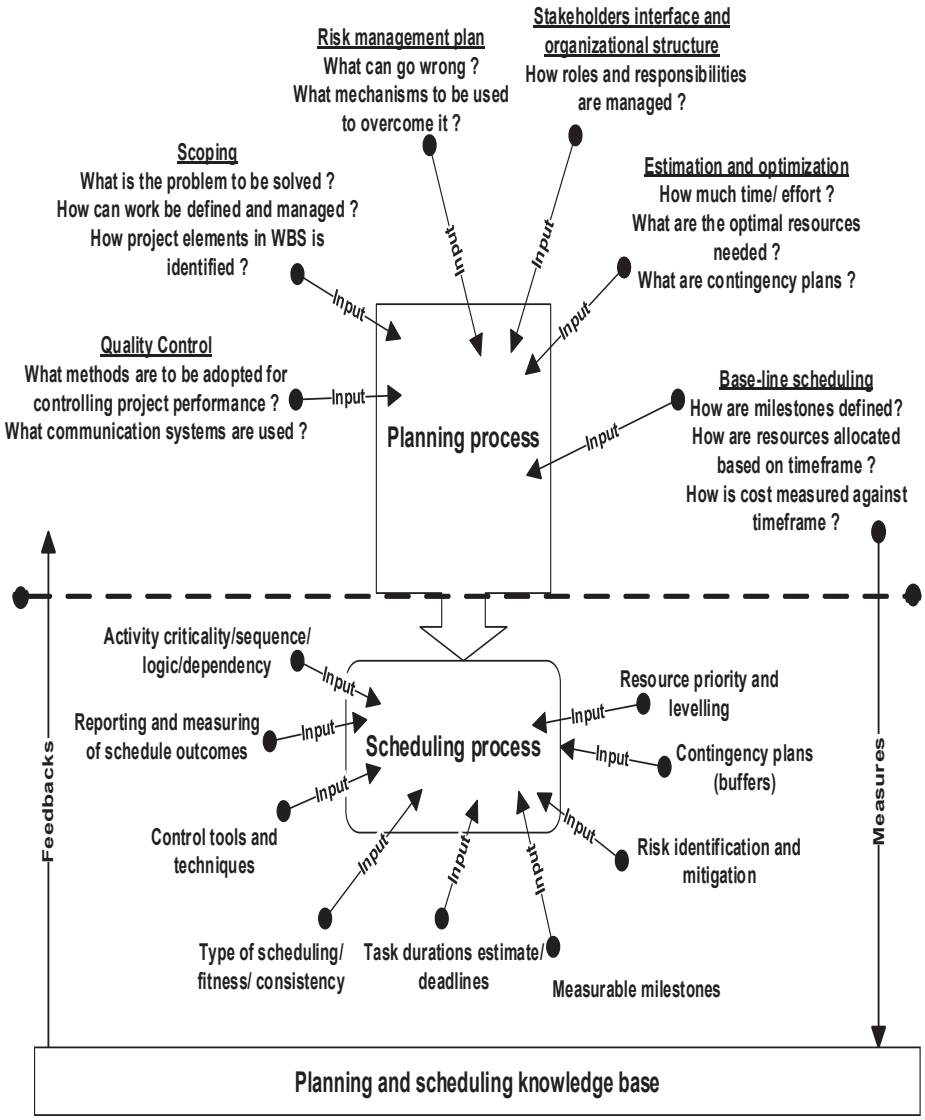

Figure 2.1 *Typical planning and scheduling systems based on (PMI, 2008) and (Kerzner, 2013).*

2.3 Significance of project planning and scheduling

The significance of project planning was recognized in early construction studies (Laufer and Tucker, 1987), in which it was argued that project planning needed to be improved by considering more efficient management strategies in planning. According to Dvir et al. (2003), there is a strong correlation between successful project planning and the success of a project from the perspective of project stakeholders. These authors also indicated that clear definitions of functional and technical specifications in project planning can lead to more effective execution of projects. They also found a strong correlation between successful implementation of planning procedures and benefits to project stakeholders. Such findings are confirmed in a later study which indicated that project success can be measured in view of the quality of project planning; whereas poor planning means uncontrolled alterations in the planning variables of time, cost and quality (Dvir and Lechler, 2004). Zwikael (2009) argued that many construction projects are more likely to be subject to the risk of poor project planning when compared to projects in non-construction sectors. Zwikael assessed the significance of project planning in construction projects and found that the extent of use of proper project planning by project managers and other project stakeholders was not at the optimal level of project requirements. He further argued that a strong emphasis should be placed on defining the project scope, project activities and costs (or budgets).

Regarding project scheduling, the development of a good project schedule is vital to an understanding of project performance and control (Ahuja and Thiruvengadam, 2004). Good scheduling represents a roadmap for project managers, planners and schedulers in monitoring and tracking critical activities and milestones during the progress of a project (Baldwin and Bordoli, 2014).

They indicated that good project planning and scheduling can provide tangible benefits for key project stakeholders. According to Baldwin and Bordoli, important benefits include: (1) the ability to forecast resource requirements and costs; (2) the ability to develop more realistic schedules with clear time deadlines; (3) the ability to communicate with clear and reliable information to project stakeholders; (4) providing reliable information for risk and opportunity assessment; (5) providing good information for monitoring and control; (6) minimizing materials wastage; and (6) providing a strong basis for team coordination and assisting in the negotiation of contractual claims. As Baldwin and Bordoli point out, these benefits cannot be achieved without strong commitment and knowledge on the part of project managers and other project stakeholders on how to manage planning and scheduling most effectively. Despite these theoretical discussions on the significance of project planning and scheduling, little empirical research has attempted to understand the effectiveness of its application in construction projects.

2.4 Project stakeholders in planning and execution

Project stakeholders can be defined as groups or individuals having a stake in, or expectation of the outcomes from, the performance of a project and by which they can positively or negatively influence the overall project strategy (Newcombe, 2003). Newcombe also indicated that stakeholders included people inside and outside the project (i.e. owners, project managers, designers, contractors, subcontractors, suppliers, funders and social communities). In this regard, the management of project stakeholders, either as groups or individuals, is a broad concept within both the internal and external boundaries of a given project and where those stakeholders have an influence upon, as well as benefits from its outcomes (Olander, 2007). Olander further indicated

that the understanding and recognition of project stakeholders involved in a construction process is important for the most efficient management of their concerns and needs.

It has been argued that project managers are responsible for including and managing the interests and expectations of project stakeholders, as well as their associated impact on the efficiency of decision-making with respect to the achievement of project success (Olander, 2007; Wang and Huang, 2006). A more recent study by Yang and Shen (2015) reveals that owners (or clients) and designers are considered to be the most dominant stakeholder organizations in construction projects. These stakeholders have been traditionally considered as primary project stakeholders as they are directly involved in a project, whilst other stakeholders have been regarded as secondary stakeholders (Newcombe, 2003).

It can be argued that it is very necessary to recognize the types of project stakeholders involved at particular project activities, such as planning and scheduling. Baldwin and Bordoli (2014) assert that all project stakeholders responsible for the management, execution and control of construction projects should participate in planning or, at the very least, propose their own plan for negotiation. According to Baldwin and Bordoli, these project stakeholders traditionally include owners, project managers, designers, contractors and subcontractors at various levels in their organizations. Understanding and considering project stakeholders' perspectives, needs and concerns in planning and execution of a project are important issues for the successful implementation of a construction project (Olander and Landin, 2005). Yang and Shen (2015) state that the analysis of project stakeholders attitudes, behaviours and opinions (or perspectives) about project activities at different stages is a vital tool for project managers' decision making and

problem solving. Providing space for more effective project stakeholder involvement in the planning and management of construction projects remains a problematic issue that needs further consideration at the strategic level of the project (Storvang and Clarke, 2014).

Although the research in this thesis does not examine the management of project stakeholders as a process, it has investigated the perspectives of project stakeholders involved in a number of construction projects, as well as those of the project management team. The primary project stakeholders are owners, project managers, designers and contractors, and secondary project stakeholders are those involved in sub-contracting and the supply chain in general.

2.5 Knowledge requirements for successful planning and scheduling

In construction projects, the maturity of the project management body of knowledge is a key issue for the successful achievement of project objectives (Morris, 2013). It can be argued that such knowledge should be focused on, and prioritized for, specific management areas in order to improve the probability of a successful project outcome. According to Kerzner (2009), project planning requires effective skills and knowledge about the collection and analysis of information, communication with project stakeholders, resource negotiations, commitment and the involvement of top management, and definition of measurable milestones. Such planning knowledge and skills on the part of project stakeholders, however, needs to be understood and assessed in practice. In the research reported here, the literature related to

project planning and scheduling was investigated in regard to following main five topics:

1. project planning and scheduling fundamentals;
2. planning and scheduling methods and tools;
3. factors affecting project planning and scheduling;
4. management roles and organizational behaviours in project planning; and
5. front-end planning in construction projects.

2.5.1 Project planning and scheduling fundamentals

As indicated earlier (Figure 2.1), clear understanding and definition of all inputs in project planning and scheduling will increase the chance of successful project performance. Fowler et al. (1995) argued that, without essential knowledge about project planning, scheduling problems will subsequently occur and the use of contingency plans might not be efficient. Recently, it was argued that a higher level of management and competency is required for the development of project plans which can be used as a reliable basis for controlling project performance (Baldwin and Bordoli, 2014). The competence of project stakeholders (i.e. owners, project managers, designers and contractors) in providing a high level of reliable and detailed inputs and deliverables in the early planning stages is crucial for the implementation of project planning in construction projects (Johansen and Wilson, 2006).

In view of the relevant literature mentioned earlier, an understanding of scheduling concepts should also involve important aspects and issues, such as resource loading and trade-offs, risk identification and mitigation, control

techniques, activity criticality and dependencies, and contingency plans or buffers. Snoo et al. (2011) asserted that the application of scheduling concepts can be evaluated on the basis of two main criteria: (1) uncertainty regarding resource loading and levelling in the development of the schedule; and (2) uncertainty regarding schedule execution and control.

2.5.2 Planning and scheduling methods and tools

Planning and scheduling methods and tools are regarded as essential parts of project planning and scheduling (Baldwin and Bordoli, 2014). It could be argued, therefore, that failures in project schedule performance should call for a specific focus on the effectiveness of existing methods and tools for managing construction schedules. In current practice, various project planning, monitoring and control methods and tools, in both traditional and modern approaches, are in use (Ahuja and Thiruvengadam, 2004; Al Nasseri et al., 2013). Planning and scheduling methods vary in use, ranging from traditional approaches such as line-of-balance, the critical path method (CPM) and program evaluation and review technique (PERT) to more sophisticated methods such as critical chain project management and the Last Planner System (Demeulemeester and Herroelen, 2002; Kenley and Seppanen, 2009). On the basis of these methods and tools, project scheduling can be classified into two main groups: resource-driven scheduling and time-driven scheduling (Memon and Mohammad, 2011). Resource-driven scheduling can be defined as a schedule that is driven by, and limited to, available resources (i.e. technical and human resources); examples are line-of-balance and the Last Planner System. Time-driven scheduling concerns the traditional scheduling of project activities on the basis of estimated durations and their dependency relationships, regardless of resource limits; examples are CPM and PERT.

These methods are already integrated into software to handle the complexities of large-scale construction project schedules. However, the complexity of project schedules can hamper the understanding of the application of these different methods and tools when executing and controlling the project (Weaver, 2009). Consequently, the effectiveness of scheduling using different methods and tools should be properly assessed by project managers and their planners. Ahuja and Thiruvengadam (2004) indicated that the construction industry has struggled to become specialized in certain types of projects that require more sophisticated methods and tools to manage schedules than is possible using a traditional approach. The authors asserted that: *"[…] the most utilized scheduling tools in the construction industry are CPM/PERT. However, the limitations of these tools are also being realized and research is going on to improve these tools and increase utilization of other tools such as linear scheduling techniques, simulation techniques, genetic algorithms for construction activities" (Ahuja and Thiruvengadam, 2004, p.21).*

Despite advances in many scheduling techniques, previous research has implied that there are still many challenges in achieving a fit-for-purpose schedule, within the allocated time and available resources, using different methods and tools (Ahuja and Thiruvengadam, 2004; Cegarra and Wezel, 2011; Shash and Ahcom, 2006). These studies suggested there might be a need to determine more appropriate mechanisms for gaining a proper understanding of the underlying concepts of different methods and tools. Yang (2007) introduced a knowledge-based construction scheduling framework to enable a better understanding of the different scheduling problems and the different methods and tools used to handle them. Yang also identified areas that need to be covered in the knowledge domain of construction scheduling (see Figure 2.2).

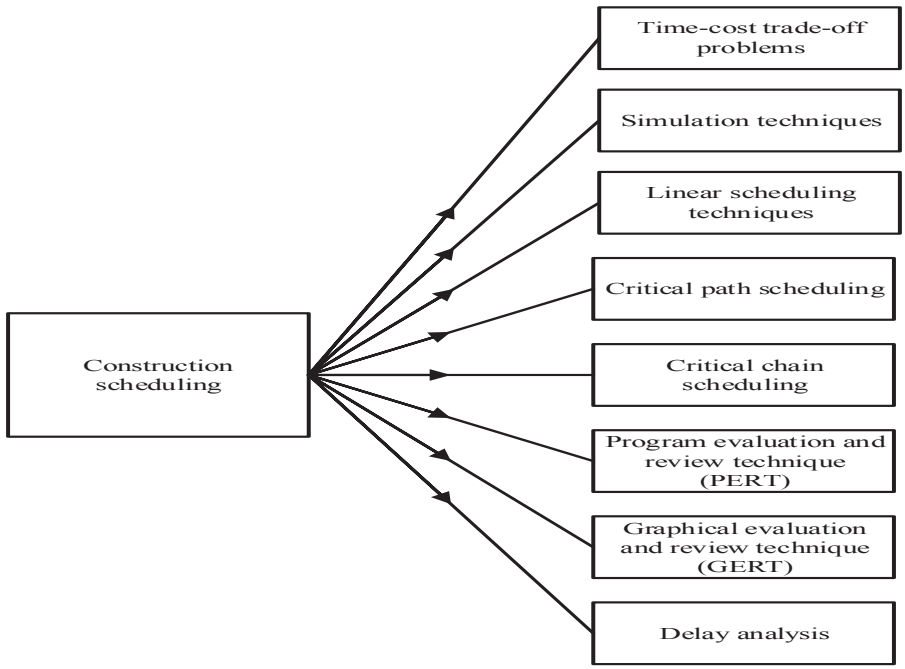

Figure 2.2 *Knowledge aspects of construction scheduling (Yang, 2007).*

2.5.3 Factors affecting planning and scheduling

A number of studies examined factors associated with the performance of planning and scheduling in construction projects; however, the main focus has been on the factors affecting schedule performance as an indicator of project success. For example, Hwang et al. (2013) studied critical factors affecting scheduling performance on public construction projects in Singapore. Their study indicated that poor site management and lack of effective coordination among project stakeholders, as well as inadequate competence in the project

management team, were ranked as the most significant factors having a negative impact on schedule performance. Voth (2009) assessed significant barriers to scheduling at the Aeronautical Systems Centre (ASC), where the findings revealed a lack of team training and acquisition of knowledge about scheduling, shortage of resources, lack of disciplined project management and schedule as the factors having the most impact on scheduling. In another study, on schedule performance in Indian construction projects, Iyer and Jha (2006) found that factors such as the commitment of project stakeholders, competence of owners and a diversity of perspectives from project stakeholders in planning were considered significant factors in the success of project schedule performance. In addition, adopting proactive scheduling, motivational programs and effective communication approaches are important factors for schedule performance (Nepal et al., 2006).

Snoo et al. (2011) assessed the factors (or criteria) affecting the performance of scheduling from the perspectives of a number of project stakeholders. The authors revealed that project schedules did not seem to be properly considered by both project managers and their planners/schedulers, as many criteria were ignored while developing and executing the project schedule. These criteria concerned reliability and robustness of information in the schedule, resource utilization and constraints, skill and competence of the planners/schedulers, and the level of uncertainty and complexity within the internal and external environments. The authors developed a scheduling performance measurement framework which categorized the factors (or criteria) impacting schedule performance into four main groups as shown in Figure 2.3.

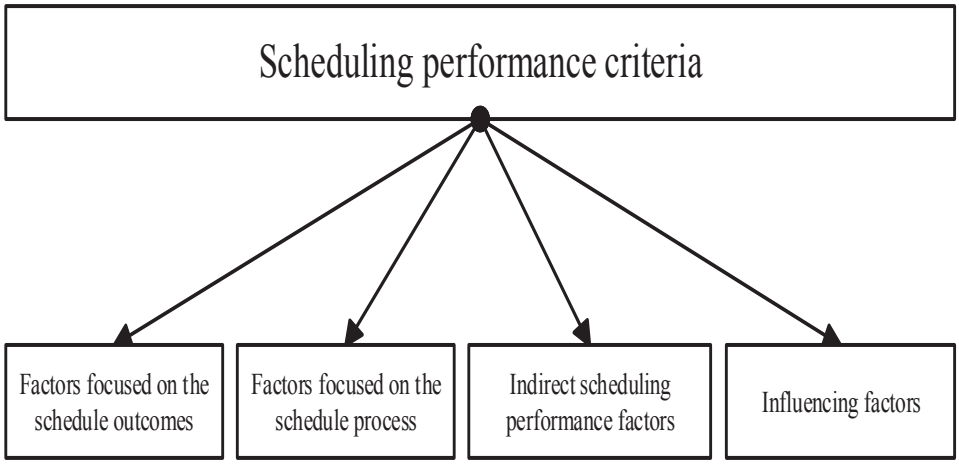

Figure 2.3 *Categories of factors (criteria) affecting scheduling performance (adapted from Snoo et al., 2011).*

Relatively few studies have investigated and analysed factors affecting project planning processes. Yang and Wei (2010) assessed factors causing delay concerning the planning and design stages of construction projects. They found that changes in the requirements of project stakeholders, especially owners, poor scope definition and an unrealistic initial or baseline plan were the top factors causing delay to a project. Consequently, there is a need to focus on factors affecting project planning, which in turn have a negative impact on the performance of the project. Dvir et al. (2003) examined the relationship between project planning and project success from the perspectives of project stakeholders. They found that the effective definition of project scope at the early planning stages is significant to the success of a project. The authors further revealed that the inadequate involvement of project stakeholders will negatively affect the effectiveness of planning.

Earlier research indicated that factors impacting project planning should be evaluated from two perspectives – factors affecting the formulation of plans within the organizational environment and factors affecting implementation of plans within the project environment (Faniran et al., 1998). According to these authors, examples of factors related to project environments are variables concerning planning time, inputs, cost, investment of resources, planning control and attitude of top management. Variables related to the organizational environment included decision-making processes, organizational structures, availability of resources, control and communication mechanisms, and specialization of firms in planning. A model proposed by these authors is portrayed in Figure 2.4.

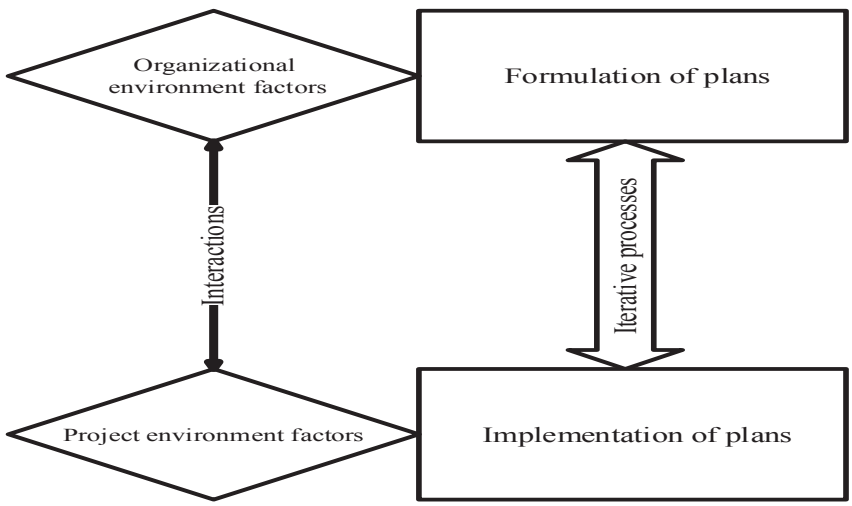

Figure 2.4 *Factors affecting project planning (adapted from Faniran et al., 1998).*

2.5.4 Project stakeholders' roles and behaviours in planning and scheduling

Improving the effectiveness of project planning and scheduling also requires an understanding of the roles and behaviour of stakeholders in a project organization. Little research has addressed such roles and behaviour, although some attempts have been made to examine project stakeholders' attitudes in construction projects. In this regard, Yang et al. (2009) revealed that the assessment of project stakeholders' behaviour and attributes is crucial for successful, i.e. predictable, execution and delivery of construction projects. More recently, Yang et al. (2014) found that successful decision-making processes in construction projects require understanding and management of attributes, behaviours and management strategies related to project stakeholders. In this connection, the authors studied the correlation, from the perspective of project stakeholders, between their attributes (power, urgency and proximity) and their behaviour (cooperative potentials, competitive threats and opposite and neutral positions). Their study revealed that there is need to try to understand such attributes and behaviours in construction projects. Prior to this study, Walker (2011) suggested that organizational behaviour and interactions among various project stakeholders do not appear to be properly considered in practice and expressed this concern as follows: *"[…] there is great scope for the behavioural characteristics of those involved to become significant in the success of firms and a project as a successful construction project required high levels of collaboration and communication. Inappropriate behaviours can have a serious effect on the smooth running of projects" (Walker, 2011, p.7).*

It is important, therefore, to understand roles and behaviours of project stakeholders, as they can serve as critical factors for successful project

performance (Yang et al., 2011; Yang et al., 2014). Understanding the behaviour of project management leadership in terms of competence, technical experiences and decision-making attitude is crucial to the success of a project (Dulaimi and Langford, 1999). Additionally, an empirical study of the understanding of such management roles affecting project performance indicated that the definition of roles and responsibilities was considered as the factor that should be given priority when managing a given project (Anantatmula, 2010).

With a specific focus on organizational behaviours, French (2011) defined organizational behaviour as the attitude of project individuals or groups and their impact on the organization at both the management and project levels. In the context of project planning and control, a study by Walker and Shen (2002) found that effective project planning and control is directly influenced by the organizational culture as well as the norms and values of both the project team and individuals. An empirical study by Johansen and Wilson (2006) indicated that the roles of particular project stakeholders (i.e. owners, contractors, office-based planners and site-based planners) in the development and control of construction planning should be clearly defined and coordinated for a successful project. From a broader perspective of project management, roles and responsibilities of the project management team should be outlined (Kerzner, 2009). However, management roles and the behaviour of project stakeholders at particular stages, such as planning and scheduling, need further assessment.

2.6 Front-end planning (FEP)

2.6.1 Definition of front-end planning

The early planning process, encompassing all project activities between project initiation and scope definition, forming the platform for more detailed design and is known as preplanning (Gibson et al., 2006). Other, recently adopted concepts of a preplanning process include front-end loading and front-end planning, depending on where it is applied (Bosfield, 2012). Front-end planning has been viewed as an essential task in the project preparation stage, yet front-end planning itself seems to be a confused topic for many project stakeholders as it has been defined and implemented from different perspectives by different disciplines (George et al., 2008). More recently, the Construction Research Institute (CII) has defined front-end planning (FEP) as a systematic procedure developed at the front end of a project. It has been developed to provide stakeholders, especially on the part of owners (or clients) with clear information regarding the opportunities and risks of a potential project prior to detailed design and execution (CII, 2012).

2.6.2 Main stages of front-end planning

According to CII (2012) and Merrow (2011), the work procedure of front-end planning is typically divided into a stage-gated process as presented in Figure 2.5. At the end of each stage, project managers and other stakeholders should be able to make the most appropriate decisions in terms of the maturity of scope definition at each stage before proceeding to the next. Merrow (2011) also argued about the importance of ensuring a high level of reliability in regard to the definition of each stage, since it feeds into the next. Failure to do

so will lead to impossible governance of project requirements and increase the risk of failure in project planning overall.

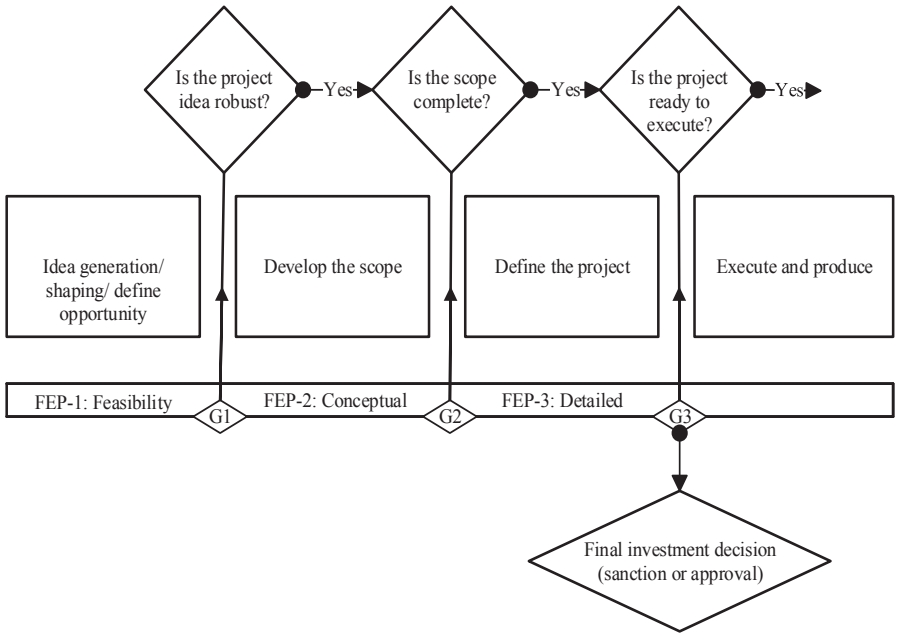

Figure 2.5 *A typical front-end planning (FEP) configuration, based on a stage-gated process (adapted from Merrow, 2011).*

2.6.3 Significance of front-end planning to project success

Front-end planning has been introduced and experienced as a preplanning approach to allow project stakeholders, especially owners, obtain necessary and clear information about potential risks in the front-end stages of a project (CII, 2012). By obtaining such information, project stakeholders should be able to define all elements of the project scope for design, execution and control (George et al., 2012). Previous research recognized the significance of front-

end planning for project success in terms of a reduction in time and cost escalation/inflation, which were experienced as common problems in worldwide industrial and construction projects (Gibson et al., 2010; Gibson et al., 2006; Merrow, 2011). The Construction Research Institute (CII) has carried out much research on developing and examining front-end planning practices. Effective front-end planning is claimed to reduce total design and construction costs, as well as schedules, by as much as 40% in comparison with projects lacking experience in front-end planning (Bosfield, 2012).

A modest number of studies have considered preplanning processes (i.e. front-end planning) from various perspectives. For instance, Mirza et al. (2013) asserted that an accurate definition of project scope early in the preplanning stage can result in more predictable outcomes with respect to the project objectives, as well as an ability to meet project stakeholders' expectations. This level of significance had previously been shown in a study by Faniran et al. (2000), who argued that successful project planning depends on the effectiveness of definition at the front-end of a project. The authors expressed this as follows: *"[…] if the front-end project management activities are not properly organized and managed, then there is a high likelihood that the assessment and evaluation of the project will not be done properly, and similarly neither will the planning… the initial expense will certainly lead to enormous time and cost savings, and a higher probability of eventual project success" (Faniran et al., 2000, p.5).*

Front-end planning has been examined in other industrial sectors, such as oil and gas which usually involve much construction work. The findings indicate a strong correlation between well-defined, front-end planning and success in terms of time/cost effectiveness, as well as project stakeholders' satisfaction with the final product (Van der Weijde, 2008). This latter study showed no

indication of whether or not front-end planning was understood and adopted on construction projects. However, a more recent study in the Saudi Arabian construction industry by Fageha and Aibinu (2014) made an initial attempt to assess the definition of project scope elements in the early planning stage. Their study showed that project cost estimates, documentation of deliverables, design of reliable schedules, and setting-up the basis of design are major elements that should be given a high priority when defining project scope at the preplanning stage. These findings support the need for assessment of front-end planning, which is one of the areas examined under the scope of this thesis. Figure 2.6 presents a model illustrating the relationship between successful front-end planning and successful project performance. This is reflected in terms of high scope definition and good execution in line with the expectations of project stakeholders.

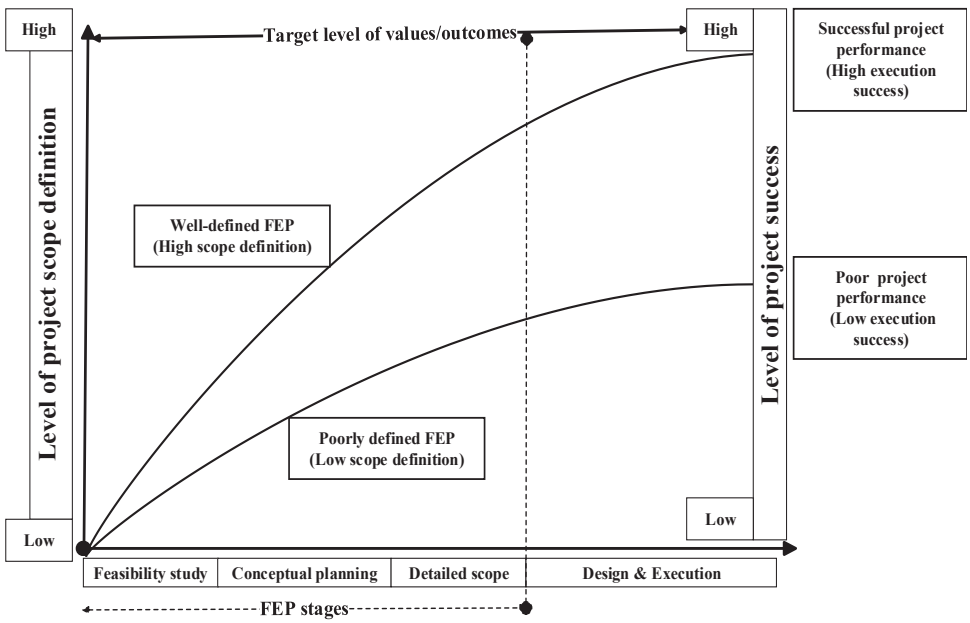

Figure 2.6 *Significance of front-end planning to project performance.*

2.6.4 Factors impacting the effective application of front-end planning

To improve the adoption of front-end planning in practice, significant barriers should be identified and mitigated. There have been attempts to understand critical factors and barriers to the application of preplanning (or, more precisely, front-end planning). For instance, Yu and Shen (2014) indicate that ineffective communication between project stakeholders when defining project objectives and poor identification of project risks are the most significant factors impacting the effectiveness of preplanning. Yu and Shen also recommend that project managers should be able to review and analyse the opinions and concerns of project stakeholders through structured workshops in order to define sufficiently the project's scope. George et al. (2008) regarded factors such as inadequate scope definition and an unclear description of project stakeholders' roles as major concerns in preplanning. A study by Bosfield (2012) found that lack of knowledge and commitment regarding front-end planning and lack of specialized front-end planning consultants were the most significant barriers preventing more widespread adoption of front-end planning in construction projects. More recently, Suk et al. (2014) argued that the development of suitable front-end planning can be also influenced by project's nature in terms of its size, characteristics, resources and technology. In spite of these insights, it can be argued that there is a need to consider what other factors might exist from the wider perspective of project stakeholders. This could provide a better appreciation of the significance of such factors to, and their impact on, the definition of project scope at the front-end of a project.

2.7 Summary of the findings from the literature

The above literature review implies justification for further investigations and exploration of project planning theories using various measures, such as assessing project stakeholder perspectives of, and knowledge about, promoting the theory of planning and scheduling in practice. Based on the findings distilled from the literature review, a number of areas are suggested as needing further investigation.

1. Planning and scheduling theories and concepts seem to be adequately covered in the project management literature. However, it is unclear how knowledgeable construction organizations and project stakeholders are about project planning and scheduling practices.
2. Despite previous research paying more attention to various factors (success and failure criteria) impacting project performance, the investigation of independent factors (enablers and barriers), particularly impacting project planning and scheduling, appears not to be explicitly examined.
3. Although project planning and scheduling challenges are relevant to all project stakeholders, the assessment and understanding of project management roles and the behaviour of these stakeholders in planning and scheduling have not been explicitly considered.
4. Knowledge gaps in planning and scheduling practices have indicated a need for an investigation of the quality of definition of project plans at the front-end. A greater investment at the front-end will likely reduce the likelihood of later scope changes and, thereby, improve project performance.

Figure 2.7 presents the research theoretical framework discussed above. It displays a bottom-up approach to research areas investigated, where the literature review (outputs) lead to the identification of planning theories investigated with respect to: (1) knowledge of, and understanding about, planning and scheduling theory and methods; (2) significant factors (enablers and barriers) impacting the effectiveness of project planning and scheduling; and (3) project management roles and behavior related to project stakeholders in planning and scheduling. In a later stage of this research, a combination of the findings (inputs) — discussed later in Chapter 4 — from the investigation of these topics implied that there is a need to identify and examine shortcomings in project planning at the front-end of a project.

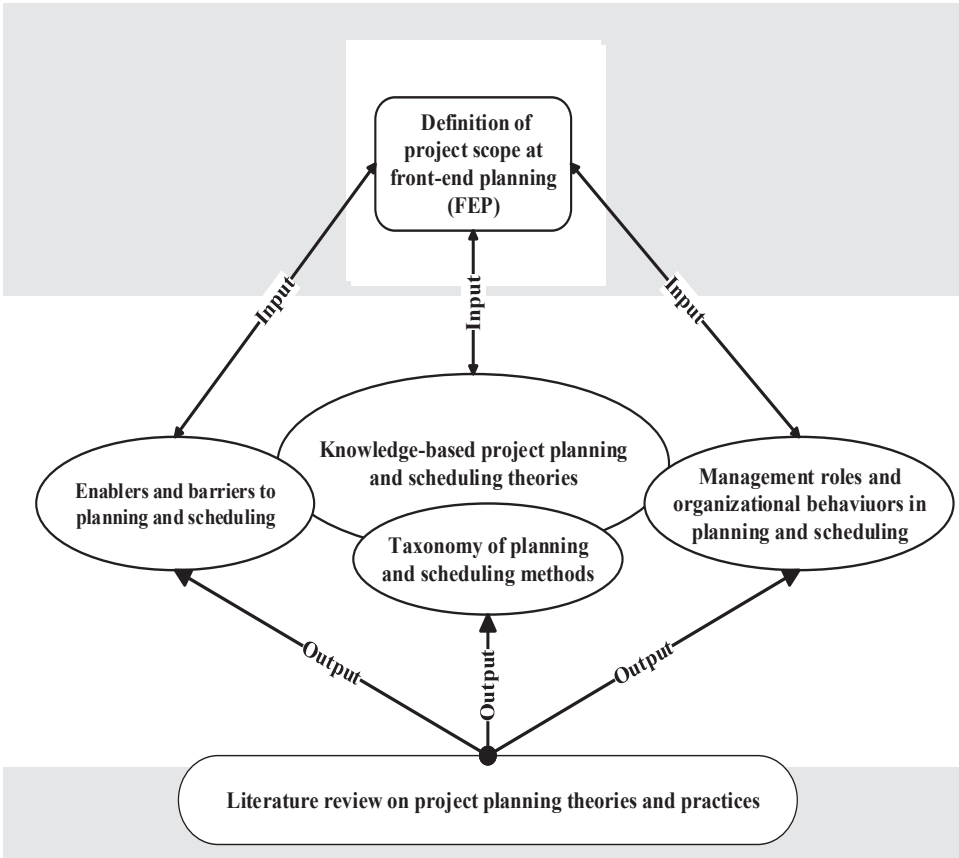

Figure 2.7 *The investigated research areas and their relationships.*

RESEARCH METHODOLOGY

3.1 Introduction

The research was conducted with the aim of examining the extent to which project stakeholders understand the application of project planning and scheduling in practice, with a specific focus on the advancement of project stakeholders' knowledge and learning in the context of project planning. Consequently, an appropriate research strategy and accompanying methods were investigated.

3.2 Research context — Oman construction projects

In general, construction projects within the Gulf region, where this research was conducted, are set in broadly similar cultures. It was reported earlier that the construction projects of the countries of the Gulf Cooperation Council (GCC), of which Oman is a part, have experienced a boom (Sivam et al., 2011). This necessitates, amongst other things, the need for more effective management of life-cycle processes for projects into the future.

Oman is considered to be the second easiest market for doing business in the Gulf region (Sachin et al., 2014). The Oman construction industry represents the cornerstone of the country's national economy, with an estimated annual growth rate of more than 5%, even though the country has a relatively small population of approximately 4 million, including around 1.8 million multi-

national (expatriate) workers. The country is expected to invest an estimated USD 50 billion in construction and infrastructure projects, including residential buildings, commercial and industrial projects, dry docks, railways, airports and expressways over 15 years (Oxford Business Group, 2014).

According to the Oman government regulatory system, public tender projects with estimated costs above approximately USD 650,000 (1USD=0.385 Omani Rail) are floated through the Oman Tender Board, which is an independent government authority responsible for tendering and awarding all types of government or public projects (Oman Tender Board, 2014). The Oman Tender Board manages the preparation of these projects through the "Standard Documents for Building and Civil Engineering Works", which is a regulated contractual procedure designed to facilitate re-measurable and lump-sum contracts, and which must be followed by all bidders participating in both public and private projects. There are, however, exceptional cases where governmental units or ministries are allowed to manage certain types of projects, such as motorways and airports, through internal tenders in coordination with the Oman Tender Board.

The boom in construction projects in the country requires best project management practices, particularly in the planning stage where many activities or scope elements have to be adequately identified and defined prior to execution. Table 3.1 presents a summary of some major construction and infrastructure projects currently under design and construction in Oman.

Table 3.1 Examples of ongoing infrastructure and construction projects in Oman based on Deloitte (2014) and Oxford Business Group (2014).

Projects	Estimated cost (USD billion)	Brief descriptions
Duqm city, dry-docks and refinery	20	A multi-phased mega-project consisting of dry-dock, residential buildings, airport and entertainment facilities
Oman railway networks	15	Links between cities and sea ports across Oman with other Gulf states
Expansion of Muscat and Salalah international airports	5.5	New passenger terminals, control towers, parallel runways and boarding bridges
Al Batinah expressway	2.6	A new motorway connecting Muscat to the UAE
Oman Convention & Exhibition Centre	1.0	Auditorium, banquet halls and meeting rooms
Salalah Medical City (phase 1)	1.0	A multi-specialty hospital, treatment facilities, medical and nursing colleges

Note. These estimated costs will be substantially spent on civil and related infrastructure works.

3.3 Research strategy

3.3.1 Research paradigms: ontology, epistemology and methodology

Research can be described as a systematic approach to defining a problem, formulating a hypothesis (or a proposition), testing and gathering facts about the problem and finding and generalizing a solution (Kothari, 2011). Ontology, epistemology and methodology are the three main philosophical paradigms of research that determine how a study is undertaken and interpreted (Fellows and Liu, 2009). These paradigms are important for grounding, creating and

shaping the structure of knowledge about research. Ontology is the philosophical assumption about the nature of reality (or originality of knowledge) and its existence that a researcher investigates (Easterby-Smith et al., 2012). Epistemology is a set of philosophical assumptions concerning knowledge about the most appropriate way of investigating the nature of the reality. Ontology must precede epistemology since researchers cannot know what is intended to be known (epistemology) unless they have reasonable assumptions about the nature of the knowledge that to be investigated (ontology) (Bates and Jenkins, 2007). These philosophical views enable the researcher to think about the formulation of the most appropriate research methodology through which the reality (or scientific knowledge) is investigated and extended, and by which solutions to research problems are found.

Research methodology is defined as the rationale for selecting a research strategy, research design and research methods needed for conceptualizing and implementing research (Neuman, 2006). It is a combination of techniques used to enquire into a specific reality and how observations about such reality are analysed and disseminated (Easterby-Smith et al., 2012). In view of the research problems (expressed as questions) discussed earlier (Chapter 1), and their related assumptions in regard to appropriate research paradigms, the overall research approach was developed as shown in Figure 3.1.

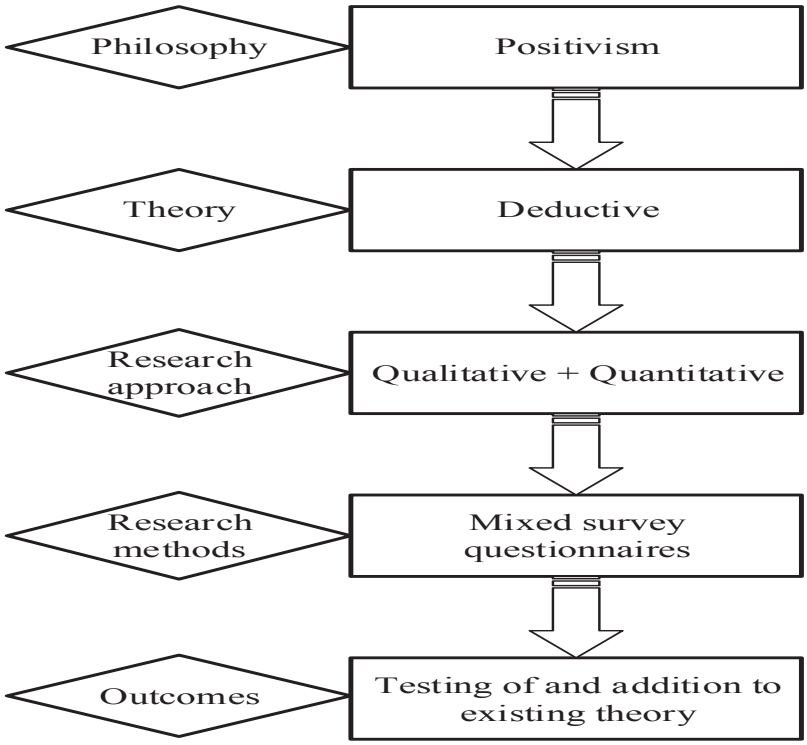

Figure 3.1 *The research strategy.*

On the basis of this strategy (Figure 3.1), a brief description of each philosophical position and its relevance to the research is presented and discussed in the following sections of this chapter.

3.4 Research philosophy

Epistemology deals with the issue of what is or should be considered (or assumed) as acceptable knowledge with regard to the research phenomenon being studied (Bryman, 2012). From the perspective of management research,

Easterby-Smith et al. (2012) described three commonly adopted epistemological philosophies: positivism, constructivism and critical realism. According to the authors, positivism assumes that world reality exists externally and can be measured through an objective method rather than the subjective reflections (or perceptions) of people. Constructivism is seen as an opposing paradigm to positivism, which assumes that world reality can be measured through people, ideas and reflections rather than objective measures (positivism) which are usually based on the limited control of observations made by a researcher. Therefore, constructivism is also referred to as an interpretive method since it is based on subjective measures of reality (Easterby-Smith et al., 2012). Critical realism offers a compromise position between positivism and constructivism. It combines, in people, perceptions and experiences (empirical views), events and actions that are either not observed or detected (actual views), as well as the causal mechanisms that have a real impact on people (real views). Specifically, a number of philosophical assumptions are developed when considering positivism (Easterby-Smith et al., 2012) and these are: (1) independence of the researcher from what is being observed; (2) the research is based on objective criteria rather than human beliefs or interests (subjective views); (3) the intention is to provide causal explanations and fundamental issues rather than understanding real beliefs and reflections; and (4) it is often based on a deductive approach of existing knowledge and generalization of perspectives, as well as representing a cross-sectional measure of data.

Research by Schrag (1992) defended consideration of positivism on the basis of the following issues (1) it treated investigated problems as causes, thereby reducing the chance to integrate perceptions into the research; (2) it assumed that problems could be investigated through uncomplicated people

interactions for a limited number of relevant factors; and (3) it considered the question of causation to be different from the question of implications.

3.5 Research theory

The relationship between theory and research is commonly based on two lines of reasoning: deductive and inductive approaches (Bryman, 2012; Fellows and Liu, 2009). The deductive approach concerns the development of research hypotheses or propositions on the basis of what is known about the research phenomenon being studied. Therefore, it follows a sequence of existing theory through observations to revision (or verification) of that theory. Conversely, the inductive approach concerns the formulation of new theory from what is known or observed. It follows a sequence of findings and observations through to the building of new theory. Whilst theory represents the input for deduction, it represents the output of induction. In relation to the epistemological positions mentioned above (Section 3.3), in contrast to constructivism which is often relying on an inductive approach of theory, positivism is more likely to rely on a deductive research enquiry (Riege, 2003). In the research reported in this thesis, the research questions were built on existing theory relating to the investigated research phenomenon. Therefore, it can be concluded that the adopted approach in the development of study (or survey) variables seems to be deductive in nature rather than inductive research enquiries used for building new theory.

3.6 Research approaches

The research started with a literature review relating to the research questions established in Chapter 1. The literature review can be described as the critical

examination of existing theories related to the research phenomenon or phenomena being investigated, with the purpose of establishing what is known and what is unknown or uncertain. There are, however, a number of other research methods within both qualitative and quantitative approaches such as surveys, interviews, experiments and case studies.

Qualitative and quantitative methods have been widely applied and so there are many different views about their appropriateness for pursuing particular lines of inquiry (Fellows and Liu, 2009). These authors further argued that the main distinction between the two approaches is the collection and analysis of data rather than the examination of theory and literature. According to Muijs (2010), quantitative methods are defined as essentially a matter of collecting numerical data to explain a particular research phenomenon. Qualitative methods are defined as approaches that seek a subjective understanding of people's perceptions, opinions and views, as well as the meaning of people's experiences, rather than verifying predetermined hypotheses (Fellows and Liu, 2009).

Whilst quantitative approaches seek the analytical testing of, and additions to, existing theory, qualitative approaches seek the discovery and building of new theory. From this perspective, quantitative approaches tend to be positivist based on a deductive approach whilst qualitative approaches tend to be constructivist based on an inductive approach (Easterby-Smith et al., 2012; Riege, 2003). In this thesis, the main study, reflected in Papers II to V, has adopted a quantitative approach in which mixed data collection questionnaires were considered and utilized.

3.6.1 Research methods

Research using quantitative and qualitative approaches varies in practice. For instance, surveys have been widely recognized as quantitative approaches for gathering data about people's opinions and attitudes towards research phenomena that can be best explained through objective measures (or positivist views) (Oppenheim, 2000). This view is also expressed by Easterby-Smith et al. (2012), who stated that survey research has been commonly regarded as quantitative and positivistic in nature compared to qualitative methods such as unstructured interviews and case studies. Surveys can be used as tools for collecting statistical (or quantitative data) from a representative sample with the aim of providing a good description about the research issues being investigated. According to Fowler (2008), a good survey involves an overall design strategy aimed at: (1) designing either an appropriate set of self-administered questions or good survey interviews (i.e. open-ended questions); (2) managing a good sampling process; and (3) gathering the most relevant data. A questionnaire-based survey should not, however, be viewed as simply a method for collecting some intended data; it should stand as a measurement approach to be integrated directly from research questions and related objectives (Oppenheim, 2000). Oppenheim expresses this view as follows: *"[…] we cannot judge a questionnaire unless we know what job it was meant to do. This means we have to think not merely about the wording of particular questions but first and foremost about the design of the investigation as a whole" (Oppenheim, 2000, p.10).* Research-based surveys can be formulated as either qualitative surveys in the form of open-ended questions or quantitative surveys in the form of closed questions (or statements) (Oppenheim, 2000).

The majority of data analysed in this study (except those in relation to Paper I) have been collected through survey questionnaires, as discussed later (Section 3.8). Thus, a comparison between survey questionnaires as a commonly adopted quantitative approach and other research methods that are closely related to the qualitative approach is necessary. The survey questionnaire is regarded as a suitable tool for collecting data on people's attitudes (or opinions) in research areas such as business, management studies and socio-political issues (Rowley, 2014). Rowley indicated that a good questionnaire-based survey normally involves hard work in designing, piloting, sampling and data collection. She further argued that the survey questionnaire has strength, but also a weakness, in gathering data as is the case for other research methods. As an example, Rowley stated that the distinguishing boundary between interviews and questionnaires is uncertain since both methods can be used to address the same sorts of questions to selected respondents, especially when using an open-ended questionnaire-based survey.

Unlike surveys, case studies might not be influenced by existing theory and so the replication of results cannot be guaranteed or claimed. Eisenhardt and Graebner (2007) suggested that only a good inductive case study can help in confirming research propositions, accentuating them and generating and discovering new knowledge (realism). Whilst surveys tend to be positivistic in nature, case studies normally follow realistic modes of inquiry (Riege, 2003). Another type of research method is the experiment, which has been used in scientific fields to study cause-effect relationships (unlike surveys) among the outcomes of specific investigations, based on a defined set of independent variables (Fellows and Liu, 2009). Experiments are best suited to measuring the impact of various independent variables (i.e. what is known) on the investigated research phenomenon (dependent variable).

In view of this guidance, this research has adopted surveys to study and examine the extent to which project stakeholders and their organizations are currently informed about the research areas investigated. This was based on the following considerations: (1) the literature review revealed the need for an empirical assessment of project stakeholders' perspectives in regard to project planning and scheduling; (2) there is a gap in previous research within the field of study; therefore, the results from the surveys might be used later as a basis for applying a more rigorous approach to solving research problems; and (3) surveys are more appropriate for generalizing from the overall findings with the aim of adjusting existing theory (Fowler, 2008). These considerations do appear to be applicable to the nature of the research questions being developed and assessed (Chapter 1). From here, the idea is to generate an overall profile by developing scales to measure the level of perspectives, agreements and attitudes of respondents in relation to identified research variables. In this research, the questionnaire-based survey has been considered suitable for collecting relevant data on the investigated topic areas or research questions (RQ2 to RQ5 in Chapter 1) by objectively measuring the perspectives of project stakeholders. On the basis of the above views, Table 3.2 presents the basic philosophical and methodological assumptions considered when developing the research strategy.

Table 3.2 Research strategy and selection criteria (adapted from Altoryman, 2014).

Quantitative approach – the survey questionnaire	
The philosophical assumption	• Positivism as the reality that is assumed to be existing; it is positively investigated and confirmed through objective and empirical measurements.
Research theory	• A deductive approach where predefined research questions (investigated criteria) are deduced from the literature. • Theory is tested and verified on the basis of research criteria where new knowledge is added.
Research process/the time zone	• Cross-sectional (i.e. non-iterative) and timely cost-effective processes. • Three related surveys were conducted separately, but each survey was implemented at one point in time with different individuals and project stakeholder organizations.
Data collection techniques	• Qualitative questionnaires – open-ended questions. • Quantitative questionnaires – closed questions. • Mixed questionnaires.
Merits of this type of research	• Integrating facts through people's opinions. • Providing descriptive metaphors about the research questions investigated. • Providing a basis for deeper investigations. • Verifying existing theories and generalizing new implications.

3.7 Research design

As noted in Chapter 1, the research consists of five related studies concerned with project planning theories and practices, and these are presented in five papers (see Appendix A). The research design was initiated from a broad literature review which was refined and narrowed as the research progressed, and which resulted in the formulation of the first research question. A critical

literature review of project planning and control, with a particular focus on planning and scheduling methods and tools was then conducted (see Paper I). In parallel with this, the literature was refined, which led to the formulation of the second and third research questions (see Papers II & III). These studies formed two essential parts of a larger questionnaire survey assessing the understanding of planning and scheduling fundamentals, including factors affecting successful planning and scheduling outcomes. Consequently, this study was aligned with the fourth study (see Paper IV) which examined project management roles and organizational behaviour in planning and scheduling. This study was concerned with human aspects of project planning and scheduling theory (or project stakeholders' attitudes). The final study (see Paper V) has examined a set of criteria (or factors) relating to the application of front-end planning in construction projects. Figure 3.2 presents the overall design of research, and shows the sequential and iterative links between the studies and the research methods adopted.

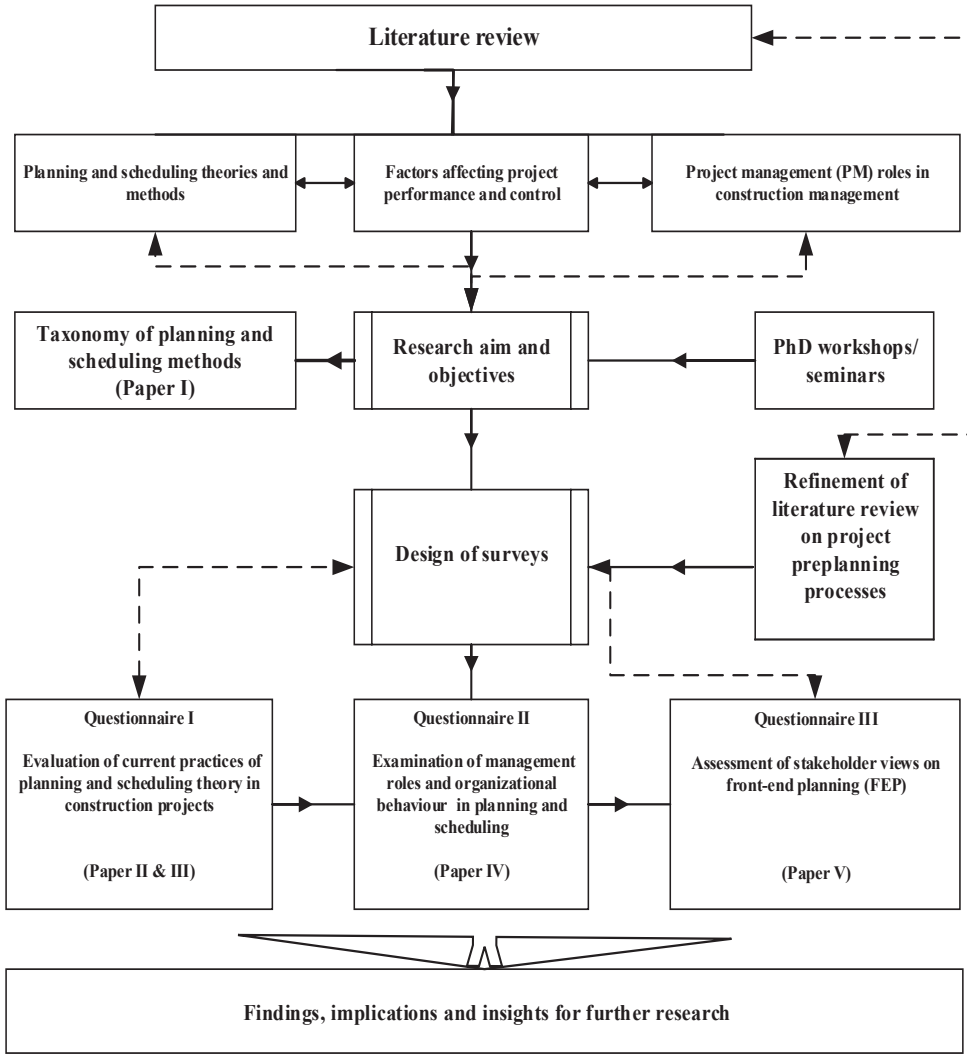

Figure 3.2 *The research design.*

3.8 Implementation – the questionnaire survey

The existence of theories relating to the phenomenon under investigation is a prerequisite for building up study criteria (or questions) that can be tested in a survey. The three surveys undertaken in the research were based upon the design of mixed-data collection questionnaires, comprising a set of quantitative questions supplemented by a number of open-ended questions. The idea of using mixed-data collection questionnaires was to allow non-subjective views from selected respondents, as well as to enrich data analysis and interpretation (see Papers II& V).

3.8.1 Pilot work – the questionnaire survey

Survey questionnaires can have weaknesses and ambiguities that need to be addressed prior to implementation. The procedures involved in testing and refining a questionnaire are called pilot work (Rowley, 2014). Rowley pointed out that pilot work has observable benefits to researchers, by improving the readability and quality of the questionnaire. It is also important to have a general understanding of relevant samples. A good pilot study can provide researchers with pre-determined facts about the nature, variability and size of targeted samples (Oppenheim, 2000). In this research, the survey questionnaires were piloted with a selected number of respondents from different construction organizations. A total of 15 respondents were involved in the first two surveys (II & III) and 20 in the last survey (III). They provided feedback on the clarity and applicability of questions and statements. Consequently, the respective questionnaires were revised before being released to the main sample. No comments were subsequently received about lack of

clarity or ambiguities in the questions and statements in the questionnaire during the implementation.

3.8.2 Data collection

The choice of methods used for delivering questionnaires to the selected sample is an essential step in the survey design procedure (Rowley, 2014). Rowley emphasized that the selection of a representative sample from the total population is important for the reliability of research findings; but pointed out the difficulty of obtaining a representative sample, regardless of the effort a researcher puts into piloting and selecting relevant samples.

Rowley described various ways of sampling and distributing a questionnaire, and she stated, based on her perspective, that there is no efficient distribution method that can help to increase response rates. However, face-to-face (by hand) and well-organized e-mail delivery methods are considered to be more effective than postal questionnaires (James, 2007). Low response rates have been experienced as a common issue by many researchers, regardless of the quality and accuracy of the survey design (Rowley, 2014). Rowley suggested a minimum response rate of 20%, and other researchers suggested that a response rate of more than 75% could be attained, depending on the power and diversity of delivery methods used (Dillman et al., 2009). In order to increase the response rate, a mixture of sampling methods should be considered (Dillman et al., 2009; Rowley, 2014).

In the surveys developed in this research, project stakeholders were drawn from public construction organizations, private construction companies and public-private partnerships. The following two main criteria were applied for

the purpose of selection: (1) participation and involvement at different stages of projects including planning; and (2) the sample should be representative of all project stakeholders. In all three surveys, the majority of respondents were chosen through convenience and snowball sampling methods. More information about the survey distribution and data collection methods of each individual study are indicated in the appended papers (see Papers II, III, IV and V).

3.9 Research quality

Quality of the research is usually assessed against two main criteria: validity and reliability (Newman, 2006). Validity has three lenses: construct, internal and external. Construct validity concerns the degree to which a measure assesses the construct with which it is concerned. In other words, it is a match between the theoretical construct and the operational (or empirical) construct. Peter (1981) argued that a construct validity should be interpreted and inferred as it can be difficult to assess directly. Internal validity means that the original measure can validate or repeat itself at certain points in time and with the same results. External validity concerns the generalizability of the study beyond its particular setting (Fellows and Liu, 2009). Newman described reliability as the internal consistency of the measurement to provide the same results whenever it is carried out after the original research has been completed.

McKinnon (1988) argued that perfect validity and reliability cannot be achieved in research, as the observer or researcher might not be able to control natural threats. These threats include complexity of human minds, researcher bias, strengths of research methods used, cause-effect social interactions between researchers and limited access to all the data needed. He expressed this as

follows: *"[…] researchers in social sciences can never attain perfect validity and reliability and can speak only of degrees of validity. A more important implication in the present context is that different research methods are differently restricted in the number and type of indicators or manifestations they can employ." (McKinnon, 1988, p.41).* McKinnon (1988) recommended a number of tactics or strategies that can be used to improve research quality (i.e. validity and reliability), although they might involve increased investment in time, cost and related management activities: (1) extension of observations or experimental times needed to collect all relevant data from the field; (2) adoption of multiple research methods; and (3) good social behaviour of a researcher while collecting data, especially in fields with data limitations.

It might be difficult to generalize from the immediate findings presented in this thesis unless further research in the field is conducted to confirm external validity. A combination of present findings and the literature review, however, implies that the areas investigated and reported here appear to be either not sufficiently explored or not properly understood in practice. So it can be concluded that the overall findings provide evidence to support the claim to external validity (or generalizability). Fellows and Liu (2009) recommended the use of coefficients of Cronbach's alpha (α) to assess the internal consistency of a set of factors or variables used in research. More specifically, the reliability of quantitative studies (surveys) using Likert scales should be measured and described by Cronbach's alpha coefficients (Santos, 1999). Cronbach's alpha coefficients for each set of the questionnaire criteria were used for the three surveys, and the results are presented later in Table 3.4.

3.10 Statistical data — Papers II, III, IV and V

3.10.1 The survey response rate and reliability

The survey strategy is presented in Table 3.3. The representative samples in the studies in Papers II, III and IV were chosen with non-probability simple random and convenience sampling procedures, while the final study (Paper V) was based on non-probability random and snowball sampling procedures. The total response rate for the first two surveys (see Papers II, III and IV) is acceptable at 61.5% and 55.8% respectively. The third survey (see Paper V), distributed using online survey software, and achieved a lower response rate of 34.6%. However, lower response rates from surveys are experienced as common issues in social sciences where researchers have less control over the population's behaviour (i.e. project stakeholders), as well as factors such as sampling procedures and distribution tools (Dillman et al., 2009; Heberlein and Baumgartner, 1978; Kaplowitz et al., 2004).

Table 3.3 Data distribution strategy of the survey questionnaires.

Survey #	Total distributed/or selected	Total collected/ participated	Valid/ used in the study	Methods	Total response rate	Type of representative sample
Questionnaire I (Papers II & III)	130	80	77	Email Face-to-face (by hand)	61.5%	Non-probability simple random/ convenience
Questionnaire II (Paper IV)	120	67	67	Email Face-to-face (by hand)	55.8%	Convenience/ non-probability simple random
Questionnaire III (Paper V)	396	137	66	Online survey (QuestionPro software)	34.6%	Snowball/non-probability simple random

Table 3.4 presents the calculated values of the Cronbach alpha coefficients for the different sets of questions (or related factors) included in the three questionnaires (see Papers II, III, IV & V). This was to test the reliability (internal consistency) of the measurement of the identified variables or factors (survey questions). The Cronbach alpha (α) coefficients for all investigated sets of questions were higher than the minimum threshold of 0.70 (Santos, 1999), so consistency among the measured statements (factors) covered under the scope of the three survey studies appears to be confirmed statistically.

Table 3.4 Cronbach alpha coefficients obtained for the surveys.

Reliability Test	**Questionnaire survey I**					**Questionnaire survey II**				**Questionnaire survey III**				
	Paper II			**Paper III**		**Paper IV**				**Paper V**				
	Part A	**Part B**	**Part C**	**Part D**	**Part E**	**Part A**	**Part B**	**Part C**	**Part D**	**Part A**	**Part B**	**Part C**	**Part D**	**Part E**
Statements as indicated in the appended papers	Q1 to Q9	Q10 to Q19	Q20 to Q32	B1 to B9	E1 to E12	F1 to F14	F15 to F24	F25 to F34	F35 to F44	FS1 to FS9	CP1 to CP6	SD1 to SD9	R1 to R8	B1 to B11
Cronbach alpha (α) coefficients	0.907	0.913	0.938	0.923	0.953	0.948	0.943	0.954	0.936	0.868	0.863	0.922	0.843	0.819

3.10.2 Kendall's coefficient of concordance (W)

Kendall's coefficient of concordance, W, is used as a non-parametric test to examine the overall agreement between several sets of judges assessing a set of tested variables or items (Field, 2005). In other words, Kendall's coefficient of concordance indicates the degree of association of ordinal assessments made by multiple respondents when rating the same investigated criteria. It ranges from 0 to 1, where the higher value of W means a stronger association among rankings. Moreover, the associated level of significance (p-values) test is used to determine whether there is significantly strong agreement among respondents on such rankings or if it is rated by chance (Siegel and Castellan, 1988). For the purpose of this study, the following hypotheses were developed:

1. H_0: There is no significant association between the overall rankings of all respondents (i.e. rated by chance or non-independently).
2. H_1: Rankings by all respondents are significantly associated (rated independently not by chance).
3. At the 95% level of confidence, reject H_0 if p-value ≤ 0.05 (i.e. accept H_1)

Table 3.5 presents the outputs from the application of Kendall's coefficient of concordance and its associated significance test. It can be observed that the degrees of concordance among the respondents on overall rankings of the survey variables are weak (close to zero) as indicated in Table 3.5 (Kendall's W) where the level of confidence at 95% is statistically significant (p-values ≤ 0.05) for almost all values of W. This implies that there is evidence to reject the null hypothesis (H_0) except where it can be predicted statistically that some rankings might be occurred by chance as indicated in Table 3.5. To conclude,

there is relatively weak agreement among the respondents on the overall ranking of the sets of the surveys variables (or factors). Nonetheless, the associated significance tests (p-values) showed that almost all rankings by respondents are rated independently or occurred randomly.

Table 3.5 Kendall coefficients of *concordance (W)* obtained for the surveys.

Reliability Test	Questionnaire survey I					Questionnaire survey II				Questionnaire survey III				
	Paper II			Paper III		Paper IV				Paper V				
	Part A	Part B	Part C	Part D	Part E	Part A	Part B	Part C	Part D	Part A	Part B	Part C	Part D	Part E
Statement as indicated in the appended papers	Q1 to Q9	Q10 to Q19	Q20 to Q32	B1 to B9	E1 to E12	F1 to F14	F15 to F24	F25 to F34	F35 to F44	FS1 to FS9	CP1 to CP6	SD1 to SD9	R1 to R8	B1 to B11
Kendall's W	0.123	0.028	0.044	0.040	0.028	0.048	0.006	0.037	0.062	0.108	0.124	0.216	0.050	0.054
Chi-Square	50.284	16.062	34.012	19.744	19.145	41.620	3.580	22.464	37.488	51.700	38.979	102.160	20.337	28.182
Significance at the 95% Confidence Interval (p-value)	0.000	0.660	0.001	0.011	0.050	0.000	0.936	0.006	0.000	0.000	0.000	0.000	0.004	0.002
Hypothesis testing	Reject H_0	Accept H_0	Reject H_0	Reject H_0	Reject H_0	Reject H_0	Accept H_0	Reject H_0	Reject H_0	Reject H_0	Reject H_0	Reject H_0	Reject H_0	Reject H_0

3.11 Ethical considerations

According to Bryman (2012), like any other philosophical approaches, quantitative research has been questioned in terms of ethical issues. These issues include confidentiality and integrity of survey design and the collection of data, as well as the analysis and reporting of data, and the dissemination of research findings to interested project stakeholders. Punch (2005) stated that, when considering a questionnaire-based survey targeting project stakeholder perspectives, it is important to consider all ethical concerns relating to those stakeholders. During the implementation of the three surveys, such ethical concerns were considered as follows: (1) informed consent; (2) pilot studies; (3) researcher awareness about current laws and standards applying to the community where field surveys were conducted; (4) treatment of collected information from the aspects of privacy and confidentiality; (5) avoiding the use of sensitive questions or statements that could cause embarrassment to respondents; (6) diversifying data collection and communication methods to reduce bias in responses; and (7) presenting the researcher, research objectives and expected outcomes to interested organizations and project stakeholders.

3.12 Limitations in the adopted research methods

The studies were mainly developed through deductive reasoning, with research questions formulated after surveying relevant literature relating to project planning and scheduling theories and practices. The research questions were then objectively examined using questionnaire-based surveys to measure project stakeholders' perspectives. This positivist view of the research phenomenon, investigated through the understanding and interpretation of

individuals' perspectives, might be considered insufficient for understanding the complexity of the underlying theory of the research problems being investigated. The conduct of the surveys was based on a cross-sectional time zoning where each survey was undertaken at one point in time with the selected representative sample. However, the questionnaire-based survey seems to be a more appropriate tool for generalizing the findings from the study. Notwithstanding such limitations, more robust methods might be used for assessing both perspectives and experiences of wider categories of project stakeholders on the research phenomenon. This will help to increase the reliability and generalizability of the study findings.

3.13 Conclusion

The chapter has presented and discussed various aspects of research methodology in terms of the overall research design, type and nature of research, research methods, other philosophical underpinnings and quality aspects. The research was based on positivist views of world knowledge (or epistemology) through project stakeholders' perspectives, and applied quantitative methods in which questionnaire-based surveys were chosen to collect data from relevant project stakeholders. The entire research was characterized by a deductive approach in which the design of research variables was developed through an investigation of the existing theory. Most empirical data were quantitative and collected through the surveys. These were complemented by qualitative data gathered through the analysis of open-ended questions.

SUMMARY OF THE PAPERS

4.1 Introduction

The summary of the overall findings from the studies, as contained within the appended papers, is interpreted and discussed in this chapter. The answers to the research questions were derived from an analysis of project stakeholders' perspectives in regard to the topics investigated and noted in Chapter 2 (see Figure 2.7).

4.2 Paper I: Taxonomy of planning and scheduling methods and tools to support their more efficient use in construction project management

Insights from the literature: A number of planning and scheduling methods and tools have been developed and introduced as part of the application of project planning and scheduling theory to practice. These different methods and tools are, however, experienced differently by project stakeholders in terms of their advantages and disadvantages in managing construction scheduling. This implies the need for new approaches (or tools) that can ensure/or consolidate a comprehensive understanding of the different planning and scheduling methods and tools used to control projects.

Purpose: The purpose of this study was two-fold: first, to conceptualize a taxonomy for planning and scheduling methods and tools that have been commonly used for managing project schedules; and second, to provide a clear view of each method and compare it with others through the use of a taxonomical framework (Figure 1; Paper I). Methods and tools have been classified into two groups: (1) traditional methods and tools, including the Gantt chart, critical path method (CPM), program evaluation and review technique (PERT) and line-of-balance; and (2) modern planning methods (or systems), including critical chain project management and the Last Planner System.

Methodology/approach: This paper has presented a critical review of the literature covering a large number of theoretical and empirical studies of long established and more recent methods and tools. The underlying theories of five planning and scheduling methods and tools were analyzed so that the taxonomy could be conceptualized and applied according to the following criteria: (1) theories and concepts; (2) key features; (3) usability and suitability; and (4) benefits and limitations.

Findings/implications: Each method or tool has its own distinctive features that make it suitable for managing particular types of project schedule. In general, modern methods have much to offer in terms of scheduling and control when compared with graphically-based activity networking based on traditional methods. The development and control of project schedules using modern methods require greater competence and skill compared with the use of traditional methods. The latter have been found to be less efficient when managing complex schedules with high levels of uncertainty. A detailed comparison between these two groups of methods and tools is summarized in the appended Paper I (see Table 2). The study represents a useful theoretical

basis for developing more advanced taxonomies as a basis for project control systems. In practice, the taxonomy can be also utilized as a support tool for project managers and planners when assessing, prioritizing and selecting methods and tools suitable for managing the schedule of a given project.

Contribution to body of knowledge: The taxonomy provides a useful platform for practitioners and researchers with common ground for investigating more advanced or multi-dimensional frameworks. The taxonomy provides insights for promoting current practices and helps to fill gaps in knowledge on the part of project management teams concerning the implementation of different planning and scheduling methods and tools.

4.3 Paper II: Assessing the understanding of planning and scheduling theory and practice in construction projects

Insights from the literature: Project planning and scheduling fundamentals have been considered as basic components of the practice of project management; yet, the extent to which project stakeholders understand the application of such theories needs to be examined. There is a mismatch between theory and practice in project planning and scheduling that needs to be overcome.

Purpose: The purpose of the study was to examine project stakeholders' perspectives on a selection of criteria concerned with project planning and scheduling theories and concepts. The project stakeholders were drawn from different construction organizations.

Methodology/approach: The study objectively measured project stakeholders' opinions. A mixed questionnaire-based survey (Survey I) was considered suitable and used to collect the relevant data against the selected

criteria. A total of 77 responses were analysed from the perspective of the various roles exercised by the project stakeholders.

Findings/implications: The overall rankings of project stakeholders' perspectives were computed using the relative importance (or impact) index (RII) to determine the significance of the criteria concerned with project planning and scheduling. The criteria investigated covered: (1) the suitability and efficiency of existing planning methods and tools (determined under the scope of Paper I); (2) scheduling development and performance control; and (3) knowledge about planning and scheduling fundamentals. The results revealed no significant variations between project stakeholders' perspectives in regard to the criteria investigated. Nevertheless, the findings revealed that most project stakeholders have a tendency towards the continued use of traditional methods and tools in planning and scheduling, despite the existence of more modern planning and scheduling alternatives. Furthermore, the findings indicated that most project stakeholders agree with the statements used to assess projects, which relate to measuring awareness or knowledge about the fundamentals of both organizational and project inputs to planning and scheduling. However, the findings imply that project stakeholders' knowledge related to planning and scheduling appears limited; therefore, there is a need for more education and training in project planning and scheduling theories and concepts, as well as their application in construction projects. Acquisition of knowledge about project planning and scheduling could help to improve the efficiency and effectiveness of the construction process. Overall, the findings implied that project managers should serve as front-end supporters and builders of their planning team by defining a creative project plan that favours integration, learning and knowledge sharing in the project planning and scheduling context.

Contribution to body of knowledge: The findings of this study contribute to the development of planning and scheduling from the measurement of the extent to which organizational learning is enabled within the project stakeholders' organization in regard to project planning. This seems to be an interesting research phenomenon (or question) that should be pursued further. Investigation could be expanded to cover related topics, such as the impact of varying levels of knowledge and competence of the different categories of project stakeholders in terms of the effectiveness of project scope definitions and cost estimates. Another possibility would be to consider the use of multiple planning perspectives to assess critical factors impacting the effectiveness of planning and scheduling in construction projects.

4.4 Paper III: Enablers and barriers to project planning and scheduling based on Oman construction projects

Insights from the literature: This study formed a substantial part of the survey discussed in regard to Paper II. The literature review revealed that there continues to be assessment of the different factors identified as either success or failure criteria affecting project performance in regard to time, cost and quality. There is a need to look closely at the significant factors impacting project planning with respect to schedule execution and control. More attention should be paid to enablers of, and barriers to, the successful integration and implementation of planning and scheduling.

Purpose: This study had the purpose of identifying and examining project stakeholders' perspectives on the significance of a set of factors identified as enablers and barriers.

Methodology/approach: The study adopted a questionnaire-based survey (close-ended questions). The collected data were analyzed using the relative importance (or impact) index (RII), which was used to measure the level of agreement on the rankings of the investigated factors as significant criteria (enablers and barriers) with respect to project planning and scheduling.

Findings/implications: The overall findings revealed a reasonable degree of agreement on the significance of the identified enablers and barriers. The findings did, however, indicate that priority should be given to the most significant factors based on project stakeholders' opinions. In this connection, lack of project stakeholders' support in the development of project plans and schedules, their poor decision-making regarding activity criticality and resource dependencies and ineffective consideration of resource-constrained schedules for use in dealing with schedule uncertainty, are considered to be the top barriers to effective planning and scheduling. On the other hand, the reliability of detailed schedules, effective resource levelling in scheduling and sufficient managerial support for motivational and training programs were considered as the top enablers. The findings implied that all enablers should be considered and enhanced but it is important to consider a mitigation strategy for the more significant barriers. The study, therefore, recommends the following mitigation strategies: (1) the effective engagement of project stakeholders in decision-making in project planning and scheduling; (2) the efficiency of decisions regarding activity criticality in regard to resource dependencies and constraints; (3) the use of computerized software tools and models to support the accuracy of planning estimates and quantification of schedule variances; and (4) the proper assignment of project management team (or project stakeholders' representatives) in planning and scheduling. Considering these strategies as a

part of project risk management (identification and mitigation) in construction project scheduling should stimulate more effective planning and scheduling.

Contribution to body of knowledge: The study provided insight into the need for a specific focus on certain criteria or factors that particularly affect the performance of project planning and scheduling and the measurement of their impact on the project.

4.5 Paper IV: Understanding project management roles and organizational behaviour in planning and scheduling based on construction projects in Oman

Insights from the literature: On the basis of the findings from previous studies (see Papers II & III), the literature review was refined to complement the examination of the application of planning and scheduling with how project stakeholders manage the development and control of planning and scheduling in practice. The literature review revealed that the study of project management roles and organizational behaviour related to those project stakeholders involved in planning and scheduling appears not to be explicitly considered and requires investigation.

Purpose: This study aimed at addressing this knowledge gap by identifying and examining a set of factors concerned with the project management roles and organizational behaviour involved in planning and scheduling practices.

Methodology/approach: The study utilized a questionnaire-based survey (Survey II) to collect relevant data from selected participants drawn from construction organizations. A total of 67 responses were used in the data analysis and interpretation.

Findings/implications: The study assessed a set of project management roles and organizational behaviour related to project stakeholders (owners, project managers, designers and contractors) identified earlier (see Section 2.4). The overall rankings computed using the relative importance (or impact) index (RII) indicated that most of the factors investigated (see Paper IV) were considered of, more or less, equal importance to current practice in project planning and scheduling. For example, the RII rankings indicated that project manager roles and behaviours concerned with: (1) the practical use of the project schedule as a tool-based managerial skill rather than a tool-based computer skill; and (2) project managers' motivational incentives for successful planning and scheduling teams, are significant factors in the management of project planning and scheduling. The project owner's awareness about the impact of unplanned changes on the original schedule and participation in coordinating and setting out performance measurement of planning and scheduling are considered as the most important factors (roles and behaviours).

Designers' roles and behaviours concerned with co-ordinating other project stakeholders in project planning and their efficiency in transferring the information, needs and inputs are important factors too. Contractors' effectiveness in following up and controlling on-site teams and in resolving their related conflicts affecting schedule performance, as well as their competence in incorporating and managing the work schedules of sub-contractors and suppliers (within the main project schedule), are also seen as important considerations. Additionally, the study provides some practical recommendations: (1) project managers should be proactive and interactive at all levels of planning and scheduling; (2) owners should be aware of the impact of poorly-defined deliverables (in the context of project scope) on the

effectiveness of planning and scheduling; (3) designers should be able to effectively transfer all needs and inputs from other project stakeholders into well-defined and measurable units for use in scheduling; (4) contractors should be competent in regard to their commitments when executing the project schedule to avoid deviations from the original plans; and (5) project stakeholders should be capable of cooperatively managing conflicting issues between the master schedule and other schedules, such as those relating to subcontracted works and supplies.

Contribution to body of knowledge: The study provides support for the need to undertake further investigations of behaviour (or attitudes) of project stakeholders involved in planning and scheduling and the impact of such behaviour on overall project performance. This matter appears not to be studied independently in current construction research.

4.6 Paper V: Understanding the application of front-end planning (FEP) in construction projects

Insights from the literature: The combination of results from the empirical studies (see Papers II, III and IV) implied that shortcomings in planning and scheduling can be sufficiently identified and overcome in the preplanning stages. The literature review was refined by approaching the concept of front-end planning (FEP). FEP is a preplanning approach that helps project stakeholders, especially owners, gather more reliable and clearer information about the potential risks associated with proposed project options. The literature review on FEP reveals that the importance of effective FEP to project success appears not to be properly recognized or applied widely. To

clarify the current situation, there is a need to assess project stakeholders' perspectives on the application of FEP in construction projects.

Purpose: The main purpose of this study was to identify and examine project stakeholders' perspectives on a set of variables (or questions) addressing issues concerned with the definition of FEP stages, their significance and the potential barriers to implementation, as well as other information seeking project stakeholders' opinions about potential improvements to practice.

Methodology/approach: The study adopted a mixed questionnaire-based survey (Survey III) to collect data about the identified aspects of FEP.

Findings/implications: The main findings can be summarized as follows according to the perspectives of project stakeholders: (1) recognition and adoption of FEP in construction projects is limited; (2) the definition of project scope related to FEP stages (feasibility, conceptual planning and detailed scope) is not adequately performed; and (3) there is a strong connection between effective definition of FEP and successful project performance. The results showed that, at the feasibility stage of FEP, elements concerned with the preliminary setting out of project scope and the evaluation of project requirements (staffing, financial resources and materials) were all reasonably well defined. During the later stage of conceptual planning of project scope, the validation of the project scope and the assessment of project risk were poorly accomplished. At the final stage of the detailed definition of project scope, the majority of scope elements covered by the WBS, final estimates (time and cost) and project execution strategy were also all reasonably well defined. The unsatisfied levels of definition of project scope during FEP can be considered as a particular problem and one that might cause time and cost growth during project execution.

Moreover, the findings implied that the most significant barriers to the application of FEP in construction projects are: (1) lack of knowledge about planning and scheduling fundamentals; (2) short timeframe and inadequate resource investments in FEP; (3) insufficient involvement of project stakeholders in FEP; and (4) ineffective owner's approval decision of a given project idea based on FEP definitions. On the basis of the analysis of the survey based on open-ended questions, a number of recommendations on how to improve the adoption of FEP in construction projects can be put forward: (1) a possible prioritization of FEP according to the FEP stage that requires more management activities and coordination between project stakeholders; (2) conditions where some of the FEP stages can be either omitted or combined in order to minimize additional investments incurred in the preplanning stages; and (3) management strategies or tools to be considered for promoting and enhancing the current applications and understanding of FEP in practice. The study implies that project stakeholders should reconsider their current planning strategies by allowing for more preplanning effort or investment. There is also a need to improve decision-making processes regarding the approval of project scope early in the preplanning stages. This can be aligned with learning and project management team training, which can help the team operate as front-end planners or builders of a more creative preplanning stage.

Contribution to body of knowledge: The study contributes to the existing theory of preplanning processes by providing insights into the need for greater consideration of the shortcomings in the implementation of project planning at the front-end of a project. Such consideration should also assess the current role of project stakeholders' participation in the preplanning stages, and their impact on the efficiency of later stages of design and execution.

4.7 Conclusion

This chapter summarizes the main findings and contributions of the five papers covered under the scope of this thesis. All papers are connected and related to the five research questions (Chapter 1). The papers contribute to existing project planning theory through an empirical understanding of project stakeholders' perspectives on the application of project planning and scheduling to practice. After analyzing the results, it can be argued that the research questions have been adequately answered.

DISCUSSIONS AND CONCLUSIONS

On the basis of the findings from the five papers (Chapter 4) connected to the five research objectives (Chapter 1), the reassessment of these objectives against the research questions (RQ1 to RQ5), related implications and the contributions to the existing body of knowledge are presented here.

5.1 Evaluation of the research objectives

The research objectives indicated earlier (Section 1.3) were as follows.

> To provide a taxonomy for planning and scheduling methods and tools.
>
> To evaluate the current level of understanding of applications of project planning and scheduling fundamentals in practice.
>
> To identify and evaluate significant enablers and barriers to project planning and scheduling.
>
> To identify and evaluate project management roles and organizational behaviour in planning and scheduling practices.
>
> To evaluate project stakeholders' understanding of the application of front-end planning (FEP).

Objective 1: To provide a taxonomy for planning and scheduling methods and tools

A critical review of the literature on various planning and scheduling methods and tools was conducted with the aim of understanding current perspectives on the use of methods and tools. The objective was to provide a taxonomy to study a number of methods and tools that have been commonly adopted for managing construction project schedules (see Section 4.2). The findings from applying the taxonomy indicated that there are notable variations in project stakeholders' perspectives regarding the effectiveness of the methods and tools. The findings implied that such variations in project stakeholders' perspectives can be attributed to a lack of understanding of the underlying concepts of these methods and tools and their implementation in practice. Consequently, new management tools (or strategies) are needed to improve project stakeholders' knowledge about, and understanding of, how and when to use these different methods and tools. The taxonomy developed in this study can, therefore, be considered as one such strategy. It can be used as a support tool for project stakeholders when prioritizing and selecting alternative planning and scheduling methods and tools for managing various types of construction project. Moreover, the taxonomy facilitates a more developed understanding of planning and scheduling methods and tools on the part of project stakeholders, especially those who are not familiar with at least one such method or tool. On the basis of the reassessment of the first objective, it is felt that RQ1 has been answered satisfactorily.

Objective 2: To evaluate the current level of understanding of applications of project planning and scheduling fundamentals in practice

The literature indicated that there was a lack of knowledge regarding project planning and scheduling practices in construction projects. There was, additionally, a mismatch between the theory and practice of planning and scheduling, which has resulted in unrealistic project schedules and, thereby, poor project performance. The objective of this study was to evaluate project stakeholders' perspectives on a number of defined factors (or criteria) concerned with the application of project planning and scheduling. The findings revealed that project managers and other project stakeholders should adopt new management tools that encourage organizational knowledge and learning in the context of project planning and scheduling. The acquisition of such knowledge requires: (1) an understanding of a number of planning and scheduling methods and tools; (2) understanding of the concepts of schedule development and control; and (3) adequate knowledge of planning and scheduling fundamentals. The integration of these knowledge requirements into the current management practices of project managers and other project stakeholders will enable them to serve as front-end planners or builders of more proactive planning teams. This could be aligned with another support tool which is the application of a project planning perspectives' system that would enable the gathering of information from project stakeholders regarding critical factors impacting project planning and scheduling. On the basis of the reassessment of the second objective, it is felt that RQ2 has been answered sufficiently.

Objective 3: To identify and evaluate significant enablers and barriers to project planning and scheduling

The factors contributing to either the enhancement or impairment of project planning and scheduling are neither considered properly nor studied independently. An assumption was that paying attention to the significant factors impacting particular stages of a project can be more productive than assessing a project from a holistic perspective. The objective was, therefore, to identify and evaluate project stakeholders' perspectives on a set of factors categorized as enablers and barriers to project planning and scheduling. A number of identified factors were considered at different stages of planning and scheduling from development through implementation to control. Some factors should be given greater priority than others depending on their degree of impact. The significant barriers can be elaborated as those mainly concerned with the efficiency of project stakeholders' engagement and their decision-making in planning; examples are the effectiveness of decision-making on resource allocation, activity criticality in scheduling, adoption of a holistic monitoring approach to controlling schedule execution, and improving the accuracy of schedule risk or uncertainty by using computerized tools and models. The expectation is that project managers and other stakeholders should be able to prioritize enablers and barriers that need either enhancement or mitigation respectively and the stages of project planning and scheduling where this should apply. On the basis of the reassessment of the third objective, it is felt that RQ3 has been answered satisfactorily.

Objective 4: To identify and evaluate project management roles and organizational behaviour in planning and scheduling practices

As an integral part of the performance measurement of project planning and scheduling, there is an argument for proper examination of project management roles and organizational behaviour. An objective was, therefore, to identify and evaluate project stakeholders' perspectives on a set of identified factors considered as project management roles and organizational behaviours. These factors were concerned with individual roles and the organizational behaviour of owners, project managers, designers and contractors (see Section 2.4). From the study, it was implied that insufficient consideration or misalignment between the roles of project stakeholders involved in the various stages of project planning and scheduling will result in inadequate development and control over their work and result in under-performance of the project. Project stakeholders are expected to adjust their current management roles and behaviour in planning in ways that enable them to cope with the nature and complexity of project planning and scheduling. A collaborative management approach between project stakeholders' roles in project planning and scheduling is needed. This is also needed to compensate for any shortcomings on the part of less competent or less experienced project stakeholders involved in the application of project planning and scheduling. On the basis of the reassessment of the fourth objective, it is felt that RQ4 has been answered adequately.

Objective 5: To evaluate project stakeholders' understanding of the application of front-end planning (FEP)

Shortcomings in the application of planning and scheduling theories and concepts, including a lack of knowledge on the part of project stakeholders, can be alleviated early in the front-end stages of a project. There seems to be a lack of knowledge about the significance of FEP to successful project performance, implying a need to promote the adoption of FEP. The objective was, therefore, to evaluate project stakeholders' understanding of the application of front-end planning. The findings from the study implied that there is a variation in the definition of project scope related to the three main FEP stages (Figure 2.5). Based on the analysis of project stakeholders' views, the findings have pointed to a number of strategies or tools for promoting the effective application of FEP in practice. These include: (1) the adoption of a balanced engagement theory of project stakeholders in front-end planning (FEP); (2) stronger alignment of FEP with opportunity realization (or the final investment decision) of a given project; and (3) the use of a SWOT analysis for each FEP stage while defining its scope elements. The findings also imply that in order to accomplish such strategies, project managers and other stakeholders should adjust their current roles in project planning by incorporating more preplanning.

The combined findings imply that there is still a need for more assessment of FEP. This assessment should be focused on how to understand the different needs and interests of the various project stakeholders and, in particular, how to reach balanced consideration of those needs and interests. This can be enabled by more thorough investigation of the significant factors impacting the decision-making process on the outcomes of front-end planning, especially on

the part of owners and project managers. On the basis of the reassessment of the fifth objective, it is felt that RQ5 has been answered sufficiently.

5.2 Analysis of Results

The main implications from the individual studies connecting to the five papers covered under the scope of this thesis can be summarized under four categories:

1. Improving organizational competence and knowledge about planning and scheduling fundamentals.
2. Focusing on and managing the significant enablers of, and barriers to, project planning and scheduling.
3. Understanding the management roles and organizational behaviour of project stakeholders in planning and scheduling.
4. Identifying and managing shortcomings in project planning early in the front-end planning stage.

Improving organizational competence and knowledge about planning and scheduling fundamentals

In this thesis, organizational knowledge about particular project management concepts, such as the application of planning and scheduling theories and concepts, has been highlighted. The need to acquire such knowledge should encourage the development and implementation of more appropriate tools for project stakeholders and their organizations leading to more effective planning and scheduling. Previous studies have attempted to study knowledge-based planning and scheduling from different perspectives. Cegarra and Wezel (2011)

examined knowledge-based planning and scheduling performance from three theoretical approaches: descriptive, formative and normative. Theses authors recommended that the efficacy of these knowledge approaches should be tested in practice. In this research, Paper II has examined the criteria related to the application of project planning and scheduling theories and concepts, on the basis of quantitative measurement and descriptive analyses of project stakeholders' perspectives. The expectation was to be able to bridge the gap between theory and practice in planning and scheduling and to improve project stakeholders' awareness and understanding in a number of basic, but important, areas of project planning.

Paper II offers a number of appropriate management strategies and tools for improving knowledge about, and understanding of, project planning and scheduling. These strategies include project management team integration in specific training programs in project planning and scheduling and the adoption of proactive planning approaches for assessing and integrating all requirements at both the conceptual and operational levels of a project. Another important insight from the study is the need for knowledge-based planning perspectives that allow project stakeholders to assess the factors impacting project planning and scheduling in a more coordinated and collaborative manner.

Another strategy that can be used to consolidate understanding of project planning theories in terms of planning and scheduling methods and tools is a taxonomy of key characteristics and the underlying concepts of such methods and tools (Al Nasseri et al., 2013). The taxonomy proposed in Paper I can be used as a support tool for project managers and planners when prioritizing and assessing planning and scheduling methods and tools in order to select those that are suited to the nature of different types of construction project. Paper II

also reports that knowledge about the application of project planning and scheduling theories and concepts should include basic project planning tools such as the work breakdown structure (WBS) and its relationship with schedule development and control. From a theoretical perspective on project management, Baldwin and Bordoli (2014) indicated that planning and scheduling fundamentals need to be re-considered independently as two essential tasks that determine project success.

Focusing on and managing significant enablers and barriers impacting project planning and scheduling

Paper III indicates that the failure to identify and assess critical factors (referred to as barriers in some literature) is detrimental to the effectiveness of project planning and scheduling and, ultimately, to overall project performance. For instance, Iyer and Jha (2006) reported that there are many factors that have been considered as having either positive or negative impacts on project performance; however, these authors argued that there is a need to reconsider the relevance of these factors. More recently, Alias et al. (2014) asserted that no comprehensive construction studies have been conducted into the assessment of critical factors impacting the application of project management concepts from the perspective of project stakeholders. Paper III identified and assessed a set of factors concerned with various technical issues at different stages of project planning and scheduling, including those related to project leadership and administration when managing project plans and schedules. Other, more technical, factors involving resource allocation and contingency plans (or buffers), as well as time-cost trade-offs and the need for optimization or simulation techniques with respect to schedule uncertainty (risk), were also assessed. The idea is that investing in managing project risk by

looking closely at specific, but significant, enablers and barriers impacting planning and scheduling in particular would be more worthwhile than attempting to assess all manner of risks affecting the entire project. A holistic assessment of the critical factors has been widely argued in the literature whilst little research has attempted to approach this problem from the perspective of project planning.

The overall findings are consistent with the relevant interpretations of the literature which imply that there is a need to reconsider particular factors impacting project management performance related to project planning, especially schedule execution and control. Examples of studies that have examined various risk (or critical factors) affecting the performance of scheduling in construction projects are those of Hwang et al. (2013); Iyer and Jha (2006); Mulholland and Christian (1999); Nepal et al. (2006); and Voth (2009). These studies support the idea that the achievement of effective planning and scheduling requires an understanding of significant factors (referred to as enablers and barriers in this thesis) whilst developing and executing project planning and scheduling.

Understanding the management roles and organizational behaviour of project stakeholders in planning and scheduling

The effectiveness of project planning and control can be also influenced by other factors or issues related to organizational culture and the project management team (Walker and Shen, 2002). The authors stated that organizational behaviour and team attitudes, responsiveness, capabilities and communications between members of the project management team in regard

to planning need to be considered as significant issues with respect to overall project performance. In more recent studies, it has been noted that understanding the management roles and behaviour of project stakeholders is, likewise, a key issue in the context of project performance (Yang et al., 2011; Yang et al., 2014). Paper IV, therefore, identifies and assesses a set of factors (or criteria) related to the management roles and behaviour of project stakeholders, who are identified as owners, project managers, designers and contractors in this research. The results imply that there is a need to consider all project management roles and behaviour pertaining to project stakeholders engaged in planning and scheduling practices. This is important in order to improve their ability to understand and respond to all necessary changes and measures while planning and scheduling a project. Walker and Shen (2002) indicated that strong support and commitment from project organizations and teams in project planning would improve the effectiveness of decision-making and communication among project stakeholders. The findings from this study (see Paper IV) imply that measurements of performance in planning and scheduling should also extend to project management roles and the behaviour of project stakeholders. This can lead to more effective planning and scheduling and better-quality execution of project schedules.

Another insight gathered from this study is that project stakeholders should be able to manage plans and schedules through more transparent and reliable communications in terms of information and feedback required for the management of project planning and scheduling. A collaborative planning and scheduling system can be considered as a support tool, where a balance between the needs and interests of project stakeholders in the development of plans and schedules can be maintained. A collaborative planning and scheduling system would help to transfer feedback and measurement from

project schedule execution to planning in terms of schedule outcomes and related constraints (Kempenaers et al., 1996). From the perspective of project management, the responsibilities of the project management team are outlined. However, project management roles and behaviour related to project stakeholders at particular stages, such as planning and scheduling, need further assessment. Paper IV is, therefore, an attempt to approach the shortcomings in the application of project planning from the perspective of human factors concerned with project stakeholders' roles and behaviours. This idea is supported by a more recent study by Rajablu et al. (2015) who examined the impact of project stakeholders' roles and behaviour on project success and found that there is a significant correlation between the positive attitude of project stakeholders and project success.

Identifying and managing shortcomings in project planning early in the front-end planning (FEP) stage

As indicated earlier (Section 2.6), particular studies on preplanning processes have implied that many of the shortcomings in the application of project planning can be effectively overcome by developing and adopting well-defined and integrated front-end planning together with an accurate definition of the project's scope. Merrow (2011) found that many mega-industrial and large infrastructure projects were subject to problems of schedule delay, cost variations and unmanageable uncertainty as a consequence of poor scope definitions during the front-end planning of a project. Despite this and other studies highlighting the importance of front-end planning to successful project performance, the concept does not seem to be properly recognized or widely adopted by project managers and stakeholders, especially those involved in

project planning. The findings from Paper V confirm that the project scope is often not sufficiently defined at the front-end of a project. Comparing the findings from this study with the literature reviews suggests that there is a common lack of comprehension about front-end planning on the part of construction practitioners and their organizations, as revealed in a number of studies (Hwang and Ho, 2011; Motta et al., 2014; Suk et al., 2014).

The findings from Paper V suggest disagreement between project stakeholders' views regarding the extent of project scope definition during the front-end planning stages. Poor project scope definition can result in inaccurate design and unrealistic cost and schedule estimates. Paper V also implies that a lack of project stakeholders' knowledge about project planning fundamentals is one of the most critical barriers impacting front-end planning. The findings also correspond with results and implications obtained from earlier research studies (see Papers II & III) regarding knowledge requirements in the context of project planning. This lack of knowledge can, however, be rectified by various management tools, including improving organizational and project stakeholders' learning and knowledge about preplanning activities. Based on project stakeholders' views, Paper V provides some recommendations for enhancing the effective application of front-end planning including, amongst other things, the need to prioritize front-end planning stages and a new participation theory of project stakeholders in front-end planning and uncertainty analysis of front-end planning stages.

5.3 Implications

On the basis of the findings and related discussions from the five studies (and associated appended Papers), useful insights into both theory and practice can be summarized and highlighted as follows.

5.3.1 Implications for theory

The research has provided some useful insights into improving understanding of the application of project planning and scheduling theories and concepts in practice. The first study (see Paper I) provides a taxonomy for the most common planning and scheduling tools and methods used in construction projects. This taxonomy can be used as a theoretical foundation for more advanced taxonomies of project planning and control systems.

An insight obtained from the findings of the second study (see Paper II) is the need to strengthen the link between theory and practice in project planning and scheduling through certain management tools and strategies. These include knowledge-based planning and scheduling perspectives, specific organizational learning in project planning, and improvement of project stakeholders, especially the owner's trust in planning.

The third study (Paper III) identifies an area that might be of interest – the need for more specific understanding of the significant factors (enablers and barriers) impacting particular stages of a project, such as planning and scheduling, and their positive and negative consequences on the entire construction process. A consideration of such enablers and barriers can be more worthwhile than assessing the factors affecting the project as a whole, which might result in a lack of differentiation between significant and less

significant factors. This consideration should also include a mitigation strategy for dealing with the most significant barriers (see Paper III).

The fourth study (see Paper IV) casts light on how to understand and manage project roles and the behaviour of different project stakeholders in planning and scheduling. Consideration of such roles and behaviour can help improve understanding of planning and scheduling theories and concepts in practice.

The last study (see Paper V) provides an important insight into the need to consider problems associated with planning and scheduling practices in the front-end stages of a project. The expectation is that investing more in preplanning is more beneficial than reacting to shortcomings and deficiencies during execution, which can entail additional resources compared to those originally planned. The research reported in this thesis has provided insights into how to link the theory and practice of project planning and scheduling at both the conceptual and practical levels of a project. This will generate more predictable outcomes in accordance with project stakeholders' needs and interests, and improve overall project strategy.

5.3.2 Implications for practice

The research has proposed a number of management support strategies to help improve project managers' and other stakeholders' knowledge of, and understanding about, the theories and practices of project planning and scheduling. The first study (see Paper I) offers a taxonomy that can be used as a support tool by project managers and planners in managing certain types of construction schedule. The taxonomy facilitates interpretation of schedule execution through the use of appropriate methods and tools.

The second study (see Paper II) proposes a number of management support tools, including specific organizational training in the context of planning and scheduling and the use of proactive planning and scheduling systems to identify potential shortcomings in planning. Paper II proposes that project managers should serve as front-end supporters of project teams in defining effective project planning.

Further management support highlighted in the third study (see Paper III) is the need to identify and mitigate the most significant barriers impacting planning and scheduling, including the adjustment of existing strategies regarding project stakeholders' participation in project planning, improving decision-making processes regarding activity criticality, and using optimization and computerized models to support the accuracy of planning and scheduling.

The fourth study (see Paper IV) argues that key project stakeholders should be able to modify or adjust their current management roles and behaviour in planning and scheduling. Such adjustments include assigning a specialized team to planning and scheduling, developing collaborative control and communication mechanisms, integrating scheduling into risk and quality management plans, and improving information sharing regarding schedule reliability and accuracy.

The final study (see Paper V) provided insights into how to improve the quality of project planning by identifying and defining all activities of the project's scope at the front-end. The study confirms the need for a more developed understanding of front-end planning by placing greater emphasis on preplanning. In addition, the findings provide insights into project activities that require clearer definitions prior to decision-making. The study does, however, suggest instances where some FEP stages can be omitted as indicated in Paper V.

In addition to the implications mentioned above, some practical outcomes from the research might offer benefits for project managers and other project stakeholders involved in the Oman construction industry.

1. Project managers and other stakeholders should be encouraged to take necessary steps towards improving team competence and organizational knowledge in planning and scheduling. More training could produce a "quick-win".
2. Key decision-makers on construction projects should take into practical consideration the enablers of more effective planning and scheduling, as well as the most critical barriers that need to be mitigated.
3. Project managers and other stakeholders should be able to identify their focal points regarding project management roles and behaviours that need to be prioritized when developing and controlling the application of project planning and scheduling.
4. Project managers and other stakeholders should invest more in preplanning to ensure that all activities covered by the project scope are defined, thereby enabling more effective and reliable design and execution. Front-end planning should be considered an essential part of construction contract specifications, unless the project scope is based entirely on a similar project that has been successfully completed.

5.4 Main contributions

The research has identified and highlighted an area of concern in the construction industry that needs to be improved, namely project stakeholders'

knowledge about, and understanding of, the application of planning and scheduling in construction projects. A contribution of the research is in proposing the need to assess organizational learning in the context of project planning and scheduling. The research contributes to existing planning and scheduling theories by highlighting the requirement for a comprehensive investigation of the critical factors impacting planning and scheduling, and how shortcomings can be alleviated in the early stages of a project. This assessment should aligned with an understanding of what is termed 'organizational behaviour' in project planning and scheduling, as well as related adjustments needed to the roles and behaviour of the various project stakeholders involved in project planning. Last, the study makes a contribution through the insights gained from the investigation of project stakeholders' participation and decision-making process in the front-end planning stages.

5.5 Further research

There is a need to investigate the impact of clients' trust in project planning on overall project success. There is also the need for a particular emphasis on the assessment of the type of relationship between the quality of front-end planning and successful project execution in terms of time and cost control. The research further recommends the application of a project planning perspectives' system which can be used to gather of the needs and interests of key project stakeholders while developing project planning and scheduling.

5.6 Closing remark

This chapter has outlined an analysis of the findings and subsequent implications from the appended papers (Appendix A) that make up the thesis.

In general, the findings have implied that proper consideration of the investigated theories and concepts of project planning and scheduling can significantly improve their application in practice. Although the research is mainly based on the analysis of project stakeholders' perspectives, interpretations of the findings from this study together with the relevant literature (i.e. existing theory) imply insufficient understanding of how to apply project planning and scheduling theories in practice.

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APPENDIX A

THE APPENDED PAPERS

Paper I

A taxonomy of planning and scheduling methods to support their more efficient use in construction project management

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Purpose – The implementation and control processes of project planning and scheduling involve a wide-range of methods and tools. Despite the development, modification and integration of project management theory with newer scheduling approaches in particular, practitioners' views on the efficiency and effectiveness of these methods and tools differ. This situation can be attributed in part to a lack of understanding of the most appropriate basis for implementing these methods and tools. This study therefore attempts to overcome this deficiency by conceptualizing and adopting a taxonomy of planning and scheduling methods. **Methodology/approach –** The study is based on a critical review of the literature covering a large number of theoretical and empirical studies. The underlying theories of various planning and scheduling methods were analyzed with respect to the taxonomy criteria adopted in the study. **Findings/implications –** Using the taxonomy, the key characteristics of planning and scheduling methods considered in this study were identified and interpreted. These included concepts and theories, key features, suitability and usability, and benefits and limitations. Overall, the findings suggest that project managers should consider the taxonomy as a support tool for selecting and prioritizing the most appropriate method or combination of methods for managing their projects. Recommendations include the need for more advanced or multi-dimensional taxonomies to cope with the diversity of project type and size. **Originality/value –** The results of the study allow project managers to improve their current practices by utilizing the taxonomy when considering the implementation of planning and scheduling methods. Moreover, the taxonomy can be considered as a tool to promote learning on the part of those less experienced in planning and scheduling. The taxonomy can be considered as an initial platform for further research in this area.

Keywords: Taxonomy, project management, project planning, scheduling, implementation, schedule control.

1. Introduction

Planning and scheduling are among the most critical tasks in construction project management, demanding the attention of competent personnel (Kerzner 2009) to determine how the work will be organized, scheduled and controlled (Babu and Suresh 1996, Haugan 2002). The planning process in general involves various tasks including: (1) integrating and developing the project scope; (2) defining the project's inputs and deliverables; and (3) setting out methodologies for executing and controlling the project schedule (PMI 2008). It has been argued that insufficient coordination and allocation of such tasks and resources in planning can obscure the management effort needed to develop and control schedules (Mikulakova et al. 2010). Although scheduling is viewed as a discrete process with unique characteristics and inputs, it is an integral part of the planning process. It is concerned with the networking of activity sequences and durations, and the resource trade-offs and controls that have been provisionally set in the planning process (Yang 2007, PMI 2008). The planning and scheduling process has a strong impact on construction projects, and so project managers and planners should consider the practical implications when implementing scheduling methods and systems (PMI 2008, Kelsey et al. 2001).

Nowadays, project planners and schedulers have increasing access to various forms of visual model and scheduling control systems; yet, the dynamic nature of projects can pose other challenges, not least in identifying and controlling risk and uncertainty during project execution. Significant among these challenges is the disconnection between the underlying theory of the different methods and control systems and how they are supposed to be applied in practice. In this connection, Hajdu (1997) argued that despite advances in the development of many scheduling techniques, project managers and their planners still face a lot of challenges in achieving a fit-for-purpose schedule within the constraints of time and resources. Hajdu attributed this to the complexity of scheduling against the ability of project managers to retain all information concerning the schedule and thus make an informed decision. This can imply that there is a need to determine appropriate mechanisms for gaining a proper understanding of the underlying theories of different methods and tools. Consequently, this would help to reduce misinterpretation of schedule results, regardless of the sophistication, or otherwise, of computer-based tools. In partial response to these challenges, a taxonomy of different methods is offered as a way forward.

This paper presents a taxonomy for the most commonly-used methods in the scheduling of construction projects based on current practice. The taxonomy can serve as a support tool to help improve learning, as well as awareness in the project team, about the key merits and pitfalls of different planning methods and tools. As a result, this might motivate the current attitudes of practitioners towards a more appropriate selection and application of methods in their work.

2. Planning and scheduling methods – an overview of existing perspectives

The correct application of planning and scheduling methods and tools for managing construction projects is unlikely without an understanding of the underlying principles (Bertelsen et al. 2007). Methods and tools adopted in practice have advanced from a traditional scheduling approach based on deterministic networks to more sophisticated scheduling approaches based on probabilistic methods (and supporting software) as demonstrated by, for example, Mongalo and Lee (1990); Burcar and Radujkovi (2003); Cegarra and Wezel (2011); and Harvey (2001). For the purpose of making a clear distinction among the aforementioned, Hajdu (1997) pointed out that *traditional* scheduling methods are those backdated to the introduction of bar charts and which have advanced from being paper-based to computer-based, as either non-network or network-based. Those methods that have departed from the concept of traditional scheduling are considered to be *modern*. To clarify, the literature regards traditional methods as those initially introduced for visualizing and optimizing total project duration rather than handling schedule uncertainties or resource constraints. Examples of traditional methods are the Gantt chart, Line of balance (LOB), Critical path method (CPM) and Program review and evaluation technique (PERT). Those regarded as modern methods, primarily Last planner (LPS) (Ballard 2000) and Critical chain project management (CCPM) (Goldratt and Cox 1984), were introduced to overcome the above shortcomings. Furthermore, they have been used as the basis for holistic project planning and control rather than as a scheduling tool alone, which makes them significantly different from traditional methods.

Another perspective is one that differentiates between activity-based scheduling and location-based scheduling (Bertelsen et al. 2007, Ahuja and Thiruvengadam 2004, Cegarra and Wezel 2011). Examples of the former methods are, as noted above, Gantt chart, CPM and PERT, and CCPM; whereas, LOB and LPS are classified as location-based methods.

Whilst further development of these methods and tools individually might be beneficial, it could be argued that the scheduling process would be all the more effective from their efficient use and integration (Weaver 2009, Kerzner 2009). In this respect, proper understanding and application of newer methods can allow project managers to effectively optimize resources (Harris et al. 2006). This latter assertion is supported by a study by Shash and Ahcom (2006) who argued that lack of knowledge of chosen methods and tools can lead to failures in work delivery against the original plan. Additionally, a study by White and Fortune (2002) revealed that practitioners' familiarity with the application of different methods was limited and, hence, they experienced some difficulty in scheduling activities. To overcome various limitations and uncertainties, the underlying statistical basis of some tools and methods have been modeled and integrated with suitable simulation and computerized approaches (see, for example, Lutz 1990, Hu 2011, Huang and Wang 2009, Liu and Wang 2012, Xie et al. 2010). Still, this has been done by specialist disciplines for specific technology-related needs, which could be far above the common understanding of many practitioners in construction.

Although more recent developments and modifications to project management and production theories have already taken hold in practice, practitioners adopt different perspectives and attitudes towards the continued use of traditional methods (Wilson 2003, Kenley and Seppanen 2009, Cegarra and Wezel 2011). Such attitudes manifest in a preference for simplicity and, hence, the ease with which they can be used for monitoring and controlling small-sized construction projects (Yang 2005). To conclude, the large body of literature that has been published on this subject shows that there are still controversial views. Some of these views result from misunderstanding over the underlying concepts of the different methods and their relationship to one another rather than their usefulness in controlling projects.

3. Evidence-based literature review

Based on the above views, there seem to be grounds for further exploration of planning and scheduling methods and their inter-relationships as an essential part of managing construction processes. Such exploration could enhance the level of learning and competence on the part of organizations and practitioners about the implementation of the underlying theories of different planning and scheduling methods and tools. In this regard, Yang (2007) argued that investigations of available scheduling methods and tools can help researchers and practitioners avoid vague understandings about their concepts and thus gain a sufficient level of knowledge.

4. The taxonomy – overview of concepts and applications

Taxonomy was initially defined as the science of species identification and classification from a biological perspective (Fox 1988, Du Rietz 1930). Thereafter, it was adopted for specific needs in other disciplines; for instance, Bloom (1956) introduced a cognitive taxonomy for improving educational learning domains. In the context of management studies in general, the study of planning theory results in three major taxonomy components (Laufer 1968): classification, nomenclature and identification.

Tsui et al. (2010) advocated the use of taxonomy as an initial model to help an organization disseminate information in the most efficient and comprehensible way for the benefit of end-users. Nowadays, apart from the original core subjects and sub-topics of taxonomy, there is little doubt that taxonomies can be introduced to, and adopted by, many disciplines based on the characteristics and objectives of the organization where the taxonomy is utilized. In numerical taxonomies, Romesburg (2004) considered cluster analysis as a useful quantitative tool aiding practitioners in various disciplines, including planning and management research, to form research hypotheses based on qualitative attributes in order to judge similarities and dissimilarities among those attributes. However, this form of mathematical taxonomy seems to be more useful for those researchers attempting to approach their research problems from a statistical perspective, particularly in studies based on deductive reasoning which need grounding in qualitative or theoretical taxonomies.

5. Conceptualization of the taxonomy study

Based on the above discussion, it seems that there have been no specific studies offering an analysis of a construct-based taxonomy for the major components of construction processes, particularly planning and scheduling theories and methods. Nevertheless, a few examples were found of attempts to initiate a conceptual framework of taxonomies; for instance, utilization of a template to classify, sort and manage the causes and effects of changes in construction projects (Sun and Meng 2009). In this regard, the authors argued that the proposed taxonomy can be used by the project team as a framework for taking necessary steps or preventive actions in a more systematic way. It can be argued, therefore, that a taxonomy of related issues or factors, such as planning methods, has the potential to be used as a tool for mapping all inputs and changes in the management and execution of construction projects.

Evidence from the literature screened by this study indicated that there were some notable variations among the different planning approaches and scheduling methods in terms of their capacity for handling project activities, input resources and statistical aspects, as well as users' satisfaction. From these perspectives, we evaluated and assessed the planning and scheduling methods covered by this study based on the criteria shown in Table 1. It should be noted that these criteria include sub-criteria. The latter include classification of scheduling methods and tools, class of scheduling problems to be resolved, management roles in handling scheduling resources, uncertainties and statistical aspects.

Table.1. Characteristic of taxonomy used in this study

Criteria	Description as used in the study
Theories and concepts	The main concepts relating to the creation of a network, the method itself and statistical or computational aspects of the planning method.
Key features	Strength and ability of the underlying theory in explaining and handling scheduling problems and the potential integration of the associated method.
Usability and suitability	Capability and/or capacity of the method in managing projects in terms of size, complexity and activity dependencies, as well as schedule resource control.
Benefits and limitations	Practitioners' perspectives on potential merits and pitfalls from applying current theories of the different planning methods.

6. Insights and potential benefits of the study

A taxonomy for the most commonly adopted methods and tools in the scheduling and control of construction projects was applied. The taxonomy aims to consolidate the existing levels of understanding and, thus, to improve the future usability of these methods. In the essence of a previous study by Yang (2007), the investigation of different planning and scheduling methods and tools can enhance their practical application.

More specifically, Sun and Meng (2009) revealed that taxonomies of construction processes provide a good basis for developing solutions and toolkits for more recent project management theories. The lack of evidence from the literature of previous attempts to establish taxonomies for project planning and scheduling methods and tools suggests a potential contribution in this field. A planning and scheduling taxonomy would assist project managers and project teams in achieving the following benefits or outcomes.

- Presents a comprehensive description of different planning and scheduling methods, which can support common understanding about the fundamentals of these methods in practice for the scheduling and control of construction projects.
- Identifies potential in, and shortcomings of, the underlying concepts of planning methods and, hence, makes their implementation clearer for practitioners.
- Conceptualizes a classification scheme for more advanced taxonomies of planning and scheduling processes that can be adopted by other disciplines.
- Provides useful guidelines for researchers in terms of cross-comparisons as well as the potential for integration of these methods instead of focusing on traditional ways of managing project schedules and related resources.

7. Research methodology – critical review of the literature

Previous studies have provided insights into the conceptualization of a new framework for consolidating current knowledge of planning and scheduling methods and tools. At the same time, it has allowed us to develop a more explicit qualitative basis for future research into taxonomies for project control systems in the broader sense. This study was based on a review and analysis of the extant literature, both theoretical and empirical to answer the primary research question which was: *'How can we consolidate a comprehensive understanding of current practice in planning and scheduling methods by the use of taxonomies?* For this purpose, the study adopted a qualitative approach in the form of documents analysis (published articles, books and reports) which is considered to be a useful means by which texts or documents can be interpreted by researchers to provide expressions and meanings around the research subjects under investigation (Bowen 2009). Moreover, Fairclough (2003 p.3) affirmed that: *'[t]ext analysis is seen as not only linguistic analysis; it also includes what I have called 'inter-discursive analysis', that is, seeing texts in terms of the different discourses, genres and styles they draw upon and articulate together.'*

According to Bryman (2012), the review of extant literature represents a useful tool for capturing and determining a number of critical issues concerned with what is lacking in existing topics and where the evidence might be contradictory. Secondary data from the literature can help to resolve potential difficulties encountered by researchers in gathering primary or original data (Cowton 1998). Moreover, a knowledge map to support database searches, as demonstrated by Yang (2007), was considered as a preliminary guideline for

gathering relevant information. On the basis of the primary results from exploring of our research question, a taxonomy was developed and populated based on the study methodology presented in Figure 1 below. Although the methodology presented in Figure 1 might be considered as a preliminary platform in terms of the discursive power of the taxonomy, it should provide new insights for the academic and practitioner communities. For academicians, it provides a theoretical basis for further development of more advanced or multi-dimensional taxonomies. For practitioners, such a taxonomy can help to prioritize the scheduling of project activities by advancing recognition of the key features of proposed methods. Consequently, this might minimize management efforts on the part of project managers and planners when controlling resources.

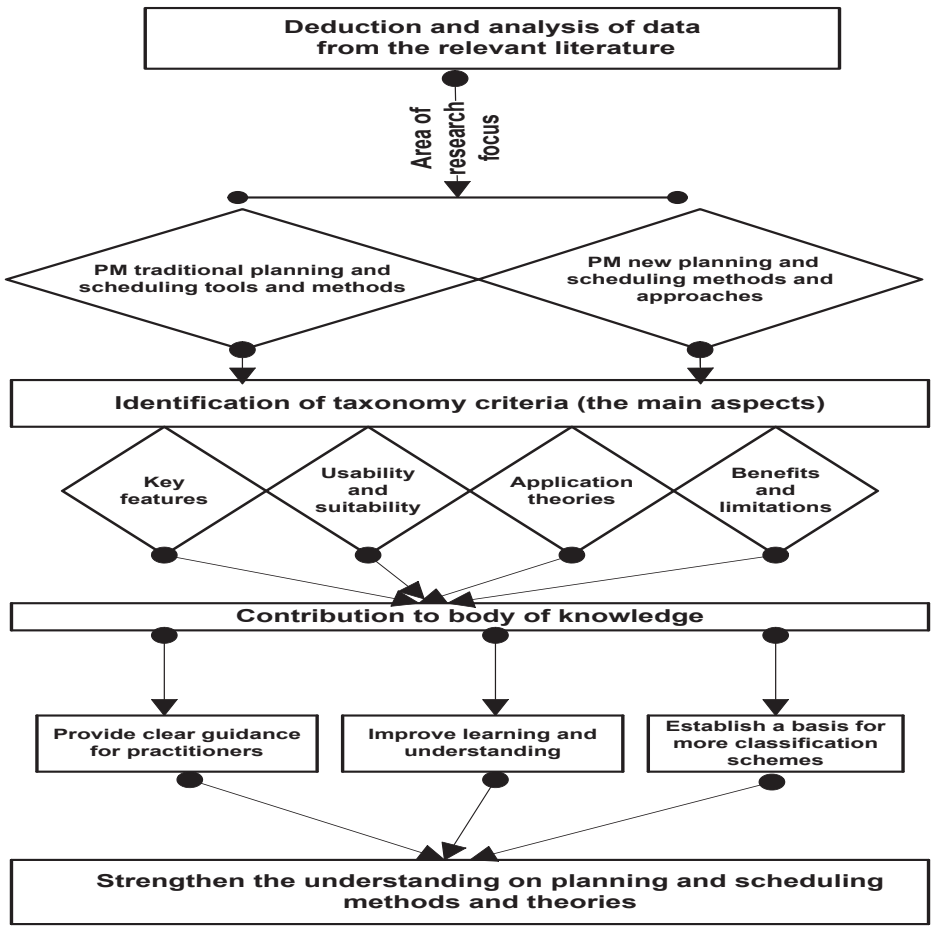

Figure 1: Taxonomy study methodology

8. Implementation of taxonomy

In order to shed light on the main distinctions between these methods, as well as to help raise readers' awareness, the taxonomical aspects of each method have been analyzed separately as presented in the subsequent sections.

8.1. Taxonomical critique of traditional planning and scheduling methods

8.1.1. Gantt chart (GC)

The Gantt chart was initially introduced as a production planning tool; it then found wide application in managing the scheduling of construction projects in the 1980s (Wilson 2003, Kumar 2005). The scheduling of activity-based network using GC was formulated and plotted in horizontal bars of time-scaled activities in sequence, showing their start and end in relation to the commencement date of the whole work (Whitty and Maylor 2009). The Gantt chart is easy to read and understand, especially for small projects with a limited number of activities; however, the use of milestones for modeling large projects is considered to be more difficult (Maylor 2001). In this regard, there are no unique features attributable to GC; nevertheless, the main distinguishing feature of GC is its simplicity in visualizing and monitoring progress against the planned schedule especially on small-sized projects (Kumar 2005). This key feature can allow project planners to be more proactive than reactive when reassessing the executed schedule (Wennink and Savelsbergh 1996, Nicholas and Steyn 2012). Aside from this, GC has some other benefits but also limitations. The Gantt chart was credited as a suitable tool for monitoring the progress of small projects with a well-defined WBS (Wei et al. 2002). In contrast, some of the claimed limitations are that it is insufficient and unsuitable for managing schedules involving multi-tasking since it has no connection with logical dependencies or consumption of work at higher management levels, as reported in the literature (Maylor 2001, Whitty and Maylor 2009, Nicholas and Steyn 2012) and that it is not able to show the intensity of activities and resources that are critical for measuring schedule performance (Bokor et al. 2011).

8.1.2. Line-of-Balance (LOB)

LOB was originally devised as a manufacturing control tool in 1940 and then developed by the US navy in the period from 1942 to 1950 for managing the schedule of projects with repetitive and linear activities (Neale 1994, Arditi et al. 2001). It has been used to control the flow of project operations in terms of number of production units, manpower and space of a set of activities in linear sequence (Georgy 2008). More recently, LOB has been cited as a superior tool, when compared to CPM, for the control of production flows and crew sizes associated with linear construction activities (Bhushan and Raghavan 2013). However, no key features have been accredited to this tool when it is used to deal with the flow of project processes.

The underlying theories of LOB have developed to include potential features to manage the flow variability of large production processes and construction projects based on lean approaches (Arditi et al. 2001, Bertelsen et al. 2007, Duffy et al. 2010). When LOB is integrated with newer tools such as 3D models (Mahdi 2004, Nageeb and Johnson 2009, Duffy et al. 2010), it can combine durations and production rate in the same graphical format and, thus, allows better visualization and optimization of management resources and crews (Arditi et al. 2002, Bhushan and Raghavan 2013, Nageeb and Johnson 2009). As a result, this can provide an even flow of schedule activities and balance them with the productivity of project crews in a more visible manner. One of the key limitations with the current concept of LOB is its inefficiency in planning non-linear or discrete activities in large construction projects (e.g. bridges and commercial developments). This is because LOB cannot take into account resource leveling at different locations (Al Sarraj 1990, Bhushan and Raghavan 2013). In addition, it has no ability to generate well-defined critical paths of the project schedule since it is location-based. To overcome such shortcomings, the development of LOB is being focused on its integration into, and possible combination with, visualization and algorithmic models. The aim is to resolve management conflicts or uncertainties relating to resource leveling of production processes in terms of time and cost (Agrama 2011, Long and Ohsato 2009, Nageeb and Johnson 2009).

8.1.3. Critical Path Method (CPM)

CPM scheduling was initially introduced in 1957; since then the method has been classified as a traditional tool providing a theoretical master schedule-based network for small and medium-sized projects (O'Brien and Plotnick 1999, Dachyar and Saputra 2009). More recently, it has been adopted as a tool for controlling and trading-off the time and cost of project schedule activities, particularly those on the critical path (Nicholas and Steyn 2012). The mathematical aspects of CPM theory have been combined with PERT probabilistic concepts – see below – to provide a clearer estimation about uncertainty since both methods adopt similar planning theory (Wei et al. 2002, Kuklan et al. 1993, Fulkerson 1962). Nevertheless, the main distinction between the two techniques is that PERT has converted CPM's computational approach of a single time estimate into three point estimates based on a probabilistic distribution of the observed mean of completion time (Main 1989, Hegazy and Menesi 2010). In this respect, CPM schedule-based PERT can be used as an integrated approach for optimizing time (Yamín and Harmelink 2001). Furthermore, CPM adopts the management by exception approach that allows project managers to focus mainly on deviations and variances of the activity from the original schedule (Main 1989, Thornley 2013, Galloway 2006). This provides the opportunity to respond to the negative risks of in-progress critical activities (Walesh 2012). Consequently, this might limit the focus of the project team on tracking activities on the critical path only, such that non-critical activities are overlooked and then become critical (Nicholas and Steyn 2012).

Practitioners have reported some important benefits of CPM. First, it shows the logic of interrelated activities and their dependencies, which have to be resolved first in the schedule (Nicholas and Steyn 2012,

Thornley 2013). Second, on small projects that are resource constrained, CPM allows priorities to be set for activities, including minimum free float (Hegazy and Menesi 2010, Chanas and Zieliński 2001). On the other hand, CPM has revealed some limitations: it is not concerned with resource allocation and the consumption of resources in non-critical activities and, as a result, any changes during execution might be difficult to plan and control (Nicholas and Steyn 2012, Thornley 2013). In partial response, heuristics' tools or algorithms have been developed for resource-constrained CPM schedules (Guerriero and Talarico 2010). Another limitation is that CPM does not pay any attention to the uncertainties inherent in activities and their durations; hence, it is seen as unsuitable for multi-tasking projects with hundreds of dependencies (Winch and Kelsey 2005, Hegazy and Menesi 2010). Many of the above limitations have, in fact, been overcome by commercial software tools that include, among other features, resource optimization.

8.1.4. Program Evaluation and Review Technique (PERT)

PERT was devised in parallel with CPM. As noted earlier, PERT was produced as a computational method to estimate the possible completion time of the CPM schedule based on three point estimates using probability distributions (Mongalo and Lee 1990, Hu 2011). PERT has been integrated with simulation models such as Monte Carlo to control and quantify the uncertainty inherent in a CPM time estimate (Nicholas and Steyn 2012). PERT does not take adequate account of the schedule estimate in relation to quality and cost control (van Dorp 2011, Archibald and Villoria 1967, Kuklan et al. 1993). Nevertheless, PERT is regarded as a suitable tool to estimate and quantify schedule uncertainty in operations management and manufacturing processes (Zhu and Heady 1994, Hu 2011).

PERT applications have been developed to control the trade-off between time and cost. Moreover, the development of classical statistical aspects of PERT (e.g. variances and means) has attracted attention from other academic disciplines, for example scientific fields driven by operations research (René 2011). In a sense, it is hardly surprising since operations researchers would lay claim to PERT and, to a certain extent, CPM since both methods were devised to bring about operational improvement in complex undertakings.

PERT has the further attraction of *what-if-analysis*, which can be helpful in identifying time uncertainties during execution of the schedule and thus improves risk control (Liu 2013, Huang and Wang 2009). Conversely, these authors have also argued that PERT estimates are based on a subjective approach to data collected from project parties that can lead to biased assumptions rather than actual estimates. Furthermore, it is claimed that PERT practitioners can make incorrect assumptions which include ignoring the interdependencies between scheduled activities. As a result, such assumptions might lead to oversights in regard to resource feeding and sharing between non-critical activities and critical activities (Nicholas and Steyn 2012).

8.2. Taxonomical critique of modern planning and scheduling methods

8.2.1. Last Planner system (LPS)

LPS was conceived as a planning and control tool to assist in simplifying variations in flow of production processes (Ballard 2000) based on lean concepts (Junior et al. 1998). Over the years, LPS has developed into a collaborative and process-oriented tool for managing and promoting inputs and commitments in the delivery of design and the planning of construction projects (LPS 2012). In this regard, a key feature of LPS is its look-ahead planning principle that concentrates on work flow towards the closing phase of projects, taking into account internal and external constraints and uncertainties (Ballard 2000, Macomber et al. 2005). In addition, the LPS look-ahead feature allows project managers and planners to pay more attention to activities at the operational level and not just at their results (Kim and Ballard 2010). This feature can allow LPS to be combined with other techniques and methods, such as critical space and CPM, to assure the quality of planning and scheduling (Winch and Kelsey 2005) and with location-based scheduling (Kim and Ballard 2010, Seppänen et al. 2010).

LPS is regarded as having some notable benefits over its application, including its use as a communicative tool for managing project objectives, commitments and adding value to the project work flow by prescreening constraints and uncertainties with forthcoming activities (Hicks 2007, Kim and Ballard 2010). In addition, the correct implementation of LPS can help site managers and the project team to be more proactive organizing their own workload plans and, hence, it minimizes the potential for unsuccessful completion of assigned activities as well as improving understanding of the root causes of schedule deviations (Harris et al. 2006, Kim and Ballard 2010);. LPS improves learning, training and team interactions through its multi-communication channel (Kenley and Seppanen 2009). Unlike traditional ways of scheduling, LPS adopts a phase pull schedule that allows planners to identify activities or milestones and organize them in a pull plan working backwards towards the phase starting date (Koskela et al. 2010, Macomber et al. 2005). Despite these benefits, LPS has been found to have some potential limitations: it has a lengthy approval procedure with short term visions that might lead to inadequate project planning for a range of stakeholders inputs (LPS 2012). The difficulty is in handling commitments from different parties such as contractors, sub-contractors, suppliers, designers and clients involved in the approval of project plans (Kim and Ballard 2010, Bortolazza et al. 2005). Moreover, LPS look-ahead principles, which are used to monitor constraints of up-coming activities in the execution phase, might latterly report a delay in the delivery schedule to (Choo and Tommelein 2001). Furthermore, LPS might not be implemented properly so there is a loss of information when exchanging between management levels, especially during the short-term planning of construction sites (Hicks 2007, Harris et al. 2006, Seppänen et al. 2010). Additionally, on phased projects, LPS can involve a high level of scheduling which can hinder proper scrutiny by the project team of the work to be done (Koskela et al. 2010, Choo and Tommelein 2001).

8.2.2. Critical Chain Project Management (CCPM)

The underlying concepts of CCPM have been adopted by many organizations for their project management (Herman 2001, Cerveny and Galup 2002, Kerzner 2013). CCPM denotes a departure from traditional CPM-based scheduling (Leach 1999). The theory of constraints (TOC) represents the driving force of CCPM implementation (Goldratt and Cox 1984, Rand 2000, Linhares 2009). CCPM is a network-based schedule that represents a set of interrelated activities with logical dependencies and leveled resources utilizing buffer management (Leach 2005). Nevertheless, it has been argued that CCPM includes activities with resource dependencies, but not necessarily logic dependencies as in CPM. This is considered to allow project managers to take account of all interdependencies (Dachyar and Saputra 2009, Herroelen et al. 2002). Buffers serve as monitoring tools that aid project managers in managing the project schedule through the switching of resources or buffers from activity-dependent critical paths to critical chain resource dependencies (Cerveny and Galup 2002, Leach 2011). Furthermore, buffers have to be used to protect and overcome variability in activity durations resulting from the use of traditional methods such as CPM and PERT (Nicholas and Steyn 2012). One of the reported key features of CCPM scheduling is its holistic solution which can be used to monitor project progress overall rather than focusing on the completion of individual activities (Cerveny and Galup 2002, Guo et al. 2012). In addition, the holistic approach is used for recovering resource conflicts in critical and non-critical chains in the CCPM network (Trietsch 2005), by allowing the project team to work on critical chain activities in more dedicated manner (Kerzner 2013). For this reason, CCPM is considered to be a hybrid approach combining and integrating the concepts of CPM-based scheduling; in addition, it has been used to manage traditional resource-constrained scheduling problems (Guo et al. 2012, Rand 2000). These key features mean that CCPM has been applied as a project planning and risk control tool by many disciplines (Ming and Wuliang 2009, Leach 1999, Patrick 2001). Its features imply that CCPM can be considered as a strategic management approach rather than as a scheduling tool alone.

Users of CCPM have experienced some significant improvements and benefits over traditional methods. Leach (2011) has reported that CCPM recovers and enhances traditional methods by mitigating improperly inserted safety times as well as by rearranging non-dedicated resources from the use of buffer management: CCPM utilizes buffers for time, capacity, cost and scope (Trietsch 2005). It minimizes multi-tasking activities by setting the buffer priorities and avoids unintended human operational behaviors such as activity padding (Herroelen et al. 2002). Nevertheless, CCPM has some limitations which are mainly concerned with inaccuracy relating to CCPM's statistical approach to estimating buffer size, as highlighted by, for example, Gao et al. (2010) and Herroelen et al. (2002). There are, though, some attempts at resolving buffer conflicts by integrating CCPM's underlying concepts into available simulation models and other algorithmic approaches; see, for example, Xie et al. (2010).

8.3. Summary

In summarizing the above analysis, it appears that the Gantt chart is a suitable tool for explicitly visualizing the status of scheduled activities at intermediate levels; however, no consideration is given to non-dedicated (human) resources as well as the trade-off between time and cost. This shortcoming has been partially overcome by integrating Gantt charts into a network to potentially handle major implicit uncertainties and thus quantify and control the connections or dependencies between activities. CPM and PERT have been merged as one technique, especially on large projects with myriad activities. In other words, the combination of a CPM-based deterministic network with a PERT probabilistic estimating method seems to be considered appropriate for managing large construction projects when embodied in Monte Carlo simulation tools. On the other hand, projects comprising many repetitive elements or activities can be handled by linear scheduling techniques such as LOB. However, any significant alteration in the progress of linear scheduling networks might result in non-linear activities that could deviate from the linearity path of actual scheduling. In short, despite the potential capabilities of traditional methods in managing certain types of scheduling, their significant limitations in switching among activities in terms of resource or buffer contentions and leveling mean that they are unsuitable for handling resource-constrained schedules. Furthermore, traditional tools are insufficient for managing and allocating all resources at the detailed level of scheduling and can thus lead to many idle buffers. These shortcomings are covered by either the introduction of advanced probabilistic algorithmic models or methods such as CCPM. The integration of lean concepts in construction has also found its way into planning tools (i.e. LPS) to allow for more reliable scheduling in the early stages of the construction process. In the following sections, a more detailed description of the main findings is highlighted.

9. General discussion on applying a taxonomy

9.1. Key features of the underlying theories and concepts

The use of taxonomy criteria and related aspects (Figure 1 & Table 1) can help to make a clear distinction between different planning and scheduling methods for the purpose of understanding their practical implementation. To achieve this position, the different features and key characteristics were scrutinized and recorded for the purpose of improving practitioners' understanding. In other words, a number of novel insights towards the development of more advanced taxonomies or classification schemes for project management control processes were highlighted.

9.1.1. Competency and requirement aspects for applying methods

Traditional methods allow the project manager and planner to focus on the completion of activities without considering potential risks relating to resource conflicts in forthcoming activities and their interdependencies. As a consequence, this behavior encourages the project team to work in a more reactive manner when

controlling schedules instead of being more proactive over scheduling constraints. On the other hand, modern methods (e.g. CCPM and LPS) have now been experienced as useful tools for managing and controlling schedules containing a large number of activities and their interdependencies. This is because such methods are concerned with the management of resource-constrained schedules. Furthermore, the underlying theories of modern methods support integration with other classes of scheduling method. Despite such potential features, users and practitioners in general should have a more developed understanding when assessing and evaluating implementation outcomes. Nevertheless, the key features of modern methods represent a significant departure from the application of traditional methods.

9.1.2. Planning and monitoring roles

The findings further imply that traditional methods tend to be centered on the monitoring stages of scheduling by focusing on a representation of progress in terms of activities' precedence relationships as well as their related statistical fluctuations of the time for delivery rather than identifying and mitigating the schedule risks. Moreover, the performance of scheduling plans using traditional methods is routinely controlled by a conformance measure of the as-built schedules against the as-planned schedules. In opposition to this, newer methods allow planners or schedulers to focus on both the planning and controlling stages of the schedule taking into account all potential constraints on both the activity and project levels. Consequently, these key features, if they are properly used, can inform project stakeholders on the optimal delivery time of the project in the most cost effective manner.

9.2. Key benefits and limitations

The use of the taxonomy supports comparison of planning and scheduling methods in terms of their key benefits and limitations contributing to existing and more recent applications or practices. The findings imply that the implementation procedures surrounding traditional methods mean that it is much easier to achieve a common understanding among the major parties involved in planning and scheduling in comparison to *modern* methods. On the other hand, modern methods are more efficient yet more difficult since the implementation procedures for adopting them are accompanied by a lengthy or even a more complicated procedure. With regard to features concerned with accuracy and quality of schedule estimates, when using the traditional methods, project managers and planners tend to assume low project risk over activity durations and, hence, can find that they are accepting less realistic estimates. As discussed earlier, this is may be due to a lack of awareness paid by project managers to resource leveling or conflicts when using traditional methods. As a result, these traditional methods and techniques are criticized or seen as unsuitable for managing large and complex projects with significant risks. The key features of the underlying concepts of modern methods can overcome the shortcomings of traditional methods concerning the handling of uncertainty and risk; this is mitigated by aligning or correlating the quality control of scheduling outcomes with that of the project's risk management and cost estimating. In this sense, the underlying statistical aspects of modern methods are intended to assume a higher level of certainty which, consequently, may enable project planners and their risk

managers to optimize precisely the occurrence of potential risks when developing the detailed schedule. This could imply that project managers and planners should consider all constraints and unintended human behavioral aspects in order to make the best decision regarding optimization of the potential risks or other unexpected events prior to implementation.

9.3. Summary of the overall findings

In connection to the above discussion, and based on the analysis of the most relevant literature, the main findings from applying the taxonomy are presented in Table 2. More specifically, Table 2 provides a summary of the major items (criteria) and sub-items resulting from the analysis of the different planning and scheduling methods covered in the study. In view of the quantitative taxonomies by Romesburg (2004), it can be argued that the classification shown in Table 2 of the adopted methods seems to be appropriate for use as the basis of further work considering the quantitative taxonomies in which the investigated methods can be identified as objects and the taxonomies dimensions can be identified as attributes. This could facilitate further quantitative assessment or classification of methods and tools. After that, a form of cluster analysis could be applied to further investigate statistical correlations and thus information about practical cross-interactions among these different attributes, especially for construction projects having multiple-schedules using different planning and scheduling methods and tools.

Table 2. Summary of the main findings

Dimensions / Methods		Traditional methods (GC, LOB, CPM, PERT)	New methods (CCPM, LPS)
Key features of the underlying theories and concepts	Classification of activity network using the scheduling methods	○ Graphical tools with computational basis ○ Can be worked on as deterministic and non-deterministic network ○ Methods-based push schedules	○ Graphical-based project planning and monitoring structure with less computational and statistical basis ○ Can be combined with both deterministic and probabilistic approaches ○ Methods-based pull schedules (LPS)
	Class of scheduling problem to be resolved	○ The network problems in their class ○ A set of activities or production units in a sequence with no logical dependencies-based resources ○ Classical scheduling problem-based activity network	○ Recovering shortcomings with traditional methods ○ A set of interrelated activity-based dependent resource (CCPM) ○ All organizational inputs and actions and activities (LPS) ○ Scheduling problems-based constrained resources (CCPM)
	Roles of planning method in scheduling	○ Input: the activity durations and precedence relationships ○ Output: activities with their probabilistic delivery time ○ Focus: the scheduling phase only ○ Controlling system: conformance measures ○ Nature of scheduling team: more reactive	○ Input: all activities and deliverables through organizational structure ○ Output: least possible completion time with accurate consumption of resources ○ Focus: all phases of the project ○ Controlling system: cross-sectional feedbacks/ risk and quality control ○ Nature of scheduling team: more proactive
	Management concept of scheduling uncertainty using the method	○ Increase amount of both dedicated and non-dedicated resources ○ Consider surplus resources as safety times ○ Focusing on statistical fluctuations only	○ Reduced amount of dedicated resources (i.e. labor and money) ○ Consider idle resources as a waste and re-plan them by implementing buffers at both project and management levels ○ Focusing on schedule risks and uncertainties
	PM Level at decision-making and control processes of scheduling	○ At the activity level in most cases	○ From the activity level to project management level through the project level

Application areas (suitability and usability)	○ In small and medium sized construction projects, repetitive production operations ○ Linear and non-linear construction projects ○ CPM-based scheduling has been embodied into computer-based tools for managing large construction projects	○ All fields of engineering based on theory of constraints ○ Construction projects based on lean production concept
Benefits	○ Implementation concepts are much easier/easy to understand ○ Monitoring/visualization tool of in-progress schedules ○ Worked on forward vision or as soon as possible (ASAP) ○ Suitable for managing and monitoring small-sized schedules with embodied conventional computer-based tools and visualization models ○ Shows more statistical potential to be integrated or combined with other advanced techniques and computer-based tools ○ Can be used as a communication tool among site management and office management ○ Can be easily integrated into computer-based tools on projects with a large number of activities	○ Eliminating unplanned contingencies or resources ○ Holistic management/ look-ahead operating approaches allow for optimizing constraints with forthcoming activities ○ Allow for more site learning, knowledge expansion and information sharing ○ Improve quality and reliability/quantify and mitigate the schedule risks ○ Allow for cooperation of project stakeholders in estimating and controlling schedule duration and risk ○ More correlation with project risk management ○ Suitable for managing multi-tasking projects ○ Assuming high risks on the schedule/more accurate estimates ○ More able to control the work flow process

Limitations	○ Assuming low risks/less realistic estimates ○ Less concern about resource leveling and contentions ○ Less concern about activity logic and dependencies ○ Not suitable for large and complex schedules with multi-tasking ○ Probabilistic approach-based biased estimating ○ Not capable of addressing human aspects and flow processes ○ Focusing on the activity critical path but not schedule uncertainty ○ Quantify the schedule risks without handling them ○ Less opportunity or not at all given to stakeholders in estimating and controlling of the schedule duration and risk	○ Implementation procedures are more complicated ○ Lengthy approvals procedures for work plans ○ Buffer sizing problems in multi-tasking projects ○ More correlated to human behavior and management competence ○ Less focus on the start of activities, works backwards from the end or as late as possible (ALAP) ○ Need of efficient resources and a qualified team ○ Might not be suitable for managing multiple linear projects with many repetitive activities ○ Allocating resources based on project priority not activity priority in multi-tasking projects

10. Conclusions and recommendations

Current practices on construction projects involve the implementation of a wide-range of project management methods and tools to support core processes, particularly planning and scheduling. The extent to which implementation of these methods is successful attracts different views from users and other practitioners. It was considered that a taxonomy of methods could broaden understanding of the underlying concepts. This study has attempted to partially fill knowledge gaps as well as aiming to consolidate understanding by conceptualizing and implementing a taxonomy. The taxonomy provides a useful platform for practitioners and researchers with common ground for investigating more advanced or multi-dimensional frameworks.

The conceptualization of a classification can help to improve understanding that would assist the project team to select, prioritize and integrate the most appropriate methods or combination of methods of project planning and scheduling. This would imply that implementation of these methods cannot guarantee the success of project schedules without knowing about the key concepts and characteristics of the underlying planning and scheduling methods concerned.

On the basis of the findings from applying the taxonomy presented, some lessons and recommendations can be proposed for consideration by project managers and their planners for the scheduling and control of their projects.

- Taxonomies can be considered as a tool for consolidating or promoting practitioners' understanding, as well as their awareness, in regard to the implementation of planning and scheduling methods and tools. A taxonomy can be implemented in a more effective way if it is integrated with project management tools and/or control processes.
- Project managers and their planners should generate greater awareness among other project team members of the different methods and tools by indicating which of them are suitable for their projects, their key merits and the pitfalls from adopting certain methods as opposed to others.
- A taxonomy study was built and developed based on the critical review and synthesis of the extant literature; therefore, it provides some useful insights for promoting current practices and for filling knowledge gaps on the part of project team members regarding implementation of different planning and scheduling methods. It also highlights common ground about how to prioritize and adopt the most suitable method or tool from available alternatives.
- In competitive environments, extensions to and innovations in the area of more sophisticated planning and scheduling methods and tools are expected or might already be in preparation. A taxonomy can serve as a useful guiding tool for project managers and planners who must select the most efficient methods to effectively manage and control their schedules.
- On large construction projects with myriad activities, a taxonomy could help project managers and planners segregate project activities in phased schedules in which a combination of different scheduling methods can be properly utilized to manage each set of activities based on their different characteristics.

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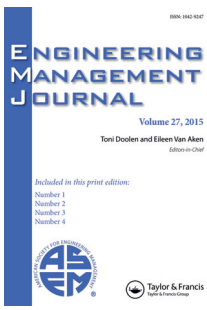
Paper II



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Assessing Understanding of Planning and Scheduling Theory and Practice on Construction Projects

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Assessing Understanding of Planning and Scheduling Theory and Practice on Construction Projects

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Abstract: Despite attention being paid to the development of planning and scheduling theory, it is unclear whether project stakeholders and practitioners have sufficient understanding about how it applies in practice. A study was conducted with the aim of assessing practitioners' perceptions of planning and scheduling theory and practice on construction projects in Oman. Data were gathered through a questionnaire-based survey and analyzed using the relative importance index. Respondents were asked to consider: (1) the suitability and efficiency of existing planning methods; (2) scheduling development and performance control; and (3) knowledge-based planning and scheduling concepts. The analysis revealed no significant variations among respondents' perceptions in regard to the above topics. The findings did, however, reveal a number of factors that are of equal importance to the development of project planning and scheduling. The overall findings imply that practicing managers should implement new management strategies that foster knowledge-based planning and scheduling concepts for a more effective construction process. Recommendations are made for improvement that include the need for practicing managers to professionalize project planning and scheduling based on a more proactive and knowledge-based planning approach, which is supported by management.

Keywords: Construction Projects, Organizational Learning, Project Planning, Schedule Performance, Scheduling Methods, Stakeholder Perspectives

EMJ Focus Areas: Program & Project Management, Economics of Engineering

In competitive environments, where construction and infrastructure projects are taking place, planning and scheduling are vital to understanding project performance (De Snoo, Van Wezel, & Jorna, 2011). More specifically, both processes have to be addressed correctly and efficiently to ensure that projects meet their objectives (Demeulemeester & Herroelen, 2002; Laslo, 2010). Furthermore, these processes are fundamental in the life cycle of construction projects as they involve the selection of the most appropriate techniques and tools, the definition and organization of a myriad of activities, and the estimation and allocation of the most economical deployment of resources (Ahuja & Thiruvengadam, 2004; Kelsey, Winch, & Penn, 2001).

Haugan (2002) argued that planning and scheduling are time-cost oriented processes and, hence, constitute a challenge to project managers and planners when managing their applications (Andersen, 1996; Oglietti, 2005). Scheduling represents a significant task within project management. Scheduling must take into account the trade-offs between time and cost based on the consumption of resources (Yang, 2007a), while minimizing project duration (Elmaghraby, Herroelen, & Leus, 2003). Planning for resources must ensure the development of reliable schedules (Kerzner, 2009). Project managers and schedulers are accountable for planning that incorporates sufficient management coordination, correct sequences (Winch & Kelsey, 2005). Shobrys and White (2000) stated that construction organizations with dispersed projects need coordinated approaches to planning, scheduling, and control more than organizations with a single or few projects at any one time. A possible obstacle to such coordinated approaches is the nature of decision flows in project organizations.

Scheduling cannot succeed without knowledge of the work being planned. Moreover, an incomplete planning process might impair the worth of schedules and, hence, lead to an uncontrolled flow of project progress (Andersen, 1996). According to Oberlender (2000), tracking of project schedules cannot be achieved properly unless effective controls are in place. Shash and Ahcom (2006) stated that project planning represents a proactive step in detecting and correcting deviations from the schedule. In this respect, separation between the two processes could lead to overlapping and partial duplication in resolving resource constraints in the schedule (Tan & Khoshnevis, 2000). Chua and Godinot (2006) noted that a well-defined work breakdown structure (WBS) in the planning phase improves the interfaces between parties and thus allows for more dynamic, as well as functional, schedules.

The study reported in this article aimed to identify and examine current practices of planning and scheduling using construction projects in Oman. The study included perspectives of practitioners' familiarity with common planning and scheduling methods, perceptions about schedule development and control processes, and awareness and knowledge-related planning and scheduling concepts. The outcomes of this study can be used to shed light on how to strengthen the current link between the theory of and practice of planning and scheduling. Moreover, the study can provide new insights for project managers and practitioners towards new management strategies and tools needed to improve the understanding of planning and scheduling concepts in current practices of construction projects.

The following sections present a review of literature, the research methods, analyses and results, the implications to theory and practice, and finally, the main conclusions and useful insights for future development and work in this area.

Literature Review

The literature review was designed to provide clear insight about, and to understand, relevant research practices in planning and scheduling. With a focus on the primary question of this research study: What level of knowledge-based planning and scheduling theory and concept do practitioners have in

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their current practice? In addition, the investigated literature indicated that this research question appears to be an important issue that needs further examination from perspectives of project managers and other stakeholders involved in construction projects.

Schedule Plan Development and Performance Control

According to Cegarra and Wezel (2011), a schedule's actual performance helps in evaluating the quality of future schedules, as well as pointing towards opportunities for improvement. This task has to be achieved by both planners and schedulers in order to control resource consumption within schedule constraints (De Snoo et al., 2011). In addition, Haugan (2002) saw the main objective of schedule control as tracking actual performance and to indicate corrective actions and contingency plans as might be required. Planners and project managers should know the current status (i.e., progress) of their projects in order to avoid misinterpretation of the executed schedule against the planned schedule (Jung & Kang, 2007). According to Rasdorf and Abudayyeh (1991), interdependency between the time and cost of a project calls for a control and feedback system to support decision making, especially when facing the recovery of lost time. Oberlender (2000) stated that an established control process could be explicitly achieved by an operational plan that links the three main components (scope, time, and cost) of the project. Scope is deemed to cover both the extent of work and its quality, although the latter is likely to be defined separately in specifications and similar documents. In regard to the use of a Work Breakdown Structure (WBS), Koelmans (2004) recognized key concepts in a typical WBS matrix that includes a coding system to support schedule control.

De Snoo et al. (2011) have analyzed schedule performance based on measures of the quality of deliverables from the perspectives of end users and other project stakeholders. That study was based on criteria used to measure schedule performance, which highlighted such issues as process input errors and behavioral concerns, for example, poor quality communication, lack of scheduler skills, and insufficient recognition of schedule risks. Other researchers have examined aspects of schedule performance from other perspectives. For instance, Glenwright and Mattos (2008) pointed out that a validated baseline schedule should be used as a control tool to check actual progress of scheduled work. Kog, Chua, Loh, and Jaselskis (1999) considered other determinants of schedule performance control, such as frequency of allocated resources and effectiveness of information communication among the parties contributing to schedule production.

Understanding Different Planning and Scheduling Tools and Techniques

In the context of construction projects, a number of methods and tools are used to plan project schedules, and most of these have their origins stretching back to the Second World War, or even earlier. They include the Gantt chart, Critical Path Method (CPM), and Program Review and Evaluation Technique (PERT) (Haugan, 2002; Popescu & Charoenngam, 1995). These methods have been found to be the most used in the construction industry (Rand 2000; Plotnick & O'Brien, 2009; Yamín & Harmelink, 2001), even though they have been criticized as somewhat traditional approaches (Antill & Woodhead, 1990; Diaz & Hadipriono, 1993). The methods were originally developed for purposes other than the scheduling of construction projects. The Gantt chart is a graphical tool used to portray a set of activities over a period (Wilson, 2003) and has been accepted as a visual tool for monitoring work in progress (Nicholas & Steyn, 2012). CPM and PERT were introduced in parallel to plan traditional construction projects using a set of tasks identified in a WBS (Siemens, 1971). Nevertheless, the main distinction between them is that CPM is based upon a deterministic network that uses a single time estimate for each task to calculate schedule duration. PERT was developed as a probabilistic network using three point estimates of time to model the uncertainty associated with the estimation of task duration (Zhu & Heady, 1994).

These traditional methods have attracted criticism due to their inability to model risk and other factors that prevail on projects and whose absence can result in misleading schedule estimates (Mongalo & Lee, 1990; Yang, 2005). Such criticism has been partly allayed through the progressive development of these methods by mathematical means based on simulation. This has been done to overcome problems, such as estimate accuracy, conflicting interdependencies, correlation, and resource criticality and priorities associated with real-time activity scheduling [see, for example, Carpio, Sydorovych, and Marra (2007); Chen, Griffis, Chen, and Chang (2012); Huang and Wang (2009); Kuklan, Erdem, Nasri, and Paknejad (1993); Trietsch and Baker (2012)].

The various shortcomings have stimulated the introduction of new management approaches (or methods), such as Critical Chain Project Management (CCPM), Theory of Constraint (TOC), and the Last Planner System (LPS). CCPM has been developed as a method derived from TOC (Rand 2000; Ma & Tu, 2002), which aims to resolve resource constraints by using a buffer management approach (Yang, 2007a). Statistical parts of CCPM have been integrated with software-based models to tackle advanced planning and scheduling problems (Xie, Yang, & Lin, 2010). On the other hand, LPS (Ballard, 2000) is based on the application of lean production principles; it has been recognized as a collaborative, as well as a communicative, approach (Junior, Scola, & Conte, 1998; Sacks, Radosavljevic, & Barak, 2010). Despite the benefits reported from the use of newer techniques, some shortcomings in providing holistic solutions for complex projects subject to resource uncertainty, especially those with a multi-chain of activities and long chains of human involvement, have been reported (Choo & Tommelein, 2001; Herroelen & Leus, 2001).

Several tools and techniques have been computerized and integrated with more advanced simulation models and algorithmic approaches for scheduling of project-based resource constraints as demonstrated by, for example, Abeyasinghe, Greenwood, and Johansen (2001); Lim et al., (2011); Liu and Wang (2012); Long and Ohsato (2008); and Trietsch and Baker (2012). These authors have investigated issues with network-based mathematical algorithms and modeling. In fact, advanced planning systems using both algorithmic and optimization approaches have received much attention in operations research. The goal of these techniques is to optimize and provide more reliable estimates of a schedule with uncertain durations, which could not otherwise be resolved using traditional approaches (Carpio et al., 2007; Cegarra & Wezel, 2011; Haugan, 2002; Huang & Wang, 2009; Xie et al., 2010). Despite their clear potential, some problems or shortcomings associated with project planning and scheduling have been recognized (Chen et al.,

2012; Jun-yan, 2012). In addition, Dawood and Sriprasert (2006) criticized traditional scheduling methods and theory and suggested that these methods are less efficient in handling constrained scheduling with multi-tasking. These authors studied this problem by integrating CPM tasks into algorithmic models, which were built based on the lean construction concept. However, the authors concluded that accurate predictability of complex construction schedules integrated into available models required adequate knowledge of theory of scheduling.

In summary, previous research on the use of different planning and scheduling tools and techniques implied that there is a need to assess practitioners' familiarity with the fundamentals of planning and scheduling as manifest in different methods and techniques. While the exact reasons behind such problems are unclear, it can be argued that these problems resulted from improper understanding of underlying principles and assumptions embodied in different tools used in planning and scheduling projects. From the literature presented, it can be reasonably argued that practitioners should be expected to have sound working knowledge of at least one planning and scheduling method and some familiarity with a number of others. Additionally, practitioners are expected to have the ability to appraise the suitability and effectiveness of such methods in satisfying their planning and scheduling needs. Our fieldwork —described later—will therefore examine (a) the extent to which practitioners are familiar with these methods and (b) their satisfaction with these methods. These project management aspects should be adequately addressed at both theoretical and practical levels by practicing managers for more effective control of project schedules and related resources.

Managerial Knowledge and Awareness About Planning and Scheduling

Knowledge about planning and scheduling is a fundamental requirement for all organizations attempting to make planning methods and tools usable for managing their projects or systems (Wilkins, 2001). From a production or manufacturing perspective, knowledge about schedule management is a critical issue that must be addressed in order to judge schedule problems by means of both experience and knowledge (Saver, 2001). This would allow for strengthening the link between the theory and practice of planning and scheduling (Smith, Frank, & Jónsson, 2000). Additionally, Yang (2007b) highlighted the need for knowledge that might ease adaptation and usability of different scheduling approaches by practitioners. Indeed, there are few studies that have attempted to focus on conceptualizations of a knowledge-based approach to project planning and scheduling. Among them, Oglietti (2005) introduced an algorithmic model for evaluating knowledge issues based on planning with incomplete information input. Mikulakova, König, Tauscher and Beucke (2010) proposed a knowledge-frame model linked to a decision-support system involving all relevant factors and other alternatives needed for regeneration of the schedule. This model was introduced for the initial purpose of resolving problems caused by unstructured knowledge that might be adopted by project managers based on their past experience. Similarly, Shobrys and White (2000) examined the use of a knowledge approach integrated with software used to analyze some of the significant factors affecting project schedules. The findings of that study indicated that the majority of schedule problems were due to lack of knowledge or awareness about the planning and scheduling systems being used. Walker and Shen (2002) investigated planning flexibility and project schedule performance using a framework that tries to facilitate construction time performance through an integrating model. The model was proposed to facilitate the transfer of stakeholder knowledge and perspectives to planning and execution processes of construction scheduling in a more efficient manner. More recently, Cegarra and Wezel (2011) examined organizational knowledge of the planning and scheduling performance from three perspectives: descriptive, formative, and normative. These knowledge-based planning perspectives have been used to examine the usefulness of future knowledge-based planning and scheduling approaches and show some promise; however, the practical application of such approaches needs to be investigated. Consequently, it is assumed that an investigation of the level of understanding of the basic principles and concepts of planning and scheduling can highlight specific gaps in knowledge and thus point towards the opportunities for improvement. This study has identified and examined practitioners' knowledge or awareness of various matters including, but not limited to: (a) schedule management and control issues and (b) planning and scheduling input roles and concepts. In light of this literature review, a suggested model for knowledge-based planning and scheduling was developed and is shown in **Exhibit 1**, which highlights the importance of having a conceptual understanding of planning and scheduling in terms of the key roles, inputs, and deliverables. It can be argued that competent management and comprehension of these aspects of planning are a prerequisite for achieving high quality scheduling.

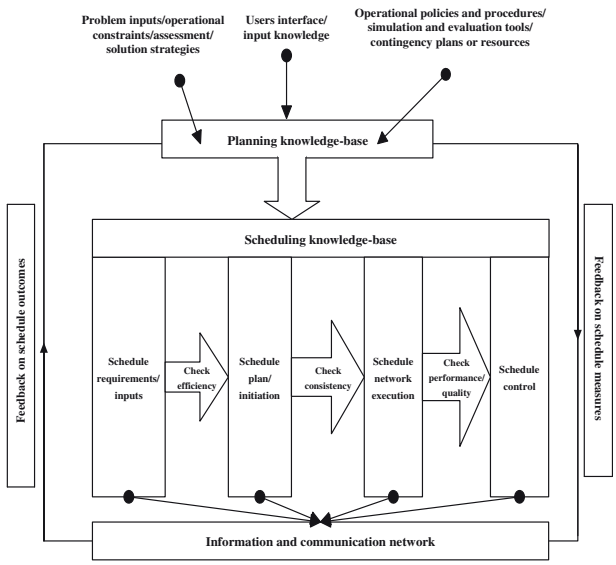
Summary of the Literature

The literature revealed that current researcher focus has been concentrated on the investigation of causes of time-cost related scheduling problems at the operational levels of projects. As noted earlier, previous research has not addressed the link between planning and scheduling theory and current practices on the part of project stakeholders and organizations. Without having knowledge about such links among theory of and practice of planning and scheduling, project managers and practitioners can face key challenges when implementing these theories and concepts in practice. Challenges should be assessed at both theoretical and practical levels on the part of organizations and practitioners. Thus, this study tries to partially fill this knowledge gap by assessing project stakeholders and practitioner familiarity and knowledge in this area in order to align such knowledge with the development of project management concepts for more effective planning and scheduling systems.

Significance of the Study

From the literature review, it is recognized that for planning and scheduling to be successfully adopted, fundamental issues have to be investigated and improved. There is a need to explore practitioner perspectives and to use these perspectives to assess awareness of planning and scheduling. For this purpose, practitioner understanding of key concepts and principles underlying planning and scheduling was pursued through a number of questions covering, among others: alignment between the WBS and the schedule; logic for determining the correct sequence of activities; data for estimating activity durations; and the methods employed for monitoring and controlling the schedule. The questions focus on planning and scheduling mostly from the perspective of those charged with responsibility for creating, maintaining, and controlling project schedules. From an

Exhibit 1. A Suggested Model for Knowledge-Based Planning and Scheduling (Adapted From Saver, 2001 and Wilkins, 2001)



organizational perspective, these perspectives can reveal the extent to which an organization has progressed from a largely technical focus—typically the implementation of traditional methods and tools—to one where knowledge capture and exchange are considered. It is anticipated that the findings from this field survey of the Oman construction industry will help further develop work that can enhance the link between theory and practice in planning and scheduling by identifying the most effective mechanisms needed to enhance organizational knowledge of project planning and scheduling for improved construction efficiency.

Research Methods and Collection of Data

Questionnaire Design

This study used a survey to explore the potential of criteria or factors adopted from the literature to make practical differences to practitioners on construction projects. In this regard, Oyedele (2013) asserts that a questionnaire-based survey is a positivist approach, especially for descriptive research seeking to investigate and analyze research problems within an area where theory has been adequately explored in the literature, that is, planning and scheduling. Moreover, a questionnaire-based survey was chosen because it enabled a large number of sources to be reached, as well as being time and cost effective (Fellows & Liu, 2009). As discussed earlier, a list of criteria or statements were developed based on the literature review by taking into account issues that are not explicitly addressed in previous studies of project planning and scheduling. Researchers then utilized brainstorming, along with experiences from stakeholders in the construction industry, to develop a final set of questionnaire statements, which were categorized into three main topical areas.

The questionnaire consisted of three main parts: the first part measured respondents' perspectives on the suitability and efficiency of scheduling methods used in practice; the second measured respondents' perspectives of their awareness of input procedures relating to schedule development and monitoring; and the third addressed respondents' levels of knowledge of planning and scheduling theory and roles. In addition, the questionnaire involved a set of open-ended questions for the sake of obtaining additional opinions from respondents regarding the examined research issues.

Sample Selection and Questionnaire Distribution

Sampling and distribution of questionnaires are important research design issues (Rowley, 2014). Rowley suggests that different sampling and distribution approaches can be used, including random, cluster, purposive, convenience, and snowball. According to Rowley, sampling is the selection of samples based on a number of accessible organizations in a certain region. Participants for this study were selected based on both random and convenience approaches. Three packages of questionnaires were sent out to practitioners involved in public and private construction organizations, as well as facilities'

management and maintenance units. The majority of respondents' organizations were located in Muscat, the capital city of Oman. In addition, participants were chosen based on their involvement at different stages of construction projects and in different sizes of projects ranging from medium- to large-sized projects. Participants were also expected to have different levels of knowledge in project planning and scheduling. The questionnaire was distributed via mail and by hand (face-to-face) to selected participants and informed consent was addressed with key project administrators prior to the distribution of questionnaires. Email and hand delivered questionnaires are typically more efficient mechanisms for gathering data, motivating responses, as well as reducing non-responses in comparison with other methods, such as postal delivered questionnaires (James, 2007; Oppenheim, 2000). Most of the emailed questionnaires were sent to participants at inaccessible organizations or construction sites. The researcher followed up and reminded participants about the questionnaire. A total number of 80 questionnaires were returned and collected out of 130 questionnaires, which were distributed based on the selection criteria discussed. Three questionnaires were not completed, resulting in 77 valid questionnaires (i.e., n = 77) for use in the analysis. As a result, the overall response rate was 61.5%, which is considered to be reasonable, particularly in light of previous studies of construction projects, which experienced lower response rates (Long, Ogunlana, Quang, & Lam, 2004; Luu, Kim, Tuan, & Ogunlana, 2009; Tam, Shen, & Kong, 2011).

Selection of Data Analysis Approaches

The questionnaire utilized a 7-point Likert scale (i.e., 1 = strongly disagree, 7 = strongly agree) in an attempt to examine respondents' level of agreement with a set of statements. Jamieson (2004) stated that researchers were in favor of using a 7-point scale as it might help in diversifying responses, although Jamieson argued that this might not result in significant variations among overall mean rankings. The overall rankings of significance of the investigated factors in the study were analyzed using the relative importance index method (RII). RII was selected as suitable for analyzing surveys from construction-based studies with ordinal scale data (Holt, 2014). Because the intervals among values of collected responses through ordinal scales cannot be presumed equal, the use of RII is more accurate in generating an average index on interval variables (Holt, 2014). The RII has been widely adopted for analyzing Likert-scale data used to measure opinions of participants on certain criteria or variables in studies similar in nature to the study context of this research (Chan & Kumaraswamy, 1997; Kumaraswamy & Chan, 1998; Mohan, 1990; Tam et al., 2011; Zakeri, Olomolaiye, Holt, & Harris, 1997). Respondent agreements collected for this study used a transformation of 7-point Likert rankings into arithmetical indices following Equation 1 and Equation 2 per Holt (2014):

$$\mathrm{RII} = \left[\sum \mathrm{w}/\mathrm{A}^{*}\mathrm{n}\right], \tag{1}$$

$$\mathrm{RII}_{\mathrm{adjust}}(\text{for a 7-point scale}) = [(116.68^{*}\mathrm{RII}) - 16.68], \tag{2}$$

where $\sum w$ (in this study) = $(7 * n_7 + 6 * n_6 + 5 * n_5 + 4 * n_4 + 3 * n_3 + 2 * n_2 + n_1)$.

For a 7-point scale, RII range = $[1 - (1/A_{max}) = 0.14$ to $0.86]$, where RII = relative importance index, w = individual weight given to each statement by the respondent, which, in this study, ranges from $A_{min} = 1.0$ to $A_{max} = 7.0$, where 1 represents "strongly disagree" and 7 represents "strongly agree." The letter A in Equation 1 represents the highest ranking point used (7), and n = the total sum of respondents selecting a particular response. However, it should be noted that the RII values (Equation 1) were calculated with respect to the total number of respondents used in the analysis (n = 77) to give a more precise estimate about interval variables among the RII rankings (Holt, 2014).

Data Analysis and Findings

Respondent Characteristics

Exhibit 2 summarizes some key respondent demographics. Respondents were from different types of organization: 40% were engaged in construction companies, around 25% in public bodies, and around 20% in construction management firms. Design consultants and other roles, such as facility managers, accounted for approximately 5% and 3% of respondents, respectively. Furthermore, the majority of respondents were engineers (40.2%), followed by senior engineers (29.3%), and project managers (11%). About 4% of respondents were operations managers, and 1.2% were risk managers. In terms of work experience, **Exhibit 2** shows that respondents with 6–10 years and 16–20 years of experience made up the largest percentage of respondents, around 21% and 20%, respectively. The majority of respondents were between 30–50 years, representing 72% of the respondents.

Exhibit 2. Characteristics of Respondents

Respondents Profile			
Position	Age (Year)	Work Experience (Year)	Nature of Organization
Engineers (40.2%)	30–40 yr (40.2%)	6–10 yr (20.8%)	Construction firms (41.5%)
Senior engineers (29.3%)	40–50 yr (31.7%)	16–20 yr (19.5%)	Public organizations (24.4%)
Project managers (11%)	20–30 yr (14.6%)	Undefined (19.5%)	Construction management firms (19.5%)
Quantity surveyors (8.5%)	Undefined (7.4%)	11–15 yr (15.8%)	Undefined (7.3%)
Undefined (6.1%)	Above 50 yr (6.1%)	21–25 yr (11.2%)	Consultancy firms (4.9%)
Operations managers (3.7%)		Above 25 yr (8.4%)	Facility management firms (2.4%)
Risk managers (1.2%)		1–5 yr (4.8%)	

Familiarity, Suitability, and Effectiveness of Scheduling Methods
Exhibit 3 displays the statements and results of responses related to the suitability and effectiveness of planning and scheduling methods. In regard to practitioners' familiarity with scheduling tools examined in this study, as represented by Q1, the schedulers still prefer to use traditional methods, such as Gantt charts, which was ranked first (RII_{adjust} = 0.439). The Critical Path Method and PERT both received equal ranks (RII_{adjust} = 0.435). Newer methods, such as Critical Chain and Last Planner System, were ranked the lowest at (RII_{adjust} = 0.197) and (RII_{adjust} = 0.299), respectively. This result may be due to the ease of use and understanding of scheduling principles within traditional methods, compared with modern methods as indicated by Q2 (RII_{adjust} = 0.638) through Q4 (RII_{adjust} = 0.671). The easy adaptation and understanding of existing methods and their sufficiency in scheduling projects received almost equal rank (RII_{adjust} = 0.645), represented by Q5. Respondents indicated that there was less likelihood of meeting schedule deadlines using existing methods as represented by Q6 (RII_{adjust} = 0.610) as well as less accuracy in estimating uncertainty (RII_{adjust} = 0.569) as represented by Q7. The limitations in existing methods imply the need for a more skilled team (Q8, RII_{adjust} = 0.666). Current methods were not highly rated for future use. This was reflected in Q9 (RII_{adjust} = 0.506). The reason for this may be either a lack of specialized schedulers or insufficient awareness about the underlying theories of the scheduling concepts and methods as discussed earlier.

Schedule Building, Development, and its Performance Control
Exhibit 4 summarizes the statements related to the inputs of scheduling using respondents' perception data. It can be seen that approximately equal attention was given to Q10 (RII_{adjust} = 0.625) to Q12 (RII_{adjust} = 0.623), indicating factors that are considered as basic inputs in the development of a schedule. The results revealed that respondents express more concern when it comes to the development of the WBS as indicated by Q11 (RII_{adjust} = 0.647) and other management priorities relating to the updating of both activity durations and activity dependencies as indicated by Q13 (RII_{adjust} = 0.638) and Q14 (RII_{adjust} = 0.664), respectively. Other factors, such as the coding system (Q15) attached to the schedule network, were ranked low (RII_{adjust} = 0.614), despite the WBS (Q11) achieving a higher rank (RII_{adjust} = 0.647). Less importance was attached to the allocation of contingency buffers or the proper utilization of safety buffers as represented by Q17 (RII_{adjust} = 0.621). With respect to quality control of schedule performance, respondents ranked the routine control system based on a bottom-up approach higher than implementation of a more efficient control system, which can assess the outputs of an executed schedule, relative to the inputs of the original plan. These results are supported by Q18 (RII_{adjust} = 0.599) and Q19 (RII_{adjust} = 0.663). The overall small variation in RII values, however, does suggest that all the factors are worth consideration by project managers and planners during the development and control of schedules.

Knowledge-Based Planning and Scheduling Roles and Concepts
Project stakeholders' and practitioners' perspectives on the required knowledge base needed for planning and scheduling practice was another critical area explored and measured in this survey (see **Exhibit 5**). The motivation of the planning and scheduling team (Q27) and necessity of adequate knowledge and skills of project managers and planners (Q25), as well as

Exhibit 3. RII Values and Rankings for Suitability and Effectiveness of Schedule Control Methods

	Effectiveness of Current Scheduling Methods	Response Frequency							RII Results		
		1	2	3	4	5	6	7	Σw	RII_{adjust}	Rank
Q1	Familiarity with:										
	Gantt charts	3	4	1	15	7	11	15	280	0.439	9
	Critical Path Method	2	5	3	12	10	16	9	278	0.435	10
	Program Evaluation and Review Technique	3	3	6	15	10	6	15	278	0.435	10
	Critical Chain Project Management	8	8	9	11	4	3	5	168	0.197	12
	Last Planner System	7	8	9	14	7	3	8	215	0.299	11
Q2	Satisfaction with suitability and type of existing methods	3	3	9	15	17	12	17	372	0.638	5
Q3	Easy to follow procedures when using existing methods	0	6	11	13	16	10	20	377	0.649	3
Q4	Easy understanding of existing methods across organization	2	7	6	14	12	15	21	387	0.671	1
Q5	Sufficiency of existing methods in meeting scheduling needs	2	5	4	22	17	11	16	375	0.645	4
Q6	Scheduling deadlines are met using existing methods	3	4	6	23	12	18	10	359	0.610	6
Q7	Accurate estimates of schedule uncertainty using existing methods	2	6	14	21	14	10	10	340	0.569	7
Q8	Skilled team used to implement existing methods	0	7	10	10	18	6	25	385	0.666	2
Q9	Existing methods considered suitable for continued use	6	12	8	16	9	13	10	311	0.506	8

Exhibit 4. RII Values and Rankings for Schedule Development and Performance Control

		Response Frequency							RII Results		
Schedule Building and Monitoring Factors		1	2	3	4	5	6	7	∑w	RII_{adjust}	Rank
Q10	Well-defined deliverables and inputs by all stakeholders	2	1	15	16	13	15	14	366	0.625	7
Q11	Well-defined WBS of essential tasks using available software	2	3	7	17	18	14	15	376	0.647	3
Q12	Well-defined links and interrelationships between project tasks	4	3	6	18	20	10	15	365	0.623	6
Q13	Updating of activity durations is controlled	2	3	8	17	12	19	14	372	0.638	5
Q14	Updating of activity sequences or priorities is controlled	2	1	8	19	14	14	18	384	0.664	1
Q15	A coding system is used for identifying various tasks	4	2	6	24	17	7	16	361	0.614	9
Q16	Critical path activities are monitored and controlled	2	1	12	13	20	14	14	374	0.643	4
Q17	Contingency and safety buffers are utilized	2	2	10	23	11	15	13	364	0.621	8
Controlling quality of the schedule (QC)											
Q18	QC is based on conformance of planning outputs to the original planned schedules	1	4	12	17	20	13	9	354	0.599	10
Q19	QC is based on a routine with bottom-up management approach to monitor schedule-based buffer resources	1	1	6	19	19	19	11	383	0.663	2

Exhibit 5. RII Values and Rankings for Knowledge-Based Planning and Scheduling Concepts

		Response Frequency							RII Results		
Planning and Scheduling Roles and Concepts		1	2	3	4	5	6	7	∑w	RII_{adjust}	Rank
Q20	Planning and scheduling is a critical area where construction interacts with operation in the organization	1	3	3	12	17	23	17	406	0.712	5
Q21	Planning reflects all inputs and needs	3	0	9	11	13	24	16	395	0.688	6
Q22	Both construction and operations managers are responsible for the selection of the appropriate methods	2	0	4	12	21	18	19	408	0.716	4
Q23	All inputs and deliverables are correctly identified in the pre-tender stage of the schedule	2	0	6	11	15	25	17	408	0.716	4
Q24	Planning methods are updated in terms of latest developments	3	1	3	11	14	20	24	416	0.734	3
Q25	Managers and planners should have adequate understanding of planning and scheduling software	1	0	6	9	19	18	23	419	0.739	2
Q26	Pull schedules are preferred to push schedules	1	0	7	20	19	16	12	377	0.649	10
Q27	Motivation of the planning and scheduling team is of high importance	0	1	5	11	10	25	24	429	0.762	1
Q28	Low productivity in terms of resources are treated as waste	2	0	6	11	19	19	19	406	0.712	5
Q29	Clients have understood the scope of planning and scheduling	2	1	6	18	15	16	18	391	0.679	7
Q30	All constraints are properly identified in the risk plan in advance of the execution of the schedules	1	0	8	22	20	10	15	378	0.651	9
Q31	A disciplined system of control is implemented top-down	1	3	4	21	14	18	15	386	0.668	8
Q32	The organization is satisfied with its planning knowledge	3	3	3	21	19	13	14	373	0.641	11

the modification and updating of planning and scheduling methods or approaches (Q24) were ranked the highest with the RII_{adjust} at 0.762, 0.739, and 0.734, respectively. These higher values and ranks are consistent with previously discussed findings that illustrate lower levels of familiarity with the use of different scheduling methods. These findings related to project stakeholder and practitioner understanding of planning and scheduling concepts confirm previous study results (Mikulakova et al., 2010; Smith et al., 2000) and highlight the importance of and the need for knowledge-based planning and scheduling concepts and methods. Two additional factors identified as significant include the selection of appropriate techniques or methods for managing a good schedule (Q22) and the exact identification of inputs and deliverables at the pre-tender stage of schedule (Q23). Both were evaluated with the same RII_{adjust} at 0.716.

Respondents also showed equal concern about the criticality of both the interaction of boundary of planning and scheduling and resource performance among both construction management and operations management as demonstrated by Q20 and Q28, which had RII_{adjust} scores of 0.712. As indicated earlier, respondents agreed that planning processes reflect inputs and needs (Q21) and had a RII_{adjust} score of 0.688, even though the client's understanding of the planning process (Q29) was ranked lower (RII_{adjust} = 0.679). In regard to the control systems being followed (Q31), respondents' agreement with the use of top-down management also attracted a relatively low score (RII_{adjust} = 0.668) and ranking. Practitioner awareness of the type of scheduling system (either push schedule or pull schedule) is demonstrated by Q26. To clarify, a push schedule means that one party in the project pushes the schedule to other parties for their approval; whereas, a pull schedule represents collaborative scheduling. Furthermore, the identification of constraints have not been sufficiently addressed (Q30) and so can be insufficiently understood as suggested by their comparatively low ranks (RII_{adjust} = 0.649) and (RII_{adjust} = 0.651). Overall, respondents seem only moderately satisfied with their planning and scheduling knowledge (Q32) as indicated by the lowest rank (RII_{adjust} = 0.641). While these findings do not imply the need for significant changes to current practices, one potentially productive line of inquiry will be to consider supplementing planning and scheduling practices with other management strategies, which are highlighted in the following sections.

Respondents' Perceptions for Improving Current Practice

To gain more insight into other aspects, such as knowledge-based planning and scheduling, each section of the questionnaire was supported by a number of open-ended questions seeking suggestions for improvement to practices. In general, the suggestions provided by respondents can be used to determine whether or not project stakeholders and practitioners have adequate awareness of knowledge-based planning and scheduling concepts. Respondents were asked how to overcome current shortcomings in planning and scheduling for future improvements with regard to: (1) management strategies needed to improve effectiveness of planning and scheduling and (2) knowledge requirements for successful planning and scheduling.

Efficiency of Planning and Scheduling Theory and Methods

Some respondents suggested measures to improve planning and scheduling efficiency. In a broader sense, respondents highlighted the need to design more proactive planning for efficient control of scheduling. For example, a project manager from a private construction firm asserted:

> […] planning and scheduling are two of the most important elements for project success. Project planning is much more than simply well-established procedures. Proper proactive planning determines the direction, goals, scope, quality and ultimately the outcomes for any given project… The purpose of project scheduling is to define activities, durations, and relationship logic to implement the project plan and monitor, update and communicate the schedule to reflect current situation and the impact of project changes. Professional planning and scheduling provide project management team with the expertise to deliver the project in the most effective manner. [Project manager]

The same opinion was expressed by another project manager from a consultancy firm who stated:

> […] in order to improve the efficiency of construction schedules, the project team must be proactive in identifying their focal points. [Project manager]

According to Alsakini, Wikström, and Kiiras (2004), proactive scheduling systems are considered more suitable than traditional approaches. This is because proactive scheduling allows project managers and planners the chance to incorporate future events and thus take proactive or corrective actions in advance and ahead of any deviations in schedules from the original plan. On the contrary, failure of project managers to proactively define good execution and control project plans will result in unrealistic scheduling and thus re-planning.

Respondents also addressed some concerns regarding the need for improving efficiency of schedule execution and control by overcoming shortcomings of currently-used tools and methods embodied in their own organizations for project scheduling and control. For instance, a risk manager engaged in a construction management firm revealed:

> […] complexity of project schedules require monitoring very closely by identifying which control systems allow to do very well … better training and understanding of the tools and complexity of programming with a multi-level of construction activities especially for non-professional planners. [Risk manager]

Practitioner perspectives about ineffectiveness of traditional tools and methods in handing complex schedules appears to be a common issue among all involved in planning and scheduling. As noted by the risk manager, this shortcoming can be addressed by specific training and education programs on new tools and methods for teams involved in project planning. For example, a senior project engineer from a public construction organization pointed out:

> […] the classical bar charts are simplistic approaches, which can be understood by all parties involved in a project… Improvement of planning needs to cover all involved by educating on new methods. [Senior project engineer]

This was aligned with comments from another senior engineer from a public construction firm who asserted:

[…] CPM and Gantt charts have posed some problems to project managers… Usually most of these methods are formulated on linear programming and this caused problems when changes happened on minor activities that are not in line with critical path activities. [Senior project engineer]

Problems of interface (or the interrelationship) between critical path activities and non-critical path activities, including minor tasks, should be properly identified and managed in the development of project schedules. In this regard, an operation manager from a facility management firm recommended:

[…] Minor activities also have to be taken into account in the preparation of the project schedule. [Operations manager]

Buffer management may be one tool to use in controlling the execution of project schedules, especially multitasking schedules (Leach, 2011). In addition, project stakeholders and practitioners should also consider other important factors, such as the coordination of delivery and supply systems for required materials when developing the schedule, correlation of the project schedule to the risk management plan, and consideration of weather history and geopolitical issues in project planning and scheduling. In this study, some of these aspects were identified as important factors by a senior project engineer from a facility management firm who asserted:

[…] during preparation of schedule it is advisable to review site weather history… It is advisable to correlate schedule with the project risk matrix … To involve contractor, subcontractors, suppliers and end user during preparation and updating the schedule … To consider the geopolitical issues that affects the progress of the project … To consider financial status of contractors, sub-contractors and suppliers.… During preparation of schedules it will be nice to use 20/80 Pareto principle. And to place buffers/contingency on all project activities between 10–25%. [Senior project engineer]

This view was shared by another senior engineer from a facility maintenance unit who suggested:

[…] any project should be planned in deep coordination with maintenance-related aspects of all materials and equipment for the life time of the project. [Senior project engineer]

Respondents also revealed that there is a need to improve the efficiency of decision-making for the entire scheduling process. In this respect, a project engineer from a public construction firm commented:

[…] From my point of view using proper planning means/ leads to better decision-making and efforts saving… If there is no good planning lots of problems will be faced related to project delays and additional costs. [Project engineer]

As discussed, the improvement of decision-making related to scheduling processes relies on understanding by project management teams involved in planning and scheduling of the key characteristics and underlying theories of different planning approaches.

Enhancing Knowledge or Awareness About Planning and Scheduling

Most of the suggestions or comments provided by respondents regarding knowledge-based planning and scheduling concepts emphasize the need for a professional and skilled team, including planners, and for in-house or on-site training. For example, a project engineer from a construction firm commented:

[…] planning systems must be prepared by very experienced planners, who know all of the practical difficulties of the scheduling process. [Project engineer]

Competencies of project leadership in controlling schedules have been classified among the principle features of successful projects (Iyer & Jha, 2006; Mulholland & Christian, 1999). As discussed earlier, improvement of practitioner knowledge should occur using training programs on the use of new methods and computerized approaches. A project manager from a construction management firm commented:

[…] traditional methods have limited features.… Therefore, assign specialized planners who can use advanced computer programs. [Project manager]

Acquisition of knowledge on project management specific tools appears to be a key factor in improving efficiency of the construction process. For instance, a recent study conducted on risk analysis of schedules using a simulation model-based PERT concept by Hwang and Ng (2013) revealed that planning and scheduling are one of the most important areas requiring particular knowledge and experience. Specifically, Hwang and Ng identified contribution to decision-making, and team delegation and problem-solving as most important for project managers. In the context of the authors' research study, respondents revealed that improvements in current knowledge have to include everyone involved in planning and scheduling by providing education and training on new methods and techniques. For instance, a project manager from a private construction firm stated that:

[…] all people who are executing the work schedule at site must be trained in new techniques such as Primavera P-7. [Project manager]

Another project engineer from a consultancy construction firm supported this claim as follows:

[…] there is no problem with new methods and techniques only people are not trained well, so efficiency of scheduling becomes […] less. [Project engineer]

The findings revealed that adoption of new techniques and methods would work if education and training were implemented for project staff. For instance, it was argued that development of knowledge-based scheduling models can enable project managers and planners to undertake a more efficient evaluation of the scheduling system (Mikulakova et al., 2010). Such models

could be used as a support tool by those who have sufficient knowledge of planning and scheduling.

In summary, it can be argued that to improve the efficiency and effectiveness of planning and scheduling, it is necessary to consider other supportive management strategies and tools. This should involve a number of new management measures including: education and training related to specific topics at particular stages in projects; ability to adopt knowledge-based models to enable the use of more modern tools and methods; ability to manage effective communication and to take proactive action when implementing schedules; and consideration of external or environmental factors based on lessons learned from past projects.

Discussions and Implications

The findings from the study have contributed to the identification of important elements or factors for improving and overcoming shortcomings in current project planning and scheduling practices. Useful implications of these findings are discussed next.

Practitioner Familiarity With Different Planning Tools and Methods

Practitioners tend to be more familiar with the adoption of what has been termed as traditional planning and scheduling methods. However, the important concern to project managers or construction policymakers is the need to advance the use of new techniques and methods for controlling project scheduling that cannot be handled through traditional tools. According to Kumar (2005) and Yamin and Harmelink (2001), the dominant use of traditional methods on construction projects is very embedded within the knowledge base of many construction organizations. This concern was also revealed in a previous study of Saudi construction firms by Shash and Ahcom (2006), which confirmed that practitioners have not paid adequate attention to different planning tools and methods adopted by their firms. This study also suggests that practitioners found the application of traditional tools much easier and better understood by organizational members. The alignment of these new findings with those reported in earlier studies implies that there is a need for a more specific management focus towards improving practitioner attitudes and for providing experiences with knowledge of different schedule and cost control tools and systems. This deep understanding needs to be driven by in-company training and learning in collaboration with software developers and planning and scheduling experts. This concern is aligned with indications of previous research, which revealed that project management teams need assistance and support tools in interpreting schedule outcomes, especially in projects with multi-activities and resource dependencies as revealed by, for example, Oberlender (2000) and Yang (2005).

In summary, despite easy adoption of the dominant tools and methods, such as the Gantt chart and CPM/PERT, significant efforts are necessary to grow understanding of other, more advanced tools in the construction market, in order to cope with the true complexities of construction projects. By achieving this understanding of different planning methods, the project management team should have the capability to address constrained-resource schedules. This will result in increasing satisfaction and trust of project stakeholders in the reliability of project schedules, thus motivating organizational learning related to new methods and techniques.

Understanding Schedule Definition, Development, and Control

In terms of the development and control process of project schedules, the study revealed that an equal level of attention should be paid to all inputs in planning and scheduling. However, the results implied that management priority should be given to a well-defined and developed work breakdown structure (WBS). This is very crucial since a WBS reflects a project's scope early in the project. In other words, the lack of a clear WBS means a poorly-defined project scope. The results also indicated that strong involvement of project stakeholders, as well as identification of interrelationships between project tasks prior to executing the project, are important for effectively managing and controlling project schedules. Aoieong, Tang, and Ahmed (2002) pointed out that the outputs from scheduling must be compatible with all inputs from the WBS to improve the efficiency of schedule performance control. Chua and Godinot (2006) found that well-defined WBS packages enable project managers to achieve more precise control over the project schedule activities and outcomes.

Another important issue is the proper identification of critical paths in schedules and updating of both the logic and duration of the schedules. Another important matter to be considered when developing schedules is contingency resource plans or buffers. This is significant for project schedule controllers when measuring executed schedules against baseline plans. In the case where there is a deviation or resource shortcoming, contingency buffers should be used to keep a project on track. In this regard, it is argued that any shortcoming in schedule buffer plans will affect the whole scheduling process (Leach, 2011). Successful implementation of project schedules also requires the most efficient monitoring systems to ensure that activities are carried out according to plan in terms of cost, time, and quality. As discussed earlier, improper selection of the control and reporting mechanisms can lead to aggressive or unrealistic scheduling and thus poor project performance.

The study results also revealed that practitioner adoption of a routine follow-up or application of controls seems to be given a higher priority than other conformance measures for monitoring schedule outcomes. Conformance measures related to schedule performance were criticized, and the policy of project management in controlling schedule performance should be redirected from conformance to more integrated measures (Maylor, 2001). Moreover, the study results imply that project managers and their planners should be able to apply other schedule-performance measures for project-related factors (i.e., risk and quality control) rather than the more common approach of measuring performance in terms of consumed resources and related cost. More recently, Olawale and Sun (2015) revealed that the current practice of project time (schedule) and cost control and monitoring systems have been implemented based on ad-hoc management controls, rather than as regular monitoring systems against actual project milestones. In summary, the overall findings of the authors' study imply that there is a need to change current organizational behaviors in monitoring project schedules, by adopting a more efficient control system that should be strongly embedded into the whole construction process, as well as through all management and operational levels of the project.

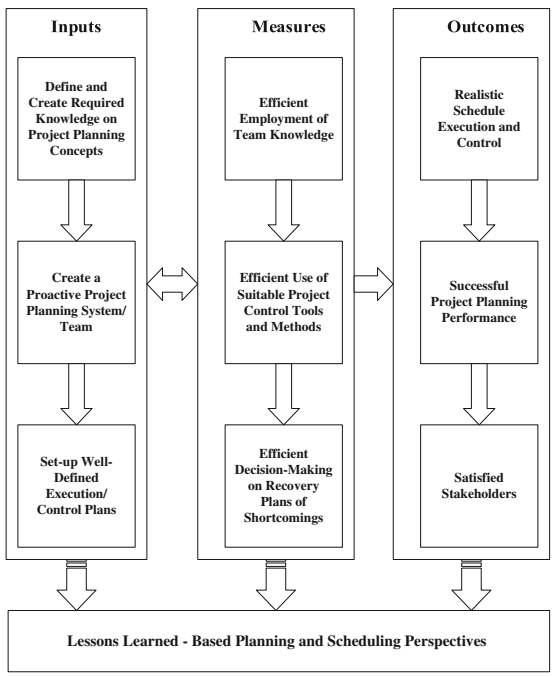
Practitioner Awareness of Planning and Scheduling Roles and Process

Practitioner knowledge and awareness of planning and scheduling of key elements of the construction process are important. The overall results from this study revealed that practitioners gave the highest attention to those factors that indicate their desire for motivation of the team, the adequacy of project manager understanding of project planning and scheduling, and the updating of planning and scheduling approaches. Project managers and planners should have competent knowledge about the complexity of project schedules and related resources for more efficient monitoring and for analyzing and addressing shortcomings in activity work schedules (Weaver, 2009). As discussed earlier, schedule quality and accuracy aspects can be maintained by proper alignment between the schedule execution and project control plans. This alignment should be clarified and properly understood at different management levels of project planning and scheduling (Smith et al., 2000). Therefore, grounding in the fundamentals of planning and scheduling is necessary for all project stakeholders. Shortcomings in project stakeholder knowledge-based project planning theory were pointed out in McKay and Wiers (1999). However, attempts to improve these shortcomings in project stakeholder and practitioner knowledge do not appear to be reflected in project planning and scheduling practices. Recently, Hwang and Ng (2013) indicated that modern projects require a wider context of managerial knowledge beyond technical competencies to allow appropriate response to project risks. In summary, the complexity of construction project management necessitates that project managers and practitioners have specialized knowledge or awareness in planning and scheduling. Acquiring such knowledge is necessary for a well-defined project planning approach, which enables project stakeholders and practitioners to effectively transfer, measure, analyze, and correct the implementation of project plans and schedules. On the basis of these findings, a planning and scheduling-based knowledge perspective approach has been developed to foster a more effective definition of planning and scheduling systems. The approach is organized using inputs, measures, and outcomes (see **Exhibit 6**).

Contribution to Practice

This study has contributed to both theory and practice by providing new insights toward better comprehension and understanding of the important aspects and concepts of

Exhibit 6. Knowledge-Based Planning and Scheduling Perspective System



planning and scheduling, which, if they are well addressed, can effectively promote the integration and alignment among theory and practice at both operational and management levels. Project managers and stakeholders should ensure the existence of mechanisms or norms enabling them to measure and examine the level of awareness of project practitioners throughout planning and scheduling. This is necessary to proactively manage project schedules in a more realistic manner.

The study results also implied that project managers and their planners should change their current control strategies by diversifying norms and project control systems related to monitoring project schedules. Another insight is the need for adoption of a more proactive approach to minimize potential risks in scheduling, which often appear as a result of a lack of knowledge or awareness about planning and scheduling theories and concepts at the conceptual stage of project planning. A proactive approach is crucial for identifying and mitigating potential risks ahead of schedule execution. Furthermore, awareness of project planning processes and concepts should be developed and integrated at an early stage in project scope definition.

The study results also revealed that project managers and stakeholders should adopt a new management philosophy focused on integration or 'enforcement' of organizational learning, as well as fostering knowledge growth. This strategy can allow a project team to assess major barriers to the effective application of planning and scheduling. This also will help to reduce workload and enable efficient control of scheduling. In this regard, project managers should only deploy planning and scheduling tools and methods that are appropriate for the complexity of a given project. Use of more sophisticated methods and techniques should be accompanied with efforts to improve team motivation and training. Other project stakeholders must also be familiar with the concepts of planning and scheduling to ensure the most economical allocation of resources and buffers. Project managers should serve as front-end supporters and builders of their planning team by defining a creative project plan that favors integration, learning, and knowledge sharing across the overall project context.

Contribution to Theory

The findings of this study have made important contributions to the development of planning and scheduling by measuring the extent to which practitioners understand how to apply theory. In this respect, a combination of both the study's methodology and findings provided some useful insights into project management areas where further investigations are needed. First, the study implied that knowledge-based planning and scheduling is a key issue for successful construction processes. Second, the study highlighted important management measures for improving planning and scheduling; however, implementation of those measures requires that construction practitioners learn from their own experiences. In fact, the extent to which organizational learning is enabled within the project and practitioner organization is an interesting question and one that should be pursued further. Third, the study indicated that despite the existence of advanced planning and scheduling tools and methods in markets, practitioners still prefer using traditional methods. Therefore, the factors impacting decision-making processes when selecting and implementing planning and scheduling tools and methods need to be investigated. Fourth, the study implied that project stakeholders should understand key characteristics of project planning to avoid a mismatch between their needs and project plans. In connection to this, there is a concern that the lack of trust on the part of key stakeholders, especially clients, impacts the effectiveness of project planning. This is because the confidence levels of project stakeholders in the overall project planning and scheduling systems can determine project success. This relationship needs further investigation. This investigation can be expanded to cover related topics, such as the impact of varying levels of knowledge and competencies among different categories of stakeholders on the effectiveness of project scope definitions and estimates. Fifth, a final topic to consider is the use of multiple planning perspectives to assess critical factors impacting effectiveness of planning and scheduling in construction projects.

Conclusion

Planning and scheduling provide the road map for organizations concerned with timely delivery of projects and the efficient use of resources. The aim of this study was to determine the nature and extent of shortcomings in the current understanding and practice of planning and scheduling practices in Oman. The study was used to identify and rank identified factors based on a survey capturing the views of different project stakeholders within the construction industry. There are some important limitations of the study as conducted. First, the study was undertaken in a relatively small country and thus the results were likely influenced by the perspectives of a localized industry at a particular time. Nevertheless, this study might offer sufficient encouragement to project managers and stakeholders to take steps to raise competence and knowledge in planning and scheduling methods. Second, the results reflect the views of a comparatively large number of engineers (albeit from different organizations) whose competence in planning and scheduling varies. Notwithstanding these limitations, the findings point towards the need for increased attention to what might be termed the professional management of planning and scheduling systems in construction projects.

The findings derived from the computed relative importance index (RII) factors revealed no significant variation in respondent scores for most criteria used to assess current practices. Nevertheless, small differences among respondents on the importance rankings of the study criteria support the need for further assessment of this area of project management. The most important conclusions drawn from this study can be summarized as follows:

- Most practitioners tend to use traditional methods and tools in planning and scheduling, despite the existence of other modern management approaches. The reason seems to be that the fundamentals of traditional methods are easier to comprehend and share with co-workers than newer, more sophisticated approaches.
- Despite most practitioners recognizing the importance of input factors for building and managing schedules, there is awareness of the shortcomings of current scheduling approaches and a call to enhance the effectiveness of these approaches. These shortcomings, however, can be improved by competently understanding the relationship between the WBS and the project schedule, as well as the suitability of tools and methods for planning and controlling certain types of projects.
- Most practitioners agree with statements used to assess projects, which relate to measuring awareness or knowledge

about the fundamentals of both organizational and project inputs to planning and scheduling. Even so, the findings imply that knowledge-based planning and scheduling remain challenging. The results, therefore, imply that there is a need for more education and training in project planning and scheduling theories and concepts, as well as the application of these theories to construction projects.

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Paper III

Enablers and barriers to project planning and scheduling based on construction projects in Oman

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Abstract

Whilst the concepts of planning and scheduling seem to be adequately discussed in the project management literature, relatively few examples of factors specifically affecting the performance of planning and scheduling are to be found. The study reporting in this paper has investigated a set of factors identified as enablers and barriers to successful project planning and scheduling on construction projects in Oman. The study adopted a questionnaire-based survey to measure the impact of the factors. The data were analyzed using the relative impact (or importance) index (RII). On the basis of RII rankings, the results revealed that the identified enablers and barriers were all considered as significant. This could be seen to imply that all of the factors should be considered equally from the perspective of project planning and scheduling, including schedule control. In addition, the results suggest that attention should be paid to the more significant barriers on the part of project managers to mitigate their potential impacts on planning and scheduling. Recommendations for mitigating those barriers are presented. The study provides useful insights into the impact of factors impacting the performance of planning and scheduling on construction projects in Oman and how improvement might be achieved.

Keywords: project planning; scheduling barriers; scheduling enablers; relative impact index; Oman.

Introduction

Planning and scheduling have a significant role in controlling project performance (Luu et al. 2009) and form an integral part of project management. They are often spoken as if they were synonymous rather than two distinct stages in a process for estimating the duration of the project and, then, for providing a workable basis upon which activities can be implemented (Ahuja and Thiruvengadam 2004). A prerequisite for successful scheduling is the definition of all the activities required to deliver the project's scope, the correct sequencing of those activities and the addition of resources and time to create the schedule (Shash and Ahcom 2006; Kerzner 2013). It would, however, be wrong to give the impression that these two stages are separate. Some iteration between planning and scheduling is necessary to achieve an optimal outcome that can be defined as a schedule that is both practicable and realistic, not least in reflecting the risks in the project. Luu et al. (2009) showed that failure to identify and assess the risks is likely to be prejudicial to the quality of planning and scheduling and, ultimately, to project performance. Understanding the distinctions between these two stages is, therefore, necessary (Kerzner 2009). In this sense, the quality of the schedule is a function of the rigor and care that have gone into planning from the front end of the project, where the project's scope was initially defined, through to project execution and close out.

It is reasonable to argue, therefore, that the quality of a project schedule is a key factor both in determining the duration of the project with sufficient accuracy (for the current stage in the project) and, later, in managing the physical execution of the work. Enablers and barriers to reliable project planning and scheduling are therefore of interest. Iyer and Jha (2006) have pointed out that the identification and measurement of the factors responsible for either enhancing or impairing schedule performance are sometimes ignored by project managers. Greater awareness of these factors would help to improve the chances of successful project planning and scheduling.

This paper presents the findings of a study aimed at understanding the enablers and barriers to successful project planning and scheduling and, in particular, the control of schedules during the execution of construction projects. The context is Oman, where a number of shortcomings in project management have been reported including poor control over scope and time and cost overruns (Ballal et al. 2007; Alnuaimi et al. 2009).

Context of the Study

Oman is considered to be one of the most regulated and attractive markets in the Middle East (Joshi and Ghosal 2013), where the construction industry has been experiencing a boom with a yearly growth rate estimated between 5% to 7% (David et al. 2013). Under the current eighth fifth-year plan (2011-2015) and until end 2017, the country will invest heavily in infrastructure and construction, with total outputs for the

above entire plan forecasted to be approximately more than US$50b (David et al. 2013; Oman Chamber of Commerce and Industry 2014; Oxford Business Group 2014). The Oman Tender Board is an independent governmental unit which is responsible for tendering processes of all public tender projects with estimated capital costs of more than 250,000 Omani Rails (1 USD = 0.385 Omani Rail). These projects are managed through either lump-sum or re-measurable contracts according to the Oman Standard Documents for Building and Civil Engineering Works.

Some of these large or mega construction and infrastructure projects were subject to contractual problems of schedule delays and cost overruns (Alnuaimi et al. 2009; Oxford Business Group 2013; Oxford Business Group 2014). This problem is not confined to Oman. Time and cost overruns are reported as commonplace in many developing countries (Ahadzie et al. 2008). Latterly, Alnuaimi and Al Mohsin (2013) quantified the delays on a sample of construction projects in Oman completed in 2009 and 2010 and found that these project were delayed on average by 42% beyond the original contract period.

Factors Affecting the Performance of Scheduling

Despite the development and integration of more sophisticated approaches and tools within project planning and scheduling, some projects fail to meet their original promises (Moneke 2012; Zhou et al. 2013; Taroun 2014). The latter found that poor project management of schedules was a major reason for such failures. This weakness can result in unintentional process and technical constraints such as the inefficient management and allocation of resources and, hence, unrealistic schedules (Bevilacqua et al. 2009; Luu et al. 2009). Project planning can be also affected by management factors relating to technical (e.g. resources and technology) and non-technical (e.g. human resources) risks and uncertainties that can act as barriers to the effective scheduling and schedule control (Schatteman et al. 2008). These factors and others that are relevant to research within both geographical and international contexts of the study reported here are summarized in Table 1.

[Insert Table 1]

Identification of factors measured in the study

On the basis of the literature review, including the aforementioned studies, a list of 21 factors were adopted and segregated into two groups: one set of barriers and another of enablers. These are presented in Table 2. Although the factors do not reflect exhaustively the nature of construction projects in general, they were considered to be the more relevant to this study. To further support the adoption of these factors, two assumptions were made in the light of previous studies: first, these factors have been commonly associated with planning and scheduling; and, second, each factor or criterion already embodies significant sub-factors to the extent that it is not necessary (or realistic) to have to detail each and every facet. It is suggested that a

priority for project managers and project planners should be the factors at particular life-cycle stages as reflected in Table 2.

[Insert Table 2]

Research method

The study reported here formed a part of a relatively larger study related to the understanding of the application of project planning and scheduling in construction projects in Oman. The study aimed at understanding the potential impact of enablers and barriers and their relative importance from a project planning and scheduling perspective. A structured questionnaire-based survey was used for this purpose, because it can be regarded as a positivistic approach to testing the applicability of the research area where theory is being developed (Fellows and Liu 2009). The questionnaire was piloted with a selected number of persons from different construction firms to ensure clarity of its content. It was sent out to a selected number of individuals and groups engaged in public and private construction organizations and projects in Oman. The respondents were chosen through a non-probability simple random selection from a public construction organization database, as well as use of convenience sampling procedures. The respondents were involved in a number of large to medium sized construction projects located in the capital city of Oman, Muscat. Our aim was also to involve a good representative sample of respondents in terms of their work experience, age and education levels.

The self-administered questionnaire consisted of three sections: the first section captured the basic profile of respondents and their projects. The second section was designed to assess the potential enablers (12 enablers) to planning and scheduling; and the third section was designed to assess the potential barriers (9 barriers). The strength of respondents' perspectives on the significance of these factors were based on a 7-point Likert scale (i.e. 1=strongly disagree, 7=strongly agree). Out of 130 questionnaires distributed based on the above selection criteria, 80 questionnaires were returned. 77 were considered complete and valid (i.e. N= 77) and used in the analysis of responses to enablers and barriers. A summary of respondents and their projects are given in Table 3.

[Insert Table 3]

Data Analysis Approach

Relative Impact Index Factor (RII)

The dispersion of the responses was initially checked through the use of SPSS for descriptive statistics (means, standard deviations), and the results showed that the majority of variables tested (factors) tended to have skewed distributions around their mean values. Consequently, the use of both descriptive and multivariate

statistical tests, such as analysis of variance (ANOVA) and correlation, were not thought to be appropriate (Hair 2009). As the primary aim was to measure the extent to which these adopted factors are significant to current practice in planning and scheduling, the study, therefore, adopted the relative impact index (RII) to rank the impact of the enablers and barriers as considered by the respondents based on the occurrences of these factors in their routine work. The RII is a simple statistical measure and has been used in previous studies of construction-related problems as demonstrated by, for example, Ghosh and Jintanapakanont (2004); Assaf and Al-Hejji (2006); and Hwang et al. (2013). The ranks of enablers and barriers were computed using the following formula adopted from (Hwang et al. 2013; Holt 2014):

Relative Impact Index (RII) = $\sum (7*n_7+ 6*n_6+5*n_5+4*n_4+3*n_3+2*n_2+n_1) \div 7*N$

RII ranges from 0.143 to 1 (i.e. a higher value of RII indicates a higher impact of the factor).

Where n = the constant responding weighting given to each factor by the respondents (on a 7-point scale), for example, n_7 = the number of respondents given the highest rank on a 7-point Likert scale to each factor (i.e. 7= strongly agree) and n_1= the number of respondents given the lowest rank on a 7-point Likert scale to each factor (i.e. 1= strongly disagree). The use of 7-point Likert scale might require highly sensitive respondents who can differentiate among different levels of ratings. However, a study by Colman et al. (1997) compared the association or equivalence among the respondents ratings using 5-point scales and 7-point scales. The results from this later study indicated that there was a high correlation (or equivalence) among the ratings using both scales.

The capital N= is total number of respondents used in the analysis, and the RII values were computed with respect to the total number of responses (N=77). The level of significance of each individual factor is measured according to the following scale adapted from Kazaz et al. (2008), where $0.143 \leq RII \leq 0.286$ (not significant); $0.286 < RII \leq 0.428$ (somewhat significant); $0.428 < RII \leq 0.571$ (moderately significant); $0.571 < RII \leq 0.714$ (significant); $0.714 < RII \leq 0.857$ (very significant); $0.857 < RII \leq 1.0$ (extremely significant).

Data Analysis and Findings

Impact Indices and Ranking of Barriers

The indices and the associated ranking of the barriers are displayed in Table 4 and are discussed in the order in which they appear. According to the scale adopted by Kazaz et al. (2008), all barriers except one are considered significant (i.e. $0.610 < RII \leq 0.688$). Factor (B2) – 'lack of support from project stakeholders in the development of plans and schedules' – is shown to be very significant (RII= 0.725). In this regard, it has been argued that successful project execution depends upon the consideration of the needs and deliverables of

all stakeholders involved in planning prior to the development of the schedule (Halpin and Riggs 1992; Chitkara 2002; Weaver 2009,).

The differences in the indices of the remaining factors are arithmetically, in most cases, very small – relatively small to justify any claims other than their relative impact rankings. Nonetheless, these factors deserve discussion. Poor decision-making regarding activity criticality (i.e. schedule activities exposed to critical constraints related to resources and dependencies) was ranked second in significance (RII= 0.688). This seems to imply that attention needs to be paid to identifying such activities in the planning phase prior to scheduling. According to (Abeyasinghe et al. 2001; Trietsch 2005), the lack of proper understanding of activity criticality and related resources in project planning can result in 'aggressive' schedules with high levels of uncertainty.

The absence of resource-constrained scheduling was found to be the third most significant barrier (RII= 0.681). Schedule-based constrained resources have been found to be a common problem on projects involving a large number of activities and their inter-dependencies (Rivera and Duran 2004). The planner needs to identify and define such resources in the planning stage; this is important in the context of the inherited uncertainty in the schedule and can help to avoid constraints in schedule execution (Abeyasinghe et al. 2001; Hartmann and Briskorn 2010). According to Table 4, other remaining barriers were perceived with almost equal perspectives about their potential significance to the schedule execution and control.

[Insert Table 4]

Impact Indices and Rankings of Enablers

Table 5 presents the results of the impact indices (RII) computed for the enablers. The overall findings reveal that the respondents consider almost all identified enablers as very significant ($0.711 \leq RII \leq 0.746$). Nonetheless, the reliability of detailed schedules was ranked first as potential enabler to successful project planning and scheduling (RII 0.746). In this respect, the reliability of detailed schedules set-up in planning can be considered to be an essential step that must be addressed prior to project execution. This was followed by factors concerned with the effectiveness of resource leveling in scheduling and the sufficiency of managerial support for motivational and training programs (RII=0.740). The involvement of the project manager in integrating the project's plans has been highlighted as an important consideration (Mulholland and Christian 1999; Voth 2009). Mubarak (2010) pointed out that the precise loading and leveling of resources in the schedule can help in interpreting the trade-off between schedule outcomes (i.e. durations) and the cost of resources. Table 5 shows that all other enablers were perceived as, more or less, equally important for project planning and schedule performance.

[Insert Table 5]

Reliability of rankings — Kendall's concordance test

The Kendall coefficient of concordance is used as a non-parametric test to examine the overall agreement between several sets of judges assessing a set of tested variables or items (Field 2005). In other words, Kendall's coefficient of concordance indicates the degree of association of ordinal assessments made by multiple respondents when rating the same investigated criteria. It ranges from 0 to 1, where the higher value of (W) means the stronger association among rankings. Moreover, the level of significance (p-values) test is used to determine whether the level of agreements among respondents on such rankings is done randomly or it is rated by chance (Siegel and Castellan 1988). For the purpose of this study, the following hypotheses were developed:

- H_0: There is no significant association between the overall rankings of all respondents (i.e. rated by chance or non-independently).
- H_1: Rankings by all respondents are significantly associated (rated independently not by chance).
- At the 95% level of confidence, reject H_0 if p-value ≤ 0.05 (i.e. accept H_1)

Table 6. Kendall coefficients of ***concordance (W)*** *obtained for enablers and barriers.*

Reliability test	***Barriers (B1 to B9)***	***Enablers (E1 to E12)***
Kendall's W	0.040	0.028
Chi-Square	19.744	19.145
p-value at the 95% confidence Interval	0.011	0.050

Table 6 indicates the level of concordance of all respondents on the rankings of the factors related to enablers and barriers. The results revealed that there is relatively a weak level of concordances (W= 0.040, Chi-square= 19.744, *p-value* < 0.05; reject H_0) and (W= 0.028, Chi-square= 19.145, *p-value* < 0.05; reject H_0) for barriers and enablers, respectively. However, the statistical level of significance indicates that this level of non-concordance on the overall rankings of both enablers and barriers are randomly occurred than might be appeared by chance. Therefore, it can be concluded that the study overall rankings are reliable.

Recommendations to mitigate barriers

Whilst accepting that the results of the study are limited to a particular context and the adoption of convenience sampling, they have helped to improve understanding of the factors affecting project planning and scheduling on construction projects in Oman. Project managers in Oman could help to bring about improvement in planning and scheduling if they are able to mitigate the more significant barriers. Key decision makers on projects in Oman should also take into account the enablers that can support the goal of developing more effective planning and scheduling systems for construction projects so that the gap between actual outturn and that planned can be closed, or at least reduced to a more acceptable level.

Efficiency of stakeholders' engagement and decision

The findings imply that incorrect utilization of project planning and scheduling systems is to large extent caused by insufficient support from, and the integration of, project stakeholders in setting-out the project plan. This means that project stakeholders in Oman should not only rely on what is documented in early planning, but they should provide their own visions of what should be incorporated at an early stage in project, i.e. at the front end. Moreover, stakeholders' commitment and support should not be limited to initial project planning, but should be visible throughout the project life-cycle.

Effectiveness of decision-making regarding activity criticality

Sufficient involvement and support of stakeholders might also result in increasing the efficiency of decision making regarding the activity criticality. González et al. (2014) argued that project managers should have sufficient experience to criticize project plans in terms of resource criticality and dependencies. This would imply that project managers and planners in Oman should prioritize their resource allocations during project planning and scheduling. In other words, key decision makers should ensure that the right resources are signed to the right activities to help minimize the effects of resource constraints that, in turn, might result in unrealistic schedules with many uncontrollable uncertainties associated with critical activities and resource dependencies. This focus on the management of activities- based constrained resources and dependencies should be applied to the entire scheduling including non-critical path activities.

Adoption of computerized approaches and techniques

The findings revealed that the failure to adopt new technology such as computerized approaches and software models for project planning and scheduling was experienced as a significant barrier to project planning and scheduling. The complex nature of many construction projects should encourage project managers in Oman to adopt new computer-based approaches and/or optimization tools. This might allow them to overcome operational errors in scheduling and to take corrective action. In this regard, White and Fortune (2002) concluded that the lack of understanding of the characteristics of different planning methods and tools can lead to misinterpretation of the inputs needed for scheduling. In other words, project managers should bear in mind that the successful adoption of more advanced computer-based scheduling approaches

can help in resolving the potential limitations and shortcomings of existing planning and scheduling methods. However, coping with new technology and techniques requires a strong management emphasis on team training, IT literacy and the willingness to accept new technology, and should be considered as an essential part of project change management. According to Nah et al. (2001), it is important that project planners embrace such technology and understand how a change of this nature can contribute to the success of planning. Furthermore, Bates and Gawande (2003) found that the most effective adoption of technology was when it is used to communicate information effectively, reduce trivial reporting and thus enhance the efficiency of decision-making when contemplating the need for corrective measures for schedule deviations.

Effectiveness of project leadership team involved in planning and scheduling

Effective leadership is important for promoting and integrating new approaches across the project. The lack of sufficiently knowledgeable project leadership has been found to be one of the most critical issues affecting schedule performance on construction projects in general (Hyväri 2006; Iyer and Jha 2006; Müller and Turner 2010). For project managers in Oman, this means placing more emphasis on performance of site team managers and other personnel in terms of their effectiveness in project planning and scheduling, including schedule control. To achieve this, key decision makers in Oman should also invest more in training the project team because, as with other construction projects, this issue has been found to be a major cause of failure in the implementation and control of schedules (Hameed 2005; Moneke 2012). The focus on the efficiency of project team should also pay a particular attention to the enhancement or adjustment of their management roles and operational behaviors (or attitudes) in planning and scheduling.

Conclusion

This study identified a number enablers and barriers to project planning and scheduling on construction projects in Oman. The literature review revealed that there is a need for more exploration and assessment of project planning, particularly in regard to the factors affecting schedule execution and control.

The overall results imply that some management preferences or priorities have to be accorded to the more significant factors to improve the project planning and scheduling. The performance or effectiveness of current planning and scheduling can be improved if the impact of the different factors is taken into account by project managers and their planners. The efficient mitigation of the investigated barriers can help to overcome the shortcomings of existing practices in Oman. Attention should be given to the front end of the project because placing effort there is far better than reworking the project schedule during execution. To conclude, the study provides insight towards the need for a more comprehensive assessment of enablers and barriers, particularly impacting project planning and scheduling from perspectives of project stakeholders.

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Research area	Significant factors studied	Geographical contexts	References
Development and scheduling	Complex communication; lack of trading-off between schedule and cost; changes and risks; shortage of resources; lack of disciplined management; complexity of the schedule; lack of knowledgeable team	USA	Voth (2009)
Quantification of uncertainty and risk in scheduling	Incompetent team and leadership; inaccurate schedule estimates; shortage of resources	Canada	(Mulholland and Christian 1999)
Efficiency of resource-driven scheduling techniques	Lack of knowledge on techniques; lack of team training; uncertain estimates of schedule and budget	Malaysia	(Hameed 2005)
Outcomes of scheduling performance	Lack of coordination; lack of knowledgeable project managers; socioeconomic environments; Indecisive project team; insufficient consideration of stakeholders' perspectives	India	(Iyer and Jha 2006)
Enhancement of scheduling performance	Poor site management; poor coordination among the parties; inadequate competence of the project team	Singapore	(Hwang et al. 2013)
Effectiveness of scheduling control	Inaccurate estimation and forecasting of the schedule in planning; lack of efficient resources; inadequate investment in manpower responsible for the implementation and control of the schedule	Nigeria	(Ibironke et al. 2013)
Schedule pressure on construction productivity	Proactive planning; team motivation; effective communication mechanisms; realistic scheduling	Singapore	(Nepal et al. 2006)
Causes of delivery delays and cost overruns in construction projects in the Gulf region	Incompetent approval of drawings; inadequate early planning and slowness of the owners' decision-making process	UAE	(Faridi and El-Sayegh 2006)
	Lack of experienced team attributed to the considerable amount of large or more innovative construction projects; undersupply of manpower in the industry	Saudia Arabia	(Al-Kharashi and Skitmore 2009)

	Owner additional works; poor communication between relevant governmental units and the owner; unrealistic design periods; non-availability of records of similar projects; non-availability of overall planning	Oman	(Alnuaimi et al. 2009)
	Poor project management factors and client's administration and site supervision practices	Kuwait	(Al Tabtabai 2002)
	Design changes, labor shortages, deficient estimates and cash flow planning	Qatar	(Jurf and Beheiry 2012)
	Lack of efficient design and coordination integration in planning	Bahrain	(Johny 2012)

Table.1. Summary of findings from studies highlighting factors that affect scheduling performance

Label	Factors identified as barriers	Stage of Planning and Scheduling in which those factors should be properly addressed			Relevant studies
		Development	Implementation	Control	
B1	Lack of effective leadership	✓	✓	✓	(Voth 2009) (Müller and Turner 2010)
B2	Insufficient support from project stakeholders in the development of plans and schedules	✓	✓		(Iyer and Jha 2006) (Davis 2014)
B3	Poor decision-making regarding activity criticality	✓	✓		(Hameri and Heikkilä 2002) (González et al. 2014)
B4	Lack of education and training in planning and scheduling	✓	✓	✓	(Nepal et al. 2006) (Hameed 2005) (Yang et al. 2011)
B5	Incompatibility of planning methods with the project schedule's nature (i.e. complexity and size)	✓	✓		(Jurf and Beheiry 2012) (Burke 2003)
B6	Absence of schedule contingency	✓	✓		(Hoel 1999) (Mulholland and Christian 1999)
B7	Trivial control and reporting system between management levels			✓	(Voth 2009) (Snoo et al. 2011)
B8	Absence of resource-constrained scheduling for dealing with uncertainty problems	✓	✓		(Elmaghraby et al. 2003) (Abeyasinghe et al. 2001)
B9	Absence of new technology and software for planning and scheduling	✓		✓	(Noronha and Sarma 1991) (Taroun 2014) (Mokhtari et al. 2011)

Table 2. ***Criteria Used to Identify Potential Enablers and Barriers to Planning and Scheduling***

Cont.… Table 2

Label	Factors identified as enablers	Stage of Planning and Scheduling in which those factors should be properly addressed			Relevant studies
		Development	Implementation	Control	
E1	Well-documented inputs, milestones and deliverables in scheduling	✓			(Odusami et al. 2003) (Kerzner 2013)
E2	Proficiency of team in managing scheduled activities, deviations and corrective actions	✓		✓	(Voth 2009) (Hameed 2005) (Hwang et al. 2013)
E3	Cost-efficiency in accelerating and reworking schedules and their activities		✓	✓	(Ibironke et al. 2013) (Mulholland and Christian 1999)
E4	Reliability of detailed schedules	✓			(Luu et al. 2009) (Iyer and Jha 2006)
E5	Focusing on a holistic approach rather than on completion of individual activities			✓	(Cerveny and Galup 2002) (Thornley 2013) (Yang 2007)
E6	Proper understanding of the interrelationship (alignment) between scope, schedule and budget	✓		✓	(Kerzner 2013) (Alsakini et al. 2004)
E7	Fast re-planning and recovery from unexpected changes in the baseline schedule		✓	✓	(Ibironke et al. 2013) (Kerzner 2013)
E8	Effective tracking of in-progress schedule deviations			✓	(Ahsan and Gunawan 2010) (Voth 2009)
E9	Availability of alternate planning methods for overcoming shortcomings with existing methods	✓			(Bokor et al. 2011) (Cegarra and Wezel 2011)
E10	Maintaining schedule quality control by excluding unintended operational behavior		✓	✓	(Moneke 2012) (Steyn 2002) (Hussein and Klakegg 2014)
E11	Effectiveness of resource leveling in scheduling		✓		(Abeyasinghe et al. 2001) (Mokhtari et al. 2011)
E12	Efficiency of managerial support for motivational and training programs	✓	✓	✓	(Müller and Turner 2010) (Yang et al. 2011)

Characteristics		Responses
Job identification (All respondents)	Junior project engineers	33
	Senior project engineers	24
	Project managers	9
	Quantity surveyors	7
	Operations managers	3
	Risk managers	1
Age (years)	20-40	47
	41-60	30
Years of experience (years)	6-10	17
	16-20	16
	>21	16
	11-15	13
	Unspecified	11
	1-5	4
Organizations	Contracting firms	33
	Public firms	20
	Construction management firms	16
	Consutlancy and design firms	6
	Facility management	2
Respondents' enrolment in projects	Construction	24
	Operation	20
	Planning	16
	Design	9
	All	8
Status of projects (nr. of respondents)	On schedule	41
	Behind schedule	36

Table 3. Background profiles of respondents

#	Barriers in descending order	RII		
		Value	Rank	Category of significance
B2	Insufficient support from project stakeholders in planning and the preparation of schedules	0.725	1	VS
B3	Poor decision-making regarding activity criticality	0.688	2	S
B8	Absence of resource-constrained scheduling for dealing with uncertainty problems	0.681	3	S
B9	Absence of new technology and software for planning and scheduling	0.671	4	S
B1	Lack of effective leadership	0.669	5	S
B4	Lack of education and training in planning and scheduling	0.655	6	S
B6	Absence of schedule contingency	0.646	7	S
B7	Trivial control and reporting system between management levels	0.646	7	S
B5	Incompatibility of planning methods with the project's nature (i.e. complexity and size)	0.610	8	S

Note: VS= Very Significant; S= Significant

Table 4. ***Impact Indices and Ranks of the Barriers to Planning and Scheduling***

#	Enablers in descending order	RII		
		Value	Rank	Category of significance
E4	Reliability of detailed schedules	0.746	1	VS
E11	Effectiveness of resource leveling in scheduling	0.740	2	VS
E12	Efficiency of managerial support for motivational and training programs	0.740	2	VS
E7	Fast re-planning and recovery from unexpected changes in the baseline schedule	0.736	3	VS
E1	Well-documented inputs, milestones and deliverables in scheduling	0.733	4	VS
E5	Focusing on a holistic approach rather than on the completion of individual activities	0.733	4	VS
E3	Cost-efficiency in accelerating and reworking schedules and their activities	0.731	5	VS
E2	Proficiency of team in managing scheduled activities, deviations and corrective actions	0.727	6	VS
E9	Availability of alternate planning methods for overcoming shortcomings with existing methods	0.727	6	VS
E6	Proper understanding of the interrelationship (alignment) between scope, schedule and budget	0.724	7	VS
E8	Effective tracking of in-progress schedule deviations	0.711	9	S
E10	Improving schedule quality control by considering unintended human operational behaviors in scheduling	0.705	10	S

Note: VS= Very Significant; S= Significant

Table 5. Impact Indices and Ranks of the Enablers to Planning and Scheduling

Paper IV

Understanding management roles and organisational behaviour in planning and scheduling based on construction projects in Oman

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ABSTRACT

There are many challenges associated with the construction processes of planning and scheduling. These challenges are relevant to all project parties or stakeholders and therefore management roles or organisational behaviours of those parties have to be properly considered and assessed. With this in mind, this study is aimed at assessing practitioners' perspectives on the current significance and applicability of a set of criteria or factors concerned with management roles and organisational behaviour of the different parties based on construction projects in Oman. The study has adopted a quantitative approach in which a questionnaire-based survey was chosen and conducted to gather responses from construction projects in Oman. A total of 67 valid responses were analysed based on the rankings and means of the respondents' perspectives on the significance and applicability of the identified factors to current practice. The overall findings indicated that all investigated factors should be critically considered as equally important to the development process of planning and scheduling. Nevertheless, the findings implied that a management priority should be given to the most important factors significantly affecting project planning and scheduling. The study provides some useful recommendations on how to improve project management (PM) roles and organizational behaviours (OB) in planning and scheduling on the part of key project parties.

Keywords: project control, management roles, organisational behaviour, planning, scheduling, project parties, Oman.

Management roles and organizational behaviours in Oman

Introduction

The complexity of planning and scheduling tasks requires rigorous effort in terms of the effectiveness of the project team, especially with regard to the project management roles and organisational behaviours that are key factors for the success of project objectives (Mubarak 2010, Ahuja and Thiruvengadam 2004). This is because planning and scheduling should be managed and controlled in the most effective way by all team involved for a successful project performance (Kerzner 2013). Therefore, the understanding of the impact of such roles and behaviour on work performance can provide tangible benefits to the success of the project (Yang et al. 2011). In this respect, a good alignment between the team's working behaviours (or human aspects) with the technical issues of a project will support the achievement of such benefits (Edum and McCaffer 2000). According to Eriksson (2010), the effectiveness of any construction management process can be potentially improved by allowing for complete perceptions and interests from all construction stakeholders. For instance, Jaffar et al. (2011) considered factors such as poor communication among the project team, lack of effective leadership and reluctance in controlling the project tasks execution and completeness as unintentional behaviours resulting in project disputes in terms of slow productivity and increased cost. A study by Cheung et al. (2003) implied that the consideration of behavioural aspects in the construction process still appears to be not sufficiently explored in current practices. More specifically, González et al. (2014) argued that there is a need to promote new management changes in project planning by clearly defining project management roles and their relevant impacts on the project performance. In addition, such management roles and behaviour, as well as other project technical issues should be effectively harmonised by all stakeholders involved in a project (Too and Weaver 2014). In this regard, project stakeholders should be able to clearly identify and define all scheduling tasks, related resources and constraints for better project outcomes (Sears et al. 2010). According to Turner (1999), improving the performance of a project requires a competent management team that can monitor and control the project activities at both planning and operational levels of the project. Turner further argued that the competence of project management team in setting out a project plan, monitoring the work progress, estimating the schedule variance, as well as taking all necessary corrective actions are significant for the success of project planning (Turner, 1999).

This study was conducted based on the Oman construction projects. In this respect, the contribution of the construction industry to Oman's GDP is forecasted at a growth rate ranging from 5 to 10% by 2020, which represents a high proportion of the country's economy (Islam and Khadem 2013, Oxford Business Group 2014). According to the Oman regulation systems, large public projects of estimated cost above 1/4 million Omani Rail (1USD= 0.385 Omani Rail) are floated and awarded by the Oman tender board in a form of unit-cost or lump-sum contracts

or other sorts of measurements (Oman Tender Board, 2014). There are, however, some exceptions for governmental authorities to manage certain types of projects internally through design-build contracts. All bidders participating in private and public projects, however, should follow the Oman Standards for Building and Civil Engineering Works as a regulated procedure. According to Oxford Business Group (2014), Oman, amongst many other developing countries, has also experienced some delays and improper cost control in a number of construction and infrastructure projects. Of course, all improper management issues causing these delays needed to be urgently addressed in a way that increased practitioners' awareness of what was lacking in their current practices. Despite this being the case, few academic studies conducted on the Omani construction industry revealed a common concern in the need for more evaluations of the current situational problems (or risk factors) pertaining to project disputes in terms of a lack of effective quality management, cost control systems and time performance measurements (Albalushi et al. 2013, Mohsin 2011, Bakar et al. 2011, Alnuaimi et al. 2009, Bakar et al. 2012). But then, such performance measurements should also be focused on the other aspects concerned in the project management roles and organisational behaviours that might lead, if not properly understood and addressed, to ineffective planning and scheduling systems. To support this argument, it can be postulated that the effective consideration of such management roles and organisational behaviours in project planning and scheduling will help overcoming the occurrence of contractual disputes related to project planning during execution.

Summarizing the above literature, there are far fewer examples to be considered when assessing the different project management roles and organisational behaviour attributed to key project stakeholders at particular stages such as planning and scheduling. These roles and behaviours should be considered and applied properly by all project stakeholders (or parties) involved in a project. Otherwise, insufficient considerations of such roles and behaviours will result in ineffective planning and scheduling, and thus low quality project execution. So, the originality of this study is based on its attempt to assess project management roles and organizational behaviour in construction planning and scheduling. This is important because giving a specific focus to the different roles and behaviours related to particular project tasks of planning and scheduling can be more worthwhile than looking at a project holistically. Consequently, this will improve the effectiveness of the implementation and control of these tasks; thus, enhancing their practical performance.

This study, therefore, aimed at addressing this lack of knowledge by identifying and assessing a set of factors concerned with management roles and organisational behaviour of the key project parties using the Oman construction projects. The primary goal was to answer the following research question: *What are the management roles and organisational behaviours of project parties that should be critically considered for effective planning and scheduling?*

In order to explore this research question, the following objectives were set:

- To identify and examine project management roles and organisational behaviour of the key project parties involved in planning and scheduling
- To provide new insights on how to improve the efficiency of such roles and behaviour in planning and scheduling.

The expected outcomes might provide useful insights for construction stakeholders and practitioners towards critically understanding and sufficiently addressing management roles and organizational behaviours for more effective planning and scheduling.

Literature review

In addition to the above literature, there are a number of research studies studied and assessed various factors pertained to different project parties, which are considered as major reasons for poor project performance. However, some of these factors can be considered as team management roles and behaviours that should be independently investigated. In connection to this view, Nepal et al. (2006) argued that project scheduling has a strong interaction with other metrics of a project, and therefore is assumed to involve other management factors that to be critically considered. More specifically, Walker (2011) stated that organisational behaviour in the construction industry is still an issue that unquestionably needs more explicit exploration in practice. Latterly, this claim has been confirmed by Kreiner (2013) who argued that the effectiveness of the construction process can be best understood and improved by properly understanding the project management team and their organisational behaviour.

In summary, there seems to be a need for specific research studies on the understanding and assessment of project management roles and organisational behaviour in planning and scheduling in the context of construction projects. As noted earlier, much previous research, however, has paid more attention to the evaluation of the success and failure factors affecting project performance with regard to time and cost constraints (Assaf and Al-Hejji 2006, Ahadzie et al. 2008, Ghosh and Jintanapakanont 2004, Sun and Meng 2009). Nevertheless, a number of these research studies have highlighted some initiatives regarding the assessment of potential effects of various factors, pertaining to the main participants (project managers, clients, contractors, consultants) in a project, on the success of project performance (Oyedele 2013, Bari et al. 2012, Enshassi et al. 2007, Jaffar et al. 2011, Mbachu and Nkado 2007, Doloi et al. 2012, Cooke-Davies 2002, Sunindijo et al. 2007, Hwang et al. 2013). In a more recent study by Davis (2014), it is found, however, that there was no common agreement in perspectives among the different project stakeholders regarding the significance of these factors to their projects. This insignificant variation among stakeholders' view can be attributed to a variability in project management roles

and organisational behaviour currently adopted in project planning and scheduling. A summary of examples of investigated factors related to key project stakeholders or parties is presented in Table 1. As mentioned earlier, however, this study is trying to pay a more particular focus on the assessment of project management roles and organizational behaviours of the key project parties involved in the implementation and control of planning and scheduling.

[Insert Table 1 here]

Study methodology

Identification of the study variables

In view of the above literature review and the subsequent discussions, the current practices in project planning and scheduling, not least in Oman, take very little account of stakeholders or practitioners' perspectives regarding the understanding of project management roles and organizational behaviour currently embraced in the development, implementation and control of project planning and scheduling. Considering this lack of knowledge indicated in the literature and by using experiences of the researcher in the construction industry, and subsequently utilizing brainstorming, a screened list of 44 factors was identified and designed. The identified factors were presumed to contribute to the project management roles and organisational behaviour of the four main parties, usually involved at a certain level of participation in project management tasks of planning and scheduling. Out of a total of 44 defined factors, 14 criteria related to project managers' roles and behaviour in planning and scheduling, 10 to clients' roles and behaviour, 10 to contractors' roles and behaviour and 10 to consultants' roles and behaviour.

Data collection methods

The study has adopted a questionnaire-based survey, which is considered a positivist tool for gathering data about research problems where their relevant theory seems to be inadequately investigated in practice (Neuman 2005). In this study, the questionnaire was distributed manually (hand-delivered copies) and electronically (mail-delivered copies) to groups of people engaged in a number of public and private construction organizations in Oman. The questionnaire tested the strength of the participant perspectives on the significance of the adopted factors based on a Likert-type point scale of 1 to 7 , where 1 represents the lowest level of disagreement (strongly disagree) and 7 represents the highest level of agreement (strongly agree). The questionnaire was responded by 67 participants out of about 120 distributed copies; which is 55.8% response rate which can be considered as a reasonable response rate. Table 2 presents the analysis of the respondents' profiles.

[Insert Table 2 here]

Data analysis methods

The study has considered the relative importance index (RII) for testing the collected data. Holt (2014) considered the RII as a suitable tool to provide more accurate rankings of responses collected through a study-based Likert-scale questionnaires than descriptive statistics. In this regard, Holt revised and modified the RII models for the aim of providing more precise estimations of the intervals of the rankings among the tested variables. Thus, the RII rankings and means of the study variables were computed based on the following equations recently developed by Holt (2014):

$$RII_{(7\text{-point, adjusted model})} = ([116.68\ (\sum w \div 7N)] - 16.68)\ \%$$ Equation (1)
based on Holt (2014)

$$\text{Where } \sum w \text{ (for a 7-point Likert-scale)} = (7*n_7+6*n_6+5*n_5+4*n_4+3*n_3+2*n_2+n_1)$$

$$RII_{(\text{Max range})} = 1-(1 \div A_{max}) = 0.86$$

$$RII_{\text{mean= SQRT.}}(RII)$$ Equation (2)

Where RII = relative importance index, w = individual weight given to each statement based on a 7-point scale (stems). A_{max} = the highest ranking point used (7 in this study), and N = the total number of respondents used in the analysis. It should be noted that the respondents were asked to rank the identified factors in the study based on the relevance or applicability of these different factors to the current practice of their construction projects. For the purpose of management priorities and practical considerations of the most significant factors (roles and behaviours), the data interpretation is based on the RII analysis of the top five factors as discussed next.

Data analysis and discussions

Management roles and organisational behaviour related to project managers

The results in Table 3 indicated that respondents assigned close RII rankings to the significance of project manager roles and behaviour to planning and scheduling. Project manager roles and behaviour concerned with the practical use of project scheduling as tool-based managerial skills rather than tool-based computer skills (F1; Mean= 0.424; $RII_{adjusted}$=0.848) and motivational incentives for successful planning and scheduling teams (F8; Mean= 0.423; $RII_{adjusted}$=0.846) were ranked as the most important factors to the current practice. In view of these findings, a study by González et al. (2013) revealed that a proper understanding of project schedules by project managers is crucial to the effective control of schedule deviations during project execution. This would imply that managerial motivations assigned for the successful planning team can improve the project team productivity in managing a more realistic and controllable scheduling.

Other roles and behaviours concerning project manager competence in understanding the complete transfer of planning outputs into scheduling plans (F6; Mean=0.418; $RII_{adjusted}$=0.836) and the best use of lessons learned when developing new project plans and schedules (F10; Mean=0.418; $RII_{adjusted}$=0.836) were received the same RII ranks as equally important factors to the current practice of planning and scheduling. This has become evident in view of the literature which implied that insufficient considerations of all inputs and deliverables in project planning will result in impractical scheduling of the project (Nepal et al. 2006, Ahsan and Gunawan 2010). This can imply that project managers should not proceed with project scheduling unless project planning is measured against the completeness of scope definition, especially time and resources estimates.

[Insert Table 3 here]

Management roles and organisational behaviour related to clients

The RII results revealed a small variation in the overall rankings of the studied roles and behaviour of clients as indicated in Table 4. Nevertheless, there is still a room for prioritizing some significant factors than others while developing project plans and schedules. In this regard, the clients' roles and behaviours concerned with: sufficient awareness about the impact of unplanned changes on the original schedule (F22; Mean=0.387; $RII_{adjusted}$=0.774) and the participation in coordinating and setting out the measurement performance tools for planning and scheduling (F18; Mean=0.385; $RII_{adjusted}$=0.771), as well as clients' flexibility in facilitating the flow of the project boundary information in planning and scheduling (F17; Mean= 0.383; $RII_{adjusted}$=0.766), were ranked as the top three factors that might be given more attention. The findings can imply that clients should play a strong role in setting out the performance control tools, as well as they should use their own competencies when addressing and evaluating their needs and relevant impacts on planning. Additionally, clients should be authentic regarding desired information needed about project boundary conditions for a more reliable project planning. Other management roles concerned with the completeness and accuracy of needs and inputs in planning on the part of clients was considered as the fourth significant factor (F16; Mean= 0.381; $RII_{adjusted}$=0.762). This was followed by project clients' roles or behaviour concerning the ability to establish trustworthy and interactive environments in planning and scheduling (F15; Mean=0.378; $RII_{adjusted}$=0.756) ranked as the fifth significant factor. A combination of these findings aligned with the same concern indicated in the relevant literature stating that the client ability to allocate contingency resources (buffers), and ability to actively participate in project planning, as well as the ability to efficiently overcome any schedule deviations during the implementation stage, are significant issues to the success of project time performance (Ahadzie et al. 2008, Hwang et al. 2013, Mbachu and Nkado 2007).

[Insert Table 4 here]

Management roles and organisational behaviour related to consultants

Table 5 presents the overall rankings and means of the factors used to judge roles and behaviours of project consultants in planning and scheduling. The results revealed that the factors identified as 'effective coordination with all project stakeholders in the implementation and control of planning and scheduling (F28; Mean=0.389; $RII_{adjusted}$=0.778)' was rated with the highest RII value as the most important role to be considered. A more recent study by Oyedele (2013) revealed that the effectiveness of consultants' co-ordination with other project stakeholders is a key issue for the effectiveness of project planning, especially in large or mega projects where many stakeholders are involved at different design stages . Subsequently, the findings from the study indicated that management roles and organizational behaviours of consultants concerned with 'the efficiency in transferring all information, needs and other inputs of stakeholders in planning (F27; Mean=0.377; $RII_{adjusted}$=0.754)'; 'the effectiveness in analysing the scheduling outcomes in conformance quality and risk aspects of project (F29; Mean=0.377; $RII_{adjusted}$=0.754)'; and 'the tendency to be proactive regarding uncertainties or risk factors causing hindrance to the schedule performance (F31; Mean= 0.376; $RII_{adjusted}$=0.751)' were considered as equally important factors to the implementation and control of project planning and scheduling. In connection to this, it was argued that delegating a more proactive team is crucial for identifying all potential risks and for allocating contingency plans; thus, mitigating uncertainty in scheduling by effectively managing risks (Schatteman et al. 2008).

Moreover, the results showed that the factor concerned with the consultant capability to adopt a variety of control methods and tools in project planning and scheduling was received the fourth RII score (F25; Mean=0.374; $RII_{adjusted}$=0.749). This would imply that project consultants should understand, choose and adopt the most suitable tools and methods that fit with the project nature (size and complexity) for managing a more realistic scheduling that meets the common understanding of other project parties.

[Insert Table 5 here]

Management roles and organisational behaviour related to contractors

Table 6 presents the RII rankings of the factors used to examine the contractor roles and behaviours in planning and scheduling. It is also very important to understand the contractor roles in the development and control of project planning and scheduling. More recently, Alzahrani and Emsley (2013) have stated that proper understanding of performance aspects and management roles of project contractors is crucial for the best likelihoods of having more achievable outcomes from the execution of construction projects. The results in Table 6 indicated that the factors concerned with the contractor effectiveness in following up and controlling in-site teams and in resolving their related conflicts affecting the schedule performance (F37; Mean= 0.417; $RII_{adjusted}$=0.833), as well as the contractor competence in

adequately incorporating and managing work schedules of sub-contractors and suppliers in the main project scheduling (F38; Mean=0.414; $RII_{adjusted}$=0.828), were received the highest RII ranks as significant roles or organisational behaviours to the implementation and control of planning and scheduling. This was followed by the factor concerning the contractor role and behaviour towards admitting the accountability for the most efficient technical implementation of project plans and schedules (F35; Mean=0.412; $RII_{adjusted}$=0.823). In addition, the contractor should also be able to manage all interferences between procurement schedules and the project schedule (F36; Mean=0.408; $RII_{adjusted}$=0.816), as well as the ability to update project schedules resourcefully based on feedbacks from other project stakeholders (F40; Mean=0.398; $RII_{adjusted}$=0.796). In this regard in, scheduling quality control can be enhanced by adequate identifying of the interference impacts of the material delivery schedule on the detailed scheduling of a project (Oberlender 1993, Belout and Gauvreau 2004). These roles and behaviours of contractors should be critically considered for high quality performance of scheduling. Other relevant studies by Iyer and Jha (2006), Jha and Iyer (2007) and Ibironke et al. (2013) also indicated the imperative of considering such factors, amongst other important factors (Table 1), while managing construction scheduling. **[Insert Table 6 here]**

Practical implications for managerial considerations

Based on the above findings and subsequent discussions, the significant factors concerned with roles and organizational behaviours should be integrated into the current philosophies of project planning adopted in the construction industry. As a result, construction practitioners and key stakeholders should be able to properly identify and adjust the existing management roles and organisational behaviour for the purpose of managing more dynamic and effective planning and scheduling systems. The project parties should be able to address, amongst other management roles and behaviours, the following issues, which can be used as guidelines for making the most effective decision in project planning and scheduling:

- Project managers should effectively recognise that their accountability is not just limited to planning, but should also be extended and communicated to the implementation and control of project plans and schedules. A specific focus by project managers should be given to the improvement of their team skills in managing effective project scheduling. This can be achieved through specific training on planning and scheduling theory, the use of control tools and other computerized techniques. In addition, project managers should be competent in setting out the most efficient control and communication plans with other parties to the project in order to allow for more realistic information sharing and feedback.

- Clients should be competent in and increase their awareness of the consequences of any uncontrolled or poorly planned changes on the effectiveness of planning and scheduling systems. Therefore, they should actively participate in coordinating and establishing the most efficient measurement tools or methodologies for planning and scheduling. Moreover, clients should be very flexible and realistic when providing and addressing all required information to other stakeholders about project boundary conditions in planning. They should be competent in addressing their needs and interests on the basis of real needs behind the project idea.
- Consultants should be effectively coordinating all inputs and deliverables from other parties in planning and scheduling. This means that consultants should be able to transfer such needs into well-defined, measurable units in planning. The consultants should be able to foster any required change in the management plan, for example, by applying new tools and techniques for controlling and analysing all uncertainties in the schedule against other measures of quality, risk and cost control.
- Contractors should be competent in applying planned and scheduled tasks into physical actions, as well as effectively communicate with their in-site team in order to be able to follow-up the implementation of such tasks on site according to the original plan. Moreover, they should be able to adequately manage interferences among materials' delivery schedules and master the work schedule as not to allow for any detraction from the original plans. In this regard, they should utilise monitoring and optimisation tools to precisely identify any deviations in scheduling in order to rapidly address such deviations to other stakeholders for necessary corrective action with no cost implications.

CONCLUSION

The study has identified and examined a set of factors identified as project management roles and organisational behaviour of the main project parties in project planning and scheduling. The literature review implied that there is a lack of knowledge on the part of construction practitioners towards the proper understanding of such roles and behaviour in the current practice. The research findings revealed that there is a strong level of agreement among the respondents on the rankings of significance of the investigated factors to planning and scheduling. Nevertheless, the study implied that there is a need to prioritize certain significant roles and behaviours than others while developing project plans and schedules. In addition, construction policy-makers should take into account that any mismatch in project management roles and organisational behaviour of the main project parties involved can result in ineffective planning and scheduling.

Despite the immediate study was limited to locally perspectives based on the Oman construction projects, it has provided some useful insights to construction practitioners and stakeholders in general. First, it highlights a new management area concerned with organizational behaviour in project planning which appears to be a relatively new concept that needs further investigations. Second, it has provided useful knowledge regarding the rankings of significance of the different management roles and organisational behaviour to current practices; thus, construction practitioners are expected to gain insight into how to prioritize certain management roles and behaviours by adjusting their current management strategies for the best development and control of planning and scheduling. The study results can be externally validated by adopting a more rigorous approach to develop a deeper insight about the research phenomena highlighted in this study.

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List of Tables

	Examples of investigated factors	Selected Literature
Project manager-related attributes	o Incomplete inputs of scope o Aggressive designed schedules o Incompetent planning o Misunderstanding of the project specifications o Poor decision-making o Ineffective communication o Ineffective leadership o Insufficient identification of boundary conditions o Reworked plans o Shortage of resources	(Ahadzie et al. 2008); (Assaf and Al-Hejji 2006); (Belassi and Tukel 1996); (Enshassi et al. 2007); (Mbachu and Nkado 2007); and (Cooke-Davies 2002)
Client- related attributes	o Poor organization structure o Inaccurate regulations of client's representatives o Centralized management o Project financing and interim payments o Uncontrolled variation orders o Less involvement in planning o Lack of team training o Ambiguity of requirements o Access restriction to site information conditions o Lack of conflict management plan	(Ahadzie et al. 2008); (Assaf and AlHejji 2006); (Enshassi et al. 2007); (Hwang et al. 2013); and (Doloi et al. 2012)
Consultant- related attributes	o Complexity of design o Inaccurate cost estimate o Planning errors o Insufficient consideration of stakeholders' needs o Incompetent technical team o Improper inspections o Use of obsolete design criteria o Unreliability of schedules o Lack of control methods o Insufficient coordination o Unrealistic resource forecast o Ignorance of non-technical aspects in design	(Faridi and El-Sayegh 2006); (Assaf and Al-Hejji 2006); (Enshassi et al. 2007); and (Ibironke et al. 2013);
Contractor- related attributes	o Faulty implementation of plans o Lack of control over sub-contractors o Delays of procurement and delivery schedules o Improper use of equipment and construction testing o Unreliable progress reports o Lack of partnering and interdisciplinary o Financial constraints o Weak motivated and low-productivity team o Improper rescheduling of actual works o Lack of new technology	(Faridi and El-Sayegh 2006); (Ghosh and Jintanapakanont 2004); (Assaf and Al-Hejji 2006); (Ibironke et al. 2013); (Mbachu and Nkado 2007); and (Enshassi et al. 2007)

Table.1. Summary of findings from relevant research studies

Characteristics		Responses frequency (count)	Percentage (%)
Work position	Senior engineers	26	38.8
	Project managers	22	32.8
	Junior engineers	17	25.4
	Quantity surveyors	2	3.0
Qualification	Bachelor	45	67.2
	Master	12	17.9
	Diploma	10	14.9
Years of experience	5-10	18	27.0
	11-16	14	19.5
	17-22	19	28.4
	>22	14	19.5
	Not defined	2	3.0
Type of firm/organization	Clients	28	41.8
	Contractors	22	32.8
	Project management	13	19.4
	Consultants	4	6.0
Phases of project respondents are currently involved in	All	19	30.6
	Execution	13	20.9
	Planning& controlling	9	14.5
	Execution and controlling	6	9.7
	Initiating, planning and execution	5	8.0
	Controlling	5	8.0
	Planning and execution	4	6.5
	Initiating	1	1.6
	Not defined	5	7.5
Total	-	67.0	-

Table.2. Background profiles of respondents

Organizational roles and behaviour of project managers in descending order		RII adjusted Equations (1) & (2)		
		Mean	Value	Rank
F1	Practicing the schedule as management based-skills rather than computer based-skills	0.424	0.848	1
F8	Motivating and rewarding the successful planning and scheduling team	0.423	0.846	2
F6	Ensuring accuracy and completeness of all outputs from planning to scheduling	0.418	0.836	3
F10	Applying past lessons gained for developing the new plans and schedules	0.418	0.836	3
F3	Cooperating with cross-functional team in all stages of planning and scheduling	0.412	0.823	4
F2	Using the schedule as an effective communicating tool for information sharing and learning	0.411	0.821	5
F9	Monitoring and guiding site managers on the actual scheduling	0.406	0.813	6
F7	Setting-out the efficient methodologies for controlling the implementation of plans and schedules	0.399	0.798	7
F5	Understanding the key characteristics of the adopted planning methods	0.338	0.776	8
F11	Fostering innovative systems in planning to overcome shortcomings with traditional systems	0.383	0.766	9
F13	Adopting flexible procedures to allow for dynamic planning and scheduling	0.379	0.758	10
F4	Allowing for all needs and inputs from project stakeholders in planning	0.378	0.756	11
F12	Delegating authority to site managers for taking necessary actions on the schedule deviations	0.376	0.751	12
F14	Understanding the team cultural differences in planning and scheduling	0.360	0.719	13

Table.3. RII rankings of project managers' roles and organizational behaviour

	Organizational roles and behaviour of clients in descending order	RII adjusted		
		Mean	Value	Rank
F22	Having sufficient awareness about the impact of unplanned changes on scheduling	0.387	0.774	1
F18	Participating in coordinating and setting-out measurement-performance tools for planning and scheduling	0.385	0.771	2
F17	Facilitating flow of boundary conditions information of project in planning and scheduling	0.383	0.766	3
F16	Addressing their needs and interests effectively in planning and scheduling	0.381	0.762	4
F15	Establishing interactive and trustworthy environments in planning and scheduling	0.378	0.756	5
F19	Having sufficient competences for confronting as-built schedules against as-planned schedules	0.374	0.748	6
F24	Allocating contingency resources needed for recovering any shortcut in ongoing schedules	0.373	0.746	7
F23	Using their competency in evaluating and verifying contractors' claims against original plans	0.371	0.741	8
F20	Approving plans and schedules based on their proper understanding of the characteristics of the different project tasks	0.368	0.736	9
F21	Letting for flexibility required for acceptance of necessary modifications in original scheduling plans	0.352	0.704	10

Table.4. RII rankings of clients' roles and organizational behaviour

Organizational roles and behaviour of consultants in descending order		RII adjusted		
		Mean	Value	Rank
F28	Coordinating effectually with other project parties for the improper implementation and control of planning and scheduling	0.389	0.778	1
F27	Liaising with all project stakeholders to efficiently transfer their inputs and needs in planning	0.377	0.754	2
F29	Evaluating and analysing planning and scheduling outcomes in relation to the project quality and risk aspects	0.377	0.754	2
F31	Working as proactive team regarding all uncertainties or risks anticipated in scheduling	0.376	0.751	3
F25	Experiencing their proficiency in adopting of alternate planning and scheduling methods	0.374	0.749	4
F33	Adopting change management for assessing all required changes and subsequent effects on planning	0.370	0.739	5
F32	Utilizing the efficient control systems for collecting feedbacks on actual performance of scheduling	0.368	0.736	6
F26	Recognizing and admitting their responsibility towards technical inputs faults in planning and scheduling	0.362	0.724	7
F34	Adequately considering all new claims or concerns from project stakeholders in the implementation of planning and scheduling	0.361	0.721	8
F30	Identifying all constraints in planning to avoid any deviation from original plans in scheduling	0.346	0.692	9

Table.5. RII rankings and means of consultants' roles and organizational behaviour

Organizational roles and behaviour of contractors in descending order		RII adjusted		
		Mean	Value	Rank
F37	Following-up and supervising the site labour for the effective implementation of scheduling	0.417	0.833	1
F38	Incorporating effectively all sub-contractors and suppliers work schedules in the master scheduling	0.414	0.828	2
F35	Admitting the accountability for the efficient implementation of plans and schedules	0.412	0.823	3
F36	Managing interferences properly among the delivery scheduling and the project master scheduling	0.408	0.816	4
F40	Updating scheduling resourcefully based on all criticisms or feedbacks from the other project parties	0.398	0.796	5
F39	Embracing the schedule contingency properly in overcoming unexpected events or variances	0.393	0.786	6
F41	Suggesting and elevating alternate scenarios for addressing the schedule constraints	0.390	0.779	7
F43	Supporting the implementation of planning and scheduling by adopting the most appropriate monitoring techniques	0.380	0.759	8
F44	Engaging specialized team in analysing the scheduling severities or disputes	0.366	0.731	9
F42	Documenting all concerns and claims effectually from other project parties	0.353	0.706	10

Table.6. RII rankings of contractors' roles and organizational behaviour

Paper V

Understanding the Application of Front-End Planning (FEP) in Construction Projects

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Abstract

Purpose: Although project planning is a key tool in determining project success, yet management efforts on early preplanning stages or front-end planning (FEP) appear to be not effectively considered in construction projects. This study, therefore, aims to assess project stakeholders perspectives on a number of criteria or factors related to FEP definitions in construction projects. ***Methodology:*** The study had measured project stakeholders' perspectives via a questionnaire-based survey using the Oman construction projects. Out of 137 distributed questionnaires, 66 responses were considered valid and used in the data analysis. ***Findings:*** The results revealed that the degree of definitions of project scope at FEP stages were not experienced as 'completely defined factors'. The results also revealed that there is a positive relationship between well-defined FEP and successful project performance. Moreover, the results indicated that a lack of team knowledge of planning fundamentals, the shortage of resources allocated to FEP and insufficient participations of project stakeholders in FEP were ranked as the most significant barriers to the application of FEP. ***Implications:*** The study implied that there is a need to reconsider current planning strategies through more effective preplanning efforts early at the front-end stage of a project where a new participation theory of key project stakeholders should be considered. ***Originality:*** The study has provided insights towards more effective integrations of FEP in construction practices. It is the first study concerned with the examination of project stakeholders' perspectives on FEP, at least within the demographical context, of this research where there seems to be nonexistence of construction studies in preplanning stages. Thus, this study can be considered as an attempt towards understanding efficiency of construction projects from the perspective of front-end planning.

Keywords: front-end planning, scope definition, preplanning, construction projects, stakeholder perspectives.

Introduction

Front-end planning (FEP) is a preplanning stage that defines a project with the high opportunity in achieving time, cost and performance targets (Batavia, 2001). FEP has aimed to provide project stakeholders, especially on the part of clients with clearer view of project's scope definition for effective decision-making regarding project justification (CII, 2012). The entire FEP stage encompasses various related activities including: determination of the mission need or business objective; the scope that fulfills such mission or objective; a basis for project design, project estimates (time and cost); the assessment of financial and staffing resources; risk factors facing the project; an organizational structure for the project; and a preliminary execution plan (Merrow, 2011, CII, 2012). Clear definitions of all these activities, however, require hard preplanning efforts that make FEP being the most critical phase of a project needed more attention by project stakeholders involved. In connection to this view, George et al. (2008) argued that FEP is a vital tool for project management team to effectively perform project estimates (scope, schedule and cost) as a basis for more detailed design. In other meanings, properly defined FEP serves as a proactive tool in measuring the completeness of project scope in a more predictable and acceptable way by project stakeholders (Sungmin et al., 2012). From another perspective, a good preplanning (or front-end planning) can be used as a reliable basis for controlling project execution (Williams and Samset, 2010).

From a wider practical perspective concerned with the significance of front-end planning, Merrow (2011) argued that nearly more than half of worldwide large infrastructure or industrial megaprojects, including the Middle East, failed to meet their goals as a result of poorly defined project estimates (time and cost) at the early planning stage. Merrow revealed that this situation can be significantly improved by paying more attention to the definition of preplanning stages of a project where the potential to revise project scope is high. This claim was aligned with views of an earlier study by Batavia (2001) indicated that poor scope definitions at the early planning stage is ranked a major factor contributing to schedule and cost overruns in construction projects. This author further argued that good scope definition at the front-end stage can result in a greatest reduction in time and life-cycle cost (LCC) growths of a project.

The literature review provides insight towards the need for a more assessment of project planning early at the front end stage. Yet, it appears that less attention is paid to the application of FEP as a separate pre-planning process in construction projects. Successful FEP requires the active involvement of project stakeholders before decisions are made that will determine the fate of a project. Therefore, this study aim to determine and understand project stakeholders' perspectives regarding the application of FEP and its integration into the context of project planning in construction projects. This aim is approached on the basis of the following objectives: a) determine the level of definitions

of FEP stages, b) assess the relationship between FEP and project success, c) identify and examine significant barriers to the application of FEP and d) propose management strategies on how to improve the application of FEP in construction projects. In this study, project stakeholders are identified as those individuals directly involved within a construction contract; those dominantly are: clients, project managers, contractors and consultants, as well those outside the contract such as quantity surveyors and governmental authorities— this is indicated later in the methodology section of this paper.

Literature review

Front-end planning (FEP): definitions and components

FEP is defined as a systematic procedure that has been developed to allow clients and project managers to make a competent decision on the efficiency of project scope prior to the detailed design (CII, 2012). More specifically, CII (2012) and Artto et al. (2001) revealed that FEP has been proposed with the aim of aiding project clients to obtain more realistic and complete information about all potential risks associated with different project alternatives. However, it was argued that FEP has been embedded in the entire project planning not as a preplanning stage (George et al., 2008). According to Sungmin et al. (2012), FEP can be managed differently depending on the project nature (complexity and size), as well as the effectiveness of project management teams in project planning. Despite there is no standardized FEP that can be used as a fit-in model for all types of projects, it has typically consisted of three stage-gated processes (see Figure 1), which are: feasibility study, conceptual planning (or preliminary scope definition) and detailed scope definition (Merrow, 2011, Gibson et al., 2010). The information developed in FEP stages will determine whether project clients will approve, terminate, or modify project scope. Unfortunately, this activity often takes place with insufficient attention from project stakeholders, who often are unaware of the process and whether it has been adequately performed. Failure to spend time at the early planning stage to get a project started right will probably spend a lot of time later to fix it (National Research Council 2001).

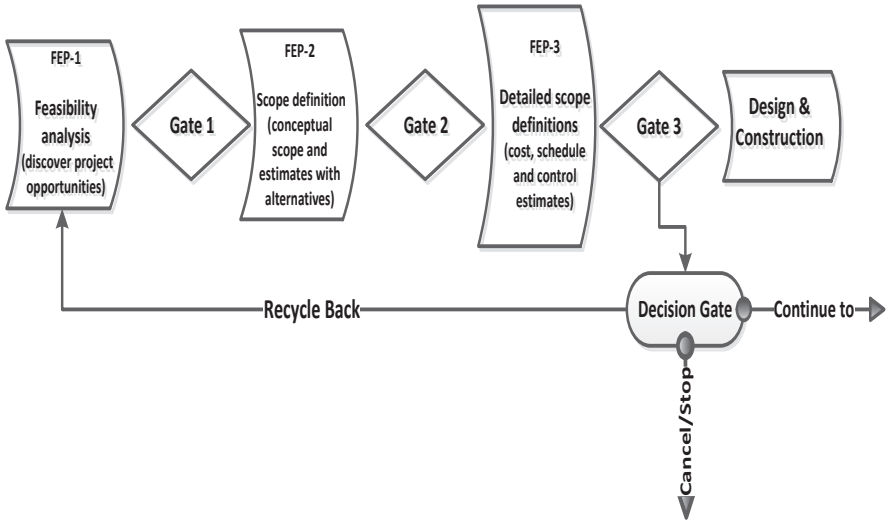

Figure 1. A typical FEP model developed based on CII (2012) and Merrow (2011)

Issues to be considered for successful applications of FEP

According to Williams and Samset (2010), the application of FEP requires a competent project management team to develop a meaningful feasibility analysis of all relevant information using their own experiences and lessons learned. These authors further revealed that properly established communication plans are important to the development of more effective preplanning. From the perspective of program management, Nobelius and Trygg (2002) indicated that effective project managers are important to the development of a suitable FEP approach that can be used for all projects managed under such program management systems. For a successful application of FEP, it is also important to effectively align all project stakeholders' requirements with project strategy (Griffith and Gibson, 2001). George et al. (2008) found that project planning inputs such as financial resources, start-up and execution plans, preliminary design criteria are important tasks that were performed with the least efficiency when developing the project scope.

FEP-1: Feasibility study

Feasibility study is considered as a set of assessment works that are used for assessing and defining project ideas and objectives before undertaking decisions about the acceptance or abandonment of the project idea (Del Cano, 1992). It comprises of technical, economic and financial feasibility assessments

(Khan, 2006). According to Khan, technical feasibility concerns with factors such as lessons learned from previous projects, availability of resources and skilled management teams, as well as technology. Economic feasibility concerns with availability of cost forecast tools, judgment of experts, decision making techniques whilst financial feasibility concerns with availability of funding resources and financial status of client organizations. Khan further revealed that a good feasibility study establishes good conditions that make later stages of project design and construction manageable. Jaafari (1990) indicated that the collection of all reliable information from involved project participants (or project stakeholders) is important to successful definitions of the feasibility study. Shen et al. (2010) asserted that effective feasibility studies are not just a set of financial projections but they are a market-driven strategic plan and a road map for all decisions at subsequent stages of a project.

Traditionally, project clients and consultants carried out the feasibility study by considering quantifiable hypotheses or optimizations for financial and human resources, project life-cycle costs, technical aspects, market conditions, economic, social and environmental factors, as well as project legislations (Graham, 2006, Del Cano, 1992). In the feasibility study, clients should work together with project managers and engineering consultants to identify and assess all economic, social and environmental attributes (or aspects) that influence later the effectiveness of project performance (Shen et al., 2010). In reality, these aspects of the feasibility study appears to be not properly considered while assessing the project idea. According to Hicks (2012), feasibility studies are often constrained by insufficient gathering and analysis of relevant information to project objectives, as well as the overly optimistic analysis of environmental and financial conditions of a project.

FEP-2: Conceptual definitions of project scope

From a broader perspective, conceptual planning of a project is a subset process of project planning, which involves a set of project activities concerning (Tatum, 1987): conceptual definitions of project scope, revision and approval of decisions on project alternatives, the development of project execution and control plans, determination of construction methods and equipment, the development of project design criteria and most importantly project risk analysis. Concerning risk management, conceptual planning is an important stage at which the greatest level of uncertainty about project risk is sufficiently encountered, as well as decisions taken in this stage tend to have a significant impact on the final estimate of project cost (Uher and Toakley, 1999). Concerning conceptual planning of project scope, at this stage only intermediate levels of work-break down structure (WBS) are developed after the detailed analysis and selection of project alternatives previously defined in the feasibility study (Khan, 2006, Merrow, 2011). It also involves the temporary design of work packages, financial and procurement strategies and project management organization, as well as setting out primary project

execution and control plans (Merrow, 2011, Abdul-Kadir and Price, 1995). At this stage, project managers and clients should be competent in setting out a basic design package (time, cost and all project requirements) for the final detailed definition of project scope for execution.

FEP-3: Detailed definitions of project scope

The FEP stage of detailed definitions of project scope is built on what are already defined and established in succeeding stages of feasibility and conceptual planning of scope. It involves clearer definitions of scope entities including detailed expansions of WBS, detailed engineering design, detailed construction and procurement plans as well as final estimates and analysis of project time, cost and risk (Khan, 2006, Fageha and Aibinu, 2013, Batavia, 2001). Project scope should be effectively prepared for a more realistic project design and manageable execution (Gibson and Gebken, 2003). An earlier study by Turner (1988) indicated that failures in developing a clear definition of the project scope would result in incomplete project designs and, hence poor control and misinterpretations of project execution. Furthermore, Turner indicated that roles of project managers in defining and measuring project scope and associated costs should be properly addressed at this stage. Recently, Mirza et al. (2013) argued that definition and approval of project scope can be improved through consideration of different strategies including the engagement of project stakeholders in the development of project scope. This is supported by Fageha and Aibinu (2013), stressing that a strong alignment between participation theory of project stakeholders with project scope definition is necessary for an effective development of project scope. It is the responsibility of project clients and project managers to effectively manage well-defined scope. This is because scope has a greater impact on other areas of project management such as risk management, procurement and contract management as well as human resource management (Khan, 2006).

Measuring the completeness of project scope definition

Beyond the completion of project scope definition in FEP, it should be accurately checked against all project deliverables prior to detailed design. For this purpose, project definition rating index (PDRI) has been introduced to check the level of completeness of detailed scope definition as part of the FEP procedures (Dumont et al., 1997). Cho and Gibson (2001) stated that PDRI is a useful checklist and authorization tool of project scope elements. Cho and Gibson (2001) argued that PDRI can be used by clients as means of negotiating consultants on incomplete defined elements of project scope.

Research methods

The survey questionnaire

From the literature, a set of variables (or factors) were identified and formulated for the questionnaire-based survey. The questionnaire was considered as an appropriate tool to gather respondents' perspectives on the identified variables. The questionnaire was pilot tested through a selected number of respondents involved in different construction projects. The pilot study aimed at improving quality of the survey questionnaire taking into account that FEP might be experienced as a new issue to majority of the selected respondents. The final version of the questionnaire consisted of five main parts:

- background information about respondents and projects
- the level of definition of FEP scope elements at different stage-gated processes (Figure 1);
- perspectives on the relation of FEP and successful project performance;
- significant barriers to the application of FEP; and
- views on how to improve FEP practices

Questionnaires were sent out anonymously through the online system to selected samples from public, private and public-private partnership (PPP) construction organizations and other sectors related to project management disciplines. The questionnaire packages managed electronically through the online web survey system (Question Pro software package) in the period between September 10th and November 10th, 2014. The samples were selected from a database records from an academic institution and a construction project department, where a final list of 396 emails were collected. Out of these emails only 137 were active and started responding to the questionnaire whilst only 66 responses were considered valid, with varying degrees of completeness provided for each part of the questionnaire. A total response rate of 34.6% was achieved and perceived as satisfactory in comparison to Ning (2014) who obtained a response rate of 7.4% (104/1440), and Zou et al. (2014) who gathered only 16 responses out of a total sample of 50 .

Data analyses and findings

The study has an attempt to draw overall descriptive views based on respondents views about the understanding of the application of FEP in construction projects. The collected data were analyzed using descriptive statistics (Mean, St. Dev). In addition, Kendall's concordance (W) test as a non-parametric statistic used to examine the level of concordance of all respondents views regarding the rankings of a set of survey variables independently measured without the need for statistical assumptions about the nature of data distribution (Legendre, 2005, Field, 2005). Kendall coefficients

range from 0 to 1, i.e. the higher W means the stronger concordance among rankings by the respondents. The significance of Kendall's concordance (W) was obtained and interpreted with respect to the following hypotheses:

H_1: *There is a strong concordance among respondents' perspectives on the rankings of definitions of project's scope elements related to the FEP stages as follows:*

> ***H_{1a}:*** *Feasibility studies*
>
> ***H_{1b}:*** *The conceptual planning*
>
> ***H_{1c}:*** *The detailed definition of scope*

H_2: *There is a strong concordance among respondents' perspectives on the rankings of FEP criteria adopted to judge the success of project performance*

H_3: *There is a strong concordance among respondents' perspectives on the rankings of the adopted barriers to the application of FEP*

Background of the respondents and their firms

Majority of respondents were engaged in the public body (about 53%) followed by those worked in private companies (25%); 17% of respondents were from public-private partnership organizations and the rest of respondents (5%) from other organizations. Regarding the respondents' roles, most respondents identified themselves as clients (about 45%). This is followed by project managers (19%), around 13% of them are consultants. These percentages were followed by quantity surveyors and contractors counted for approximately 11% and 8%, respectively. The remaining 4.2% of respondents were identified as other governmental authorities.

Adoption of FEP

The status of the current use of FEP in respondents' organizations is presented in Figure 2. Major proportions of respondents (30%) indicated that FEP is sometime adopted while about 23% of respondents revealed that FEP is always adopted in projects. Whilst about 20 % of respondents rarely or never practiced FEP in their projects. Subsequently, the respondents especially, those who have already had background about FEP, were asked to identify stages of FEP are mostly involved in. Figure 3 shows that around 30% of the respondents were involved in all FEP stages whilst 17% of the respondents were not involved at all in FEP. Comparing these findings from this study with that found in fewer relevant literature confirms the need for wider understanding and adoption of FEP by project stakeholders and other construction practitioners. For instance, a more recent study on the use of FEP

in the Brazilian mega projects indicated that only 46% of large companies knew and applied FEP (Motta et al., 2014). Another study on the Singapore construction projects showed a close percentage in which nearly 40% of the respondents recognized the use of FEP in their organizations (Hwang and Ho, 2011). A combination of the above findings, therefore, supports the need for more development works of FEP for wider understanding and thus more successful applications in construction projects.

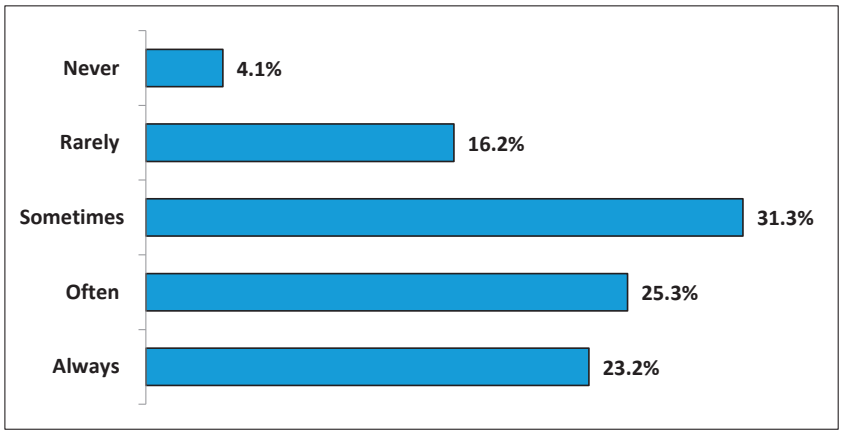

Figure 2. Respondents' percentages versus frequencies of current adoption of FEP

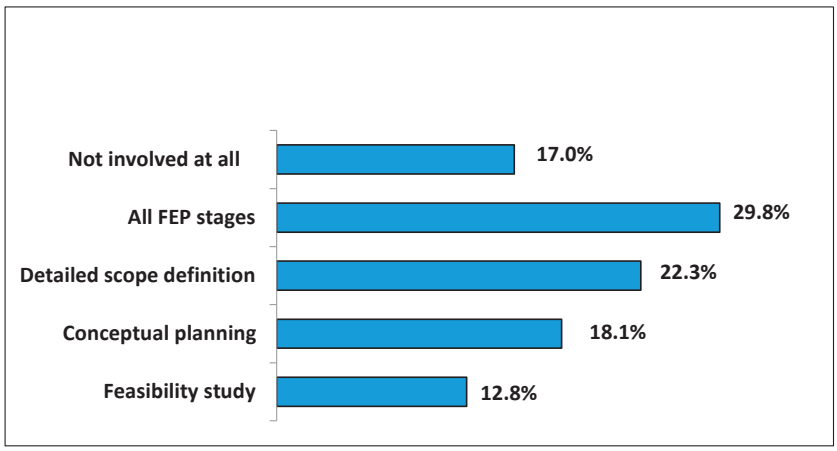

Figure 3. Percentages of Respondents involvement in different FEP stages

Time and cost growths versus the original plan

Figures 4-5 illustrate the results obtained for time and cost variations compared to the original plan. The highest portion of respondents (about 36%) indicated that projects exceeded the original cost estimates by approximately 6-11% whilst only 19% of respondents showed that they completed projects within the original cost estimate. About18% of respondents replied that projects exceeded the original costs by 12% or more up to 20% beyond the original plan. Regarding schedule delays, the results showed that 26% of respondents revealed that projects were delayed by 6-11% beyond the original plan while 22% of respondents replied that works were run behind the schedule by more than 20%. A small proportion of respondents (about 16%) only estimated that projects were undertaken on or ahead of project schedules.

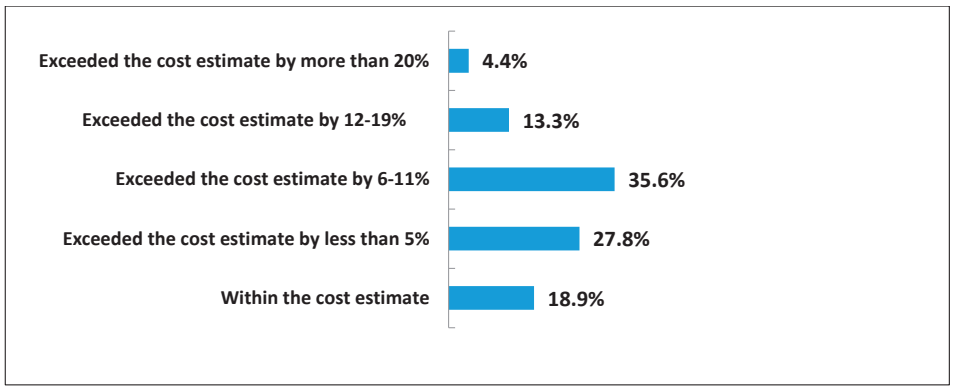

Figure 4. Percentages of respondents versus cost overruns

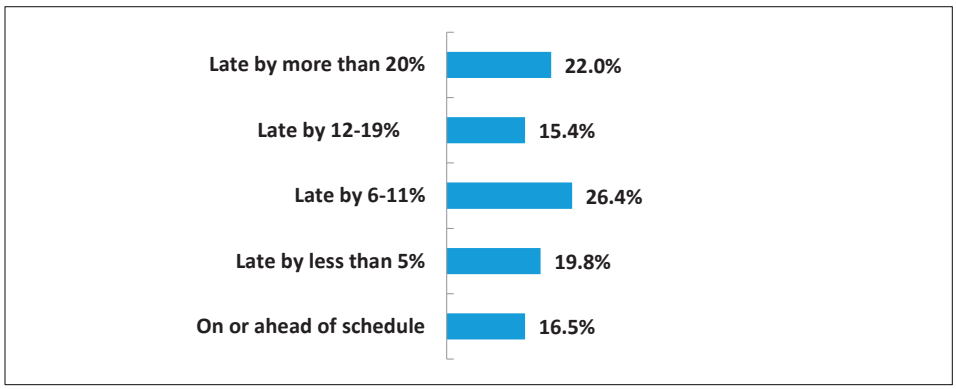

Figure 5. Percentages of respondents versus schedule delays

Measuring the degree of definition of FEP stages

This part of the survey questionnaire was designed to measure respondents' perspectives on the degree of definitions of FEP scope elements based on their experience gained from the most recently completed projects. They were asked to rate the degree of definition based on a 5-point Likert scale where: 1=undefined; 2=poorly defined; 3= reasonably defined; 4=well defined; and 5=completely defined. Descriptive and non-parametric statistical analyses of the collected responses on the overall rankings of the investigated criteria are presented next.

Feasibility study

As shown in Table 1, there are slight variations in the rankings of the factors or criteria identified to judge definition of the feasibility study. The results revealed that the factors identified as 'developing a basis for an impact assessment of FEP on project performance' was considered as poorly defined element (Mean=2.82; St. Dev= 1.036). Majority of the investigated factors used to examine the FEP development at the feasibility stage were almost all perceived as reasonably defined elements. It is obvious that respondents considered 'the evaluation of project financial resources' as the most reasonably defined factor (Mean= 3.72; St. Dev= 0.875). This was followed by the factors concerned with: 'the preliminary setting out of project scope with the help of lessons learned' and 'the evaluation of project materials and equipment requirements' received close mean scores of 3.48 and 3.45, respectively. These findings are consistent with views of the relevant literature; for instance, George et al. (2008) indicated that complete estimates of preliminary time and cost require a sufficient information about all project requirements up front at the feasibility stage. This was aligned with another subsequent study revealed that a lack of sufficient information about: preliminary scope estimates, preliminary execution plans and the identification of appropriate project alternatives, was experienced with the least consideration during preplanning or feasibility stages (George et al., 2012).

Table 1. Descriptive statistics of the FEP scope elements related to feasibility study

	Investigated factors	**N**	**Mean**	**St. Dev.**	**Level of definition***
FS1	Evaluation of project financial resources	65	3.72	.875	RD
FS2	Preliminary setting out of projects scope with the help of lessons learned	66	3.48	.812	RD
FS3	Evaluation of project materials and equipment requirements	66	3.45	.995	RD
FS4	Consideration of project stakeholders needs and concerns	66	3.41	.859	RD
FS5	Evaluation of staffing requirements	63	3.38	.974	RD
FS6	Determination of projects' success criteria	62	3.35	.907	RD
FS7	Identification of boundary conditions (environmental factors) of project	66	3.24	.946	RD
FS8	Opportunity analysis and selection of project alternatives	66	3.17	.887	RD
FS9	Developing a basis for an impact assessment of FEP on project performance	66	2.82	1.036	PD

**Note. PD= poorly defined; RD= reasonably defined*

At the 95% confidence level of interval, the results presented in Table 2 indicate that there is a weak level of concordance between all respondents on the rankings of a set of factors concerned with the definition of FEP at the feasibility stage which is statistically significant (W= 0.108, Chi-square= 51.7, *p-value* < *0.05*; reject H_{1a}). This indicates that the level of respondents' disagreement on the overall rankings of the examined factors are beyond that which could be rated by chance.

Table 2. Kendall's concordance on the feasibility study

Kendall's W			0.108
Chi-Square			51.700
d_f			8
Monte Carlo Sig.	Sig.		.000
	95 % Confidence Interval	Lower Bound	.000
		Upper Bound	.000

Conceptual planning of scope definition

Table 3 shows the mean values obtained for the factors adopted to test degrees of definition of the conceptual planning stage of FEP ranging from 3.42 to 2.77. The estimates of project time and cost is ranked as the most reasonably defined element (Mean=3.42, St. Dev= 0.956). This is supported by the literature view argued that poor estimates of time and cost early at the front-end stage are contributing to unsuccessful project performance (Williams and Samset, 2010). Evaluations of project scope in view

of realistic needs of respondents is considered as the second reasonably defined element (Mean= 3.27, St. Dev= 0.859). This result appears to be recently confirmed by Yu and Shen (2015) revealed that balanced engagement of project stakeholders interests and requirements early at the briefing stage of scope definition is significant for successful project performance. The factor concerns with the appropriate selection of the best project alternative at this stage is ranked as the third reasonably defined element (Mean=3.12, St. Dev= 0.781). According to Table 3, two scope elements were measured as poorly defined factors, which are: probabilistic risk analysis of project time (duration) and cost from the standpoint of project nature and technology (Mean=2.77, St. Dev= 0.880) and the development of a validation tool for testing efficiency of definition of project scope elements (Mean=2.98, St. Dev= 1.008). These results are in agreement with a wider practical perspective by Merrow (2011) who asserted that poor definitions of preliminary estimates of such elements (time and cost) at the front-end stage are major reasons behind common problems of delays and poor project execution.

Table 3. Descriptive statistics of the FEP scope elements related conceptual planning

	Investigated factors	**N**	**Mean**	**St. Dev.**	**Level of definition***
CP1	Estimates of project time duration and cost	64	3.42	.956	RD
CP2	Evaluation of project's scope to account for all needs and concerns of project stakeholders	64	3.27	.859	RD
CP3	Final selection of identified project alternatives	65	3.12	.781	RD
CP4	Formulation of all inputs in feasibility study into a measurable set of scope entities (i.e. project activities)	64	3.08	.965	RD
CP5	Developing a validation tool for testing the effectiveness of definition of the project's scope elements	64	2.98	1.008	PD
CP6	Probabilistic risk analysis of project time (duration) and cost from the standpoint of project's nature and technology	65	2.77	.880	PD

**Note. PD= poorly defined; RD= reasonably defined*

Table 4 indicates the level of concordance of all respondents on the rankings of the factors related to conceptual planning of scope. The results revealed that there is no strong level of concordance (W= 0.124, Chi-square= 38.98, *p-value* < 0.05; reject H_{1b}); the level of significance indicates that the level of respondents' disagreement on the overall rankings are randomly occurred rather than by chance.

Table 4. Kendall's concordance on the conceptual planning

Kendall's W			0.124
Chi-Square			38.979
d_f			5
Monte Carlo Sig.	Sig.		.000
	95 % Confidence Interval	Lower Bound	.000
		Upper Bound	.000

Detailed scope definition

Table 5 presents mean values for the degree of detailed definitions of scope. The results showed that respondents ranked the definition of project objectives as a well-defined factor (Mean=3.94, St. Dev= 0.765) during the development of this FEP stage. This is followed by the project breakdown structure (WBS) ranked as the second reasonably defined factor (Mean=3.66, St. Dev= 0.895). Subsequently, the factors identified as 'final review of project scope elements' and 'project organization structure' were almost rated with close mean rankings at 3.52 and 3.47, respectively. The results revealed that almost all factors at this stage are reasonably defined except the definition of 'project risk management plan' was ranked as a poorly defined factor (Mean= 2.82, St. Dev= 1.048). A complete definition of project scope at this stage is crucial for the effectiveness of decision-making regarding project design and execution. The significance of the final scope definition is also expressed in the literature; for instance, Mirza et al. (2013) implied that complete definitions of project scope are associated with more predictable outcomes from project execution. In addition, Fageha and Aibinu (2013) revealed that properly defined project scope is a key tool in determining project success, which however needs a strong participation of project stakeholders.

Table 5. Descriptive statistics of the FEP scope elements related detailed scope definition

	Investigated factors	N	Mean	St. Dev.	Level of definition*
SD1	The project objectives	62	3.94	.765	RD
SD2	Project work breakdown structure (WBS)	64	3.66	.895	RD
SD3	Final review of project scope elements	63	3.52	.840	RD
SD4	Project organization structure (POS)	64	3.47	.942	RD
SD5	Cost estimates for each work package	64	3.39	.789	RD
SD6	Time duration estimates for each work package	64	3.31	.924	RD
SD7	Project execution strategy (PES)	64	3.25	.926	RD
SD8	Communication and control plans	64	3.17	.952	RD
SD9	Project risk management plan	62	2.82	1.048	PD

Note. PD= poorly defined; RD= reasonably defined

Table 6 indicates reading outputs from the Kendall concordance test which shows that the level of concordance between respondents on the rankings of the factors identified is fairly weak (W= 0.216, Chi-square= 102.160, p-value < 0.05; reject H_{1c}). This level of disagreement between the respondents, however, is likely occurred randomly rather than by chance.

Table 6. Kendall's concordance on detailed scope definition

Kendall's W			.216
Chi-Square			102.160
d_f			8
Monte Carlo Sig.	Sig.		.000
	95% Confidence Interval	Lower Bound	.000
		Upper Bound	.000

The relationship between FEP and successful project performance

This part of the questionnaire aimed at examining type of the relationship between well-defined FEP and successful project performance. This was based on the following scale: 1=strongly disagree; 2= somewhat disagree; 3= neutral; 4= agree; and 5= strongly agree. However, the response mean intervals are dispersed among different points of the above scale; therefore, the level of agreement are categorized as follows:

1.0 ≤ Mean < 3.0 (Disagree); 3.0 ≤ Mean < 3.4 (Neutral); 3.5 ≤ Mean < 4.4 (Agree); 4.5 ≤ Mean ≤ 5.0 (Strongly agree)

Table 7 indicates that the highest mean score of the respondents' agreement was obtained for the factor identified as 'more efficient control of the project execution than is normally experienced' (Mean= 3.90, St. Dev= 0.877). This was followed by the factor 'increased sense of project team accountability than is normally experienced' (Mean=3.77, St. Dev= 0.920). Overall results implied that the respondents agreed that the factors (or criteria) indicated in Table 7 can positively affect project performance. From a common perspective of previous studies, it has been indicated that well-defined FEP as a preplanning stage has significantly contributed to successful project performance (Gibson et al., 2010, George et al., 2008, Jergeas, 2008) in terms of reductions of time and cost growths. It can be concluded, therefore, that time-cost effectiveness of a given project is substantially relying on the effectiveness of definition of project scope in front-end planning

Table 7. Relationship among effective FEP processes and the project success criteria

	Identified criteria (i.e. presumed propositions)	**N**	**Mean**	**St. Dev.**	**Level of agreement***
R1	More efficient control of the project execution than is normally experienced	60	3.90	.877	A
R2	Increased sense of project team accountability than is normally experienced	61	3.77	.920	A
R3	Improved accuracy and effectiveness of design phase than is normally experienced	60	3.75	.932	A
R4	Proper understanding of the implementation of project plan by project stakeholders than is normally experienced	62	3.61	1.046	A
R5	Strong alignment/or matching among project's outcomes and project stakeholders' expectations than is normally experienced	61	3.59	.844	A
R6	Far fewer scope changes in the implementation stage than is normally experienced	61	3.44	.975	N
R7	Better risk management in the implementation stage than is normally experienced	60	3.43	.963	N
R8	Significant reduction of growth in time and cost than is normally experienced	61	3.39	1.084	N

**Note. A = agree; N= neutral*

Table 8 indicates that there is almost no concordance among all respondents on the rankings of the criteria used to judge the relationship among FEP and project success (W= 0.05, Chi-square= 20.337, p-value < 0.05; *reject* H_2). Once again, the level of significance reveals that this non-concordance is independently obtained than it is occurred by chance.

Table 8. Kendall's concordance on FEP criteria of project' success

Kendall's W			.050
Chi-Square			20.337
df			7
Monte Carlo Sig.	Sig.		.004
	95% Confidence Interval	Lower Bound	.003
		Upper Bound	.005

Barriers to the effective application of FEP

The respondents' agreement on the degree of the impact of the investigated barriers to the application of FEP was based on the following scale: none=1; insignificant = 2; minor = 3; significant = 4; and major = 5. For the best interpretation of results, this scale was categorized as follows:

$1.6 \leq \text{Mean} < 2.5$ (insignificant); $2.6 \leq \text{Mean} < 3.5$ (minor); $3.6 \leq \text{Mean} < 4.5$ (significant); $4.6 \leq \text{Mean} \leq 5.0$ (major).

Table 9 shows that almost all examined barriers are ranked as significant factors ranged from 4.02 for the factor 'lack of team knowledge on project planning fundamentals' to 3.46 for the factor 'insufficient resources allocated to FEP'. The factor concerned with a lack of strong contributions from project stakeholders was considered as the third significant barrier to the application of FEP at mean score of 3.84. This appears an important issue when developing FEP which is also highlighted in the literature. For instance, Griffith and Gibson (2001) argued that good alignment or integration of project stakeholders' needs with and in the project scope definition is a key issue that to be considered at the preplanning stage. A more recent study by Yu and Shen (2015) reveal that effective communications between project stakeholders regarding all project requirements and potential risks are significant to the success of project scope at the briefing stage. For achieving this, Yu and Shen recommend that project managers should arrange for structured workshops among project stakeholders while defining and developing criteria of project scope early in preplanning. With a specific focus on the significant factors to FEP, fewer literature indicated a number of significant issues to FEP which seems to be aligned with the findings from this study indicated in Table 9. For examples, George et al. (2008) found that inadequate scope definition, unclear definition of roles and responsibilities of project stakeholders and inadequate identification of risk were practiced as common problems associated with the development of preplanning stages, i.e. FEP. Sungmin et al. (2012) claimed that FEP should be developed based on project's nature in regard to size, characteristics and technology.

Table 9. Degree of the impact of barriers to the effective implementation of FEP

	Identified barriers	N	Mean	Std. Dev.	Degree of impact
B1	Lack of team knowledge on project planning fundamentals	54	4.02	1.037	S
B2	Insufficient resources allocated to FEP	56	3.96	.830	S
B3	Insufficient contributions of project stakeholders during FEP	56	3.84	.949	S
B4	Inadequate timeframe provided for FEP	56	3.82	.811	S
B5	Ineffectiveness of the clients decision when finally approving the detailed scope definition	56	3.82	1.029	S
B6	Lack of standardized guidelines for the startup and control of FEP	55	3.78	.875	S
B7	Insufficient adoption of lessons learned from past projects when developing FEP for the new project	56	3.77	.874	S
B8	Lack of realistic information about the project strategy	56	3.70	.952	S
B9	Improper alignment among the FEP development stages	55	3.51	.791	MS
B10	Costly efforts incurred in FEP on the part of clients	54	3.50	.841	MS
B11	Overly complex or large projects	56	3.46	1.061	MS

**Note. S = significant; MS= minor significant*

Regarding the level of concordance among the respondents on the rankings of identified barriers to FEP, Table 10 shows that there is almost no concordance among the respondents on the significance of individual barriers to FEP, which is statically significant (W= 0.054, Chi-square= 28.182, *p-value* < *0.05*; reject H_3); this implies that these disagreements are beyond that can have occurred by chance.

Table 10. Kendall's concordance on barriers to FEP

Kendall's W			.054
Chi-Square			28.182
Df			10
Monte Carlo Sig.	Sig.		.002
	95% Confidence Interval	Lower Bound	.001
		Upper Bound	.002

Summary of the findings

Based on perspectives of project stakeholders involved in this study, the results indicate that only 19% of recently completed projects were carried out within budgeted costs and around 18% within or ahead of their planned schedules. Such common problems of time and cost overruns might be contributed to a lack of consideration of the definition of these issues early at the front-end stage of a project. The study implies that there might be practically a strong cause-effect relationship between properly defined FEP stages (feasibility, conceptual and detailed scope) and successful project performance within time and cost estimates and quality standards. In addition, the study revealed that all potential barriers to the application of FEP should be considered; however, this can also imply that such factors should be prioritized based on their significance to, and impact on, the effectiveness of FEP. Such prioritization management should be also able to improve project stakeholders' decision-making regarding the most important activities that should be given higher levels of definition early at the front-end stage of a project.

An analysis of the survey interview

The questionnaire involved a number of open-ended questions designed to gather insights from the interested respondents (referred as project stakeholders in this study), especially those who might have good background about FEP. The analysis of collected answers were interpreted and presented as follows.

Prioritizing FEP stages

According to the respondents' view, the feasibility study provides the client with: (1) the opportunity to determine if the project should proceed to scope definition, (2) the opportunity to determine if project stakeholders' information and needs are realistic, (3) a preliminary definition of risk management plan, and (4) the alignment of project stakeholders' needs with the overall project strategy. Based on the respondents' view all these issues make the feasibility study more complex stage; therefore, a strong and timely focus by project managers and other involved stakeholders should be allocated to this stage. These suggestions are in agreement with a study by Shen et al. (2010) recommended that there is a need for thorough participations from project stakeholders, including clients, architects, engineering consultants, suppliers and contractors for a more sustainable feasibility study in construction. This was also claimed by George et al. (2012) argued that the effective definition of the feasibility study depending on the strong presence of project stakeholders. In addition, the respondents implied that FEP at the feasibility stage should be guided as an early warning sign before proceeding to the next stage based on the reliability of available information in the feasibility study. Otherwise, this might result in poor decision-making or recycling back from project scope definition

to the feasibility stage with additional or new investments. Mapping the study findings with the literature views confirm that there might be a need to prioritize early stages of front-end planning. Because this will allow providing all realistic and complete information required in formulating the FEP preliminary estimates prior to a more detailed definition of project scope.

Towards possible omissions of FEP

There are different views captured from the respondents regarding potential omissions of FEP stages. On one hand, some respondents revealed that FEP stages function as one model connected to each other with interrelated links. Therefore, a clear definition of inputs of each individual stage should be developed completely by all project stakeholders involved. According to the respondents, this is important because scope definitions of each preceding stage represent feeding inputs to the following stage of FEP. However, the respondents to this question suggested a number exemptions where some FEP stages can be either omitted (or skipped) or combined together as one stage for the reason of minimizing total investments in project planning. Based on the respondents view, these exemptions can be summarized as follows: (1) no need for FEP when a new development of project scope is exactly adopted from a similar project; (2) conceptual planning can be merged in project scope definition when the feasibility is sufficiently defined; (3) the feasibility can be omitted in projects with well-known boundary conditions, as well as the understanding of such conditions by project stakeholders; (4) FEP can be skipped in case of small-sized projects where project managers are competent in applying their own experiences to define project scope; (5) the feasibility study might not be needed in certain projects designed according to specific needs and requirements by individual stakeholders. In summary, the results reveal that it is possible to either omit or combine some of FEP stages although FEP serves as one single model with three or more linked stages. Nobelius and Trygg (2002) argued that there is no standardized FEP that can be used for all types of projects. Nobelius and Trygg further argued that project managers should be able to develop a suitable FEP that can be used as a fit-in model for projects with similar scope entities. Such a fit-in model, however, should consider the above mentioned conditions where some FEP stages might not be required for certain types of construction projects. This will also minimize unnecessary investments allocated to the entire front-end planning stage.

How to enhance the application of FEP

Respondents were also asked to address their opinions on how to enhance the application of FEP as standalone process in construction organizations. Some suggestions were made concerning strategies to be followed for a more effective use of FEP. These included: (1) balanced engagement theory of project stakeholders in front-end planning; (2) proper alignment of the FEP development with

opportunity realization process; (3) continuous training of project management teams in project planning with particular focus on FEP; (4) standardized applications of FEP as part of construction contract requirements; (5) SWOT analysis of all FEP stages as part of quality control management; (6) the use of project management (PM) guidelines; and (7) consideration of socio-economic factors and health, safety and environment (HSE) in FEP. In summary, these suggestions regarding the above support strategies should be integrated into project management roles and behavior of project stakeholders through organizational learning and training in the context of front-end planning concepts. In connection to these suggestions, the relevant literature also provided insights into considerations of other factors. For instance, George et al. (2008) revealed that identifications of project stakeholders community, public relations and compilations of project strategy with technical, commercial and the client requirements are important issues for the success of FEP. Williams and Samset (2010) argued that socio-political and organizational corporate decision-making should be considered when developing front-end planning.

Contributions to theory and practice

The study has made contributions to both theory and practice in different ways. In regard to theory, there is a need for more assessments of the factors impacting project performance from perspectives of project stakeholders involved in preplanning efforts, i.e. front-end planning. This study provides insights towards the need for evaluating and determining project success through project stakeholders' perspectives early at the front-end stage of a project. In connection to this, another insight is that there is a need to consider and examine balanced engagement theory of project stakeholders in the development of front-end planning for a more efficient application in construction projects. This will help to give a greater emphasis on the determination of project success and failure factors or criteria early at FEP based on multiple perspectives from project stakeholders involved. On the basis of this insight, the assessment of such factors particularly disturbing the efficiency of front-end planning appears to be underexplored research phenomena that needs further investigation.

In regard to practice, the findings from the study provide a number of managerial and practical implications to project managers and other stakeholders. First, project managers and stakeholders would be expected to modify their current roles in project planning, and thus allow for more effective front-end planning efforts as a response to current problems of time and cost overruns. Second, the findings provide insights towards project activities that are not completely defined early at the front-end stage of a project. This will help project stakeholders, especially those who are recently involved in the initiation phase of their projects, to revise their decisions regarding project activities that need much attention or a complete definition prior to detailed design. Third, project clients should be competent in adjusting current decision-making regarding the assessment and approval of detailed

definitions of project scope for project execution. In summary, considerations of the above strategies or insights require acquisition of new knowledge of preplanning processes through a change management plan that should be utilized to improve the effectiveness of front-end planning in construction projects. In this regard, project managers should allow for a more efficient engagement of involved project stakeholders in decision-making processes regarding the definition and approval of project scope early at all front-end planning stages. While developing FEP project managers should pay equal emphases on all FEP stages taking into consideration that the full completeness of definition of each successor stage is crucial for feeding the following stage. In view of the above insights from the study, it is worth mentioning that FEP should be regulated as demanding subset of project planning as part of the construction contract technical requirements.

Conclusion

The literature review indicated that improving understanding and integration of project stakeholders is a key tool for successful development and application of FEP. Therefore, this study was attempted to examine the extent to which project stakeholders and other practitioners understand FEP in practices. This was examined based on a set of identified criteria (factors) concerning different aspects of FEP taking into account areas that need a more explicit assessment. Despite the immediate study is subject to the analysis of project stakeholders' perspectives using the Oman construction projects, the overall findings and contributions appear to be generalizable to other construction projects with similar contexts, especially where there is still a lack or shortage of construction research in preplanning, i.e. front-end planning. In view of the findings from this study, it is recommended that project managers and other project stakeholders should invest more in front-end planning efforts for increasing opportunities of alleviating common problems of time and cost overruns and thus project success.

To conclude, the above findings are indicative rather than conclusive; therefore, further research should be implemented to gain deeper insights through longitudes of cluster construction projects. This is to improve the study generalizability as a basis for further development works of FEP within the general context of construction project management. This can be done through the use of deeper approaches to explore the rationality of project managers and other stakeholders while planning projects early at front-end stages.

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