The Hong Kong Polytechnic University

Department of Building and Real Estate

Measuring the Performance of Value Management Studies in Construction

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

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ABSTRACT

Value management (VM) is widely regarded as a useful method in addressing challenges such as budget constraints and project complexity in the construction industry. It has been reported to be useful in reducing costs while maintaining or even improving the performance of a project at the same time. However, many potential users in the construction industry are reluctant to use VM because of a lack of tools to assess the effectiveness of VM studies. It appears that performance measurement of VM studies is rarely conducted due to the lack of rigorous models. Therefore, organizations have no clear way of knowing whether adequate returns have been achieved on their investment in VM studies. Without a reasonable assessment of the effectiveness of VM studies in achieving clients' target, it is also difficult to know what changes can be made to obtain more benefits.

The overall aim of this research is to develop a framework which can measure the performance of VM studies effectively, rigorously, and continuously throughout the VM process. The objectives of this research are (1) to investigate the strengths and weaknesses of the existing performance measurement models used in measuring the performance of VM studies in construction; (2) to develop, validate, and refine a performance measurement framework that is capable of measuring the processes and outcomes of VM studies in construction on a timely basis; and (3) to implement the framework in a computer-aided toolkit that will be integrated with collaboration tools for VM studies, so that the measurement and improvement can be carried out easily and timely. Research methods including a critical review, interviews, questionnaire

surveys, theoretical analysis, case studies and focus group meeting are used in this research to achieve the objectives.

A comprehensive literature review has been conducted on both VM and performance measurement. The benefits and critiques of VM in construction are summarized. The strengths and weaknesses of the existing measurement frameworks are critically reviewed in the context of VM studies in construction, thereby accomplishing the first research objective. Thirteen factors which have a major impact on the performance of VM studies in construction are identified from the literature review. Based on these factors, a theoretical structure and a theoretical framework for the measurement framework are established.

The development of a performance measurement framework based on the literature review and the theoretical framework is introduced in detail. A preliminary framework is developed to explain how the desired features could be achieved in measurement. The identification of the key performance indicators (KPIs) by a questionnaire survey is then presented. A detailed framework which consists of the measurement processes, data providers, weightings of KPIs and definitions of the scoring is then developed. In order to validate and refine the developed framework, case studies, focus group meetings and interviews have been conducted. A refined framework is then presented and the performance indexes are built.

A computer-aided toolkit has been developed to take advantage of the information technology (IT) in the measurement processes. The benefits of IT supported performance measurement in VM studies in construction are discussed. A detailed

introduction to a web-based collaboration system entitled “Interactive Value Management System” (IVMS), which was developed by the colleagues of the researcher, is presented and the integration of the performance measurement framework into this system is then explained. A trial implementation of the system to measure the performance of VM studies is conducted to validate the effectiveness and efficiency of this computer-aided toolkit.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION

1.1 Introduction

This chapter gives an overview of the thesis. It first introduces the background of the research. The research objectives, key issues and problems are then addressed. Next, the research framework and research process are presented. Finally, the organization of the thesis is introduced.

1.2 Background of the Research

Value management is a structured and analytical process that seeks to achieve value for money by providing all of the necessary functions at the lowest cost consistent with required levels of quality and performance (AS/NZS 4183,1994). A VM study is normally organized in the form of a workshop that brings together a multidisciplinary team of stakeholders to review the project, making sure the team understands customer requirements and develops a cost-effective solution under the direction of a professional facilitator who follows an established set of procedures. If properly implemented, it enables organizations to adopt a consistent approach towards decision-making, taking into account the needs of the business, the environment within which it is operating, and the people involved (BS EN12973, 2000). As an effective tool for meeting the increasing demands for value enhancement by clients (Dell'Isola, 1982; Kirk et al., 1988; Barton, 2000), VM has been widely used in many countries for at least five decades. The US government requires all executive branches and federal agencies to establish and maintain cost-effective VM procedures and processes in all programmes and projects (SAVE International, 2001).

There has been a surge of interest in VM in the construction industry in Hong Kong, especially after the Asian financial crisis in 1997 (Shen and Kwok, 1999). A number of government departments and private enterprises in Hong Kong have applied VM to ensure value for money for their projects. The technical circular issued by the Works Bureau (1998) demands that VM studies be carried out for major projects in the public works programme. This circular was reviewed by the Environment, Transport and Works Bureau, and the revised circular (ETWB, 2002) calls for wider use of the VM methodology. The Construction Industry Review Committee (2001) also recommends that "VM should be used more widely in local construction, because it can help clients and project teams focus on the objectives and needs of the project and of all stakeholders, both long-term and short-term".

In recent years, the "Rethinking Construction" (Egan, 1998) and "Accelerating Change" (Construction Task Force, 2002) reports have set demanding improvement targets for the construction industry. These include a 10% reduction in capital cost and construction time, a 20% reduction in defects and accidents, a 10% increase in productivity and turnover and profits, and a 20% increase in predictability. To achieve these targets, a key recommendation of the Task Force was to accelerate supply-side integration and the integration of teams. In response to these challenges, the construction industry is undergoing a series of changes. Teamwork and information sharing, for example, are preferred to the old adversarial culture. The VM methodology is ideally placed to bring multidisciplinary teams and stakeholders together and to work towards the same direction of value creation for customers.

The help that VM provides organizations to compete more effectively in local, national and international markets is often cited. VM does this by decreasing costs,

increasing profits, improving quality, expanding market share, saving time, solving problems, and using resources more effectively (SAVE International, 2008). In construction, frequently referred benefits of using VM also include: reducing construction costs, decreasing operational and maintenance costs, simplifying procedures, improving project schedules, reducing waste, increasing procurement efficiency, using resources more effectively, and developing innovative solutions. The realization of these benefits depends very much on the performance of the VM studies. The performance measurement of VM studies is, however, rarely conducted in practice due to the lack of appropriate and rigorous measurement models for this purpose. There are at least two major problems in this area: (1) due to the lack of effective methods to measure performance, companies at present have no way of knowing whether adequate returns have been made on the investment in these studies; (2) it is difficult to know what changes can be made to improve performance and to obtain maximum benefits from these studies. As a result, some companies have had second thoughts as to whether to continue to use VM, and many other companies are still reluctant to adopt it in the future. The need to convince end users, especially client organizations, of the claimed benefits, and the ability to measure and monitor the performance of VM studies to ensure that these benefits are fully achieved, are two serious problems hindering the wider use of VM in construction (Shen and Chung, 2002).

Measuring performance is crucial to improving performance. This is widely accepted and practiced in the manufacturing and service sectors. In the last decade or so, several performance measurement models have been developed, e.g. the SMART model by Cross and Lynch (1988), the performance measurement questionnaires by Dixon et al. (1990), the balanced scorecards by Kaplan and Norton (1996), and the

European Business Excellence Model (EFQM, 2003). Major barriers to using these tools have also been identified (Bititci and Carrie, 1998; Bourne and Neely, 2000). For example, many existing performance measurement tools use historical data. As a result of this, they actually measure past performance, leaving a lack of immediacy between measurement and improvements. These tools often require cumbersome and time-consuming procedures of data collection, sorting, maintenance, and reporting. Many companies do not see the justification for the resources required. This seriously undermines the perception of the value and usefulness of these tools. There is also a lack of appropriate models to effectively take into consideration non-financial and less tangible factors. The combination of these problems often results in a vicious circle of negative perceptions, which leads to insufficient resources being made available, which in turn leads to poor measurements, and, eventually, a loss of support and commitment from senior management.

The construction industry and the government have awakened to respond to the need to measure and improve performance. For example, the recent studies on benchmarking and KPIs by Construction Best Practice Program (CBPP, 2004) are construction-specific performance measurement initiatives. The KPIs are commonly used in construction and form the basis of a more comprehensive set of performance measures. Although this development is a step forward, the barriers identified above still apply. The measurement of these KPIs relies on data (some of them are very subjective) usually collected at the end of a project. This may compromise the accuracy of the measurement results. Furthermore, these KPIs are still at a very high level. They do not establish the link between performance and processes. Even when a project performs well, it is difficult to identify why it did so and how this can be repeated in future projects. The Development Bureau of the Hong Kong Special

Administration Region (HKSAR) is also preparing to conduct a review of the VM studies which has been conducted by the works departments in the past years. The result of the review of these VM studies will be used to revise the *Technical Circular (Works) No. 35/2002* published in 2002.

Although there is a growing interest in the use of VM among organizations in the construction industry, the lack of effective methods for measuring the processes and outcomes of VM studies restricts the wider use and further development of this methodology. The recent development of collaboration tools for VM studies, on the other hand, has created good opportunities for the measurement of performance in these studies to be conducted immediately and continuously. This potential is, however, not fully exploited at present. If these data can be used in measuring performance, not only will time be saved and measurement be made possible, but opportunities will also be provided to implement measures for improvement. It is these issues that led to the development of this research.

1.3 Research Objectives

The overall aim of this research is to develop a framework which can measure the performance of VM studies effectively, rigorously, and continuously throughout the VM process. The specific research objectives for this research are as follows:

1. To investigate the strengths and weaknesses of the existing performance measurement models used in measuring the performance of VM studies in construction.

2. To develop, validate, and refine a performance measurement framework that is capable of measuring the processes and outcomes of VM studies in construction on a timely basis.
3. To implement the framework in a computer-aided toolkit that will be integrated with collaboration tools for VM studies, so that the measurement and improvement can be carried out easily and immediately.

1.4 Key Issues and Problems

As a value-enhancing tool, VM has an important role to play in ensuring value for money for the stakeholders of a project. The lack of appropriate performance measurement models for VM studies, however, hinders the wider use of this methodology in construction. The primary research question for this project is how the performance of VM studies can be measured effectively, rigorously, and continuously throughout the VM process so that improvement to the VM study can be made immediately. Several key issues will be addressed in detail. They are:

1. How do clients measure and monitor the performance of VM studies for their project?
2. What are the strengths and weaknesses of the existing performance measurement framework?
3. How can such a framework be used to measure the performance of VM studies on a continuous basis?
4. How can we successfully integrate the proposed framework with the existing collaboration tools for VM studies?
5. What benefits would the end users get from using the proposed framework and the toolkit?

1.5 The Research Framework

This research develops a framework for measuring the performance of VM studies in construction by combining information from a number of sources. Having clarified the nature of the research project, a research methodology is established to reach the research objectives. Figure 1.1 illustrates the research framework by means of a flow chart.

A comprehensive literature review is undertaken to obtain an overall understanding of both VM and performance measurement. Based on the review and interviews with VM practitioners, thirteen major factors which influence the performance of VM studies are extracted and the theoretical structure and theoretical framework are built upon these factors. A questionnaire survey is undertaken to identify the KPIs of performance measurement of VM studies. Case studies and comparison studies are used to validate various aspects of the framework. Focus group meetings and follow-up interviews are conducted to seek the opinions of VM clients as well as VM facilitators to make sure that the framework measures the performance of VM studies

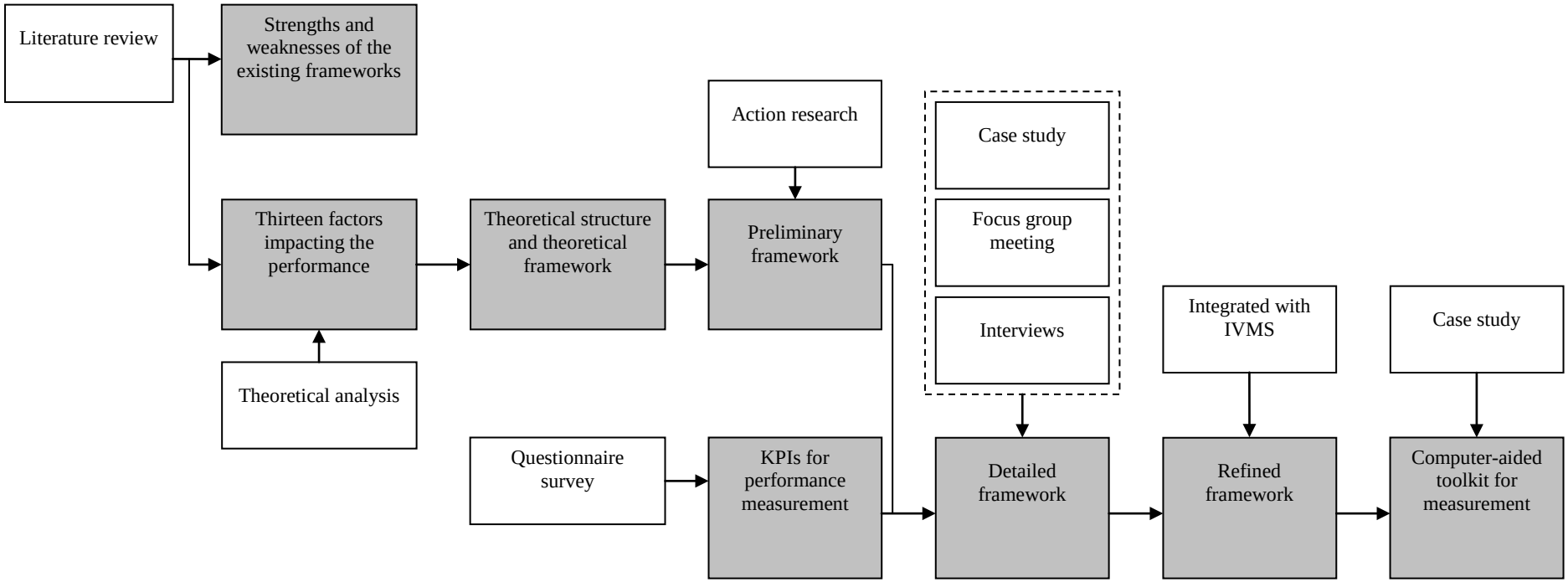

Figure 1.1 The research framework

properly. This refined framework is integrated with the existing computer system and comparison experimental studies are undertaken to validate the effectiveness and efficiency of this computer-aided toolkit.

Chapter 4 will discuss the specific methods used relating each to the interactive holistic research framework. The methods will be considered independently, bearing in mind their concurrent interdependence.

1.6 The Research Process

Step 1. Investigation and evaluation of existing performance measurement models in the context of VM

The literature review investigates and evaluates existing performance measurement models in general and models for VM studies in particular, and ascertains the strengths and weaknesses of the models in the context of VM studies in project-based construction practices. Interviews with industrial partners who have used VM in a large number of projects, such as the Architectural Services Department (ASD), Water Supply Department (WSD) and Highways Department (HyD), were conducted to establish how performance is measured and what is measured (key performance objectives) in order to identify the key inhibitors and enablers in measuring the performance of VM studies. The interviews also revealed problems and gaps in the current KPI measurement methods.

Step 2. Development of a theoretical framework

The factors which have a major impact on the performance of VM studies in construction are identified at the end of the literature review. The theories in social research which are related to this research were also investigated. Based on factors and existing research theories, a theoretical framework underpinning performance measurement was developed to form a theoretical foundation for further research.

Step 3. Development of a performance measurement framework for VM studies

A process and outcome-based performance measurement framework was developed with the capability of measuring the performance of VM studies in construction on a continuous basis. The process includes issues such as the collection of background information and interaction among the participants, whereas the outcome includes issues such as the quality of reports, the acceleration of the decision making, and the satisfaction of the clients. The framework was built on the experience of existing performance measurement models reviewed in Chapter 3. A questionnaire survey was conducted to identify the KPIs of the framework. The follow-up interviews conducted helped identify the KPIs and refine the framework.

Step 4. Validation of the framework

In order to validate and refine the developed framework, it was applied in several VM workshops. This application was conducted in the form of participatory action research, to fully utilize this highly rigorous yet reflective approach (Berg, 2001). The framework was used to measure the real performance of these studies. Feedback and comments were collected to further develop and refine the proposed framework. The usefulness, appropriateness, and validity of the framework in assessing VM studies

were discussed through focus group meetings and interviews to form a final framework.

Step 5. Implementation of the proposed framework in a computer-aided toolkit

A computer-aided toolkit that implements the measurement framework was developed and integrated with the Interactive Value Management System (IVMS). This group decision support system (GDSS) for VM studies was first developed by Shen and Chung (2002) and further developed by Fan et al (2006, 2007). The toolkit was developed to a prototype stage to demonstration its feasibility. The functional requirements for input data and the contents of the user guidance are explained. Figure 1.2 shows the architecture of the toolkit.

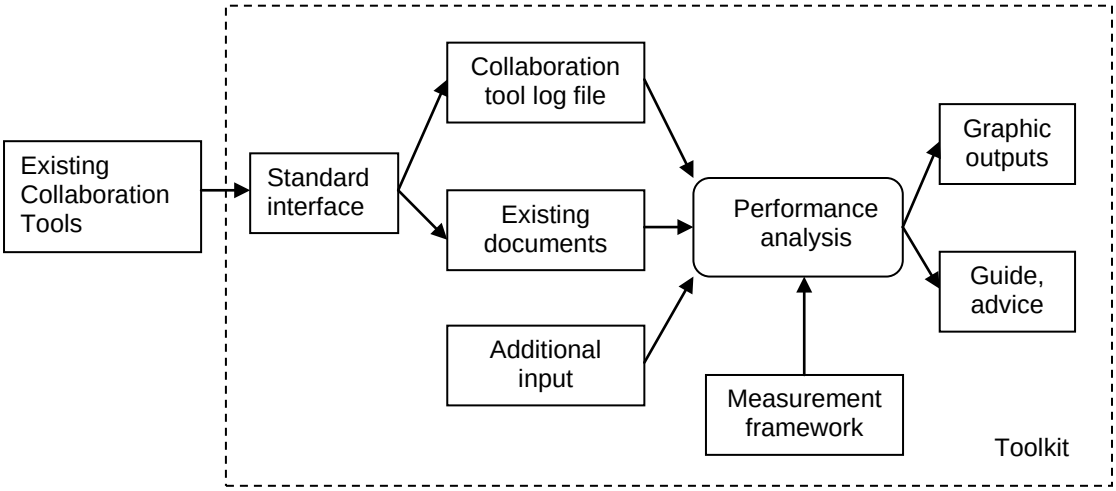

Figure 1.2 Architecture of the proposed toolkit

Step 6. Testing and refining the developed toolkit through case studies

The developed toolkit was tested through experimental studies. Research students were invited to participate in a benchmarking test to compare two types of VM studies: (1) studies that did not use the computer-aided toolkit; and (2) studies that used the toolkit. This test established the benefits of using the toolkit. Guidelines and advice were also provided on the best use of the toolkit.

1.7 Organisation of the Thesis

Chapter 1 introduces the background of the research, including the research background, objectives, research methodologies and research processes.

Chapter 2 reviews the relevant literature about the background and history of VM, terminology and definitions, existing VM frameworks and benefits and critiques of VM in construction.

Chapter 3 reviews the relevant literature about the background and history of performance measurement, terminology and definition, performance measurement in construction and in VM. This chapter also investigates the benefits and critiques of existing measurement frameworks in the context of VM.

Chapter 4 explains the research methods which have been used in this research including interviews, questionnaire survey, focus group meeting, action research and case studies.

Chapter 5 reviews the existing measurement theories in social management. Thirteen factors which have a major impact on the performance of VM studies are identified in this chapter. Based on this, the theoretical structure and theoretical framework for the measurement framework are introduced in the chapter.

Chapter 6 introduces the desired features of the measurement framework. The development of the preliminary framework, the identification of KPIs and the development of a detailed framework are also presented in this chapter.

Chapter 7 refines and validates the developed framework with a case study, an action research, a focus group meeting and interviews. The refined framework is also presented.

Chapter 8 integrates the measurement framework into the IVMS and tests the system by trial implementation in VM studies.

Chapter 9 summarizes the contributions, conclusions and findings of this research. It also addresses the limitations of the research and proposes directions for future research.

CHAPTER 2 VALUE MANAGEMENT IN CONSTRUCTION

2.1 Introduction

VM is the critical object of this research. It is therefore important to have a clear understanding of VM before investigating its performance measurement. This chapter presents a review of the literature relating to VM. It begins with the background and history of VM. Key terminology and definitions, approaches to VM in construction, as well as existing frameworks for VM are provided. Benefits and critiques of applying VM in construction are addressed.

2.2 Terminology and Definition

2.2.1 Value

It is widely believed that what has made VM different from traditional cost control is that, rather than focusing on simple cost, it concentrates on achieving value for clients/users (Kelly and Male, 1988; Green and Popper, 1990; Shillito and Marle, 1992). Value is one of the most fundamental concepts in value techniques. However, value is a term with different interpretations in different situations. In order to obtain a clear understanding of the term, the following paragraphs will examine what value is in the context of VM.

Value has both objective and subjective qualities. It is presented in terms of use, qualities which accomplish a use, work or service; esteem, features which make

ownership of an object desirable; cost, the sum of the labour, material, overhead and other costs required to produce it; and exchange, properties enabling its exchange (Mudge, 1976; SAVE International, 2001). It is also suggested that the definition of value is dependent on whether one is looking from the producer's perspective or from the user's (Miles, 1972).

Miles (1989) stated that a 'product or service is generally considered to have good value if that product or service has appropriate performance and cost'. By this definition, he pointed out two ways to increase value:

1. Decreasing costs and maintaining performance;
2. Increasing performance if the customer needs, wants, and is willing to pay for more performance.

He sequentially argues that what the customer wants in products or services are functions. In this respect, Miles essentially considers value as the relationship between function and cost.

Kelly et al. (2004) defined value as the equivalence of an item expressed in objective or subjective units of currency, effort, or exchange. Equally, value can be measured on a comparative scale that reflects the desire to obtain or retain an item/object. In this respect there are two components to value. One is an objective component and stems from looking at value from an economic perspective. The other subjective component for value derives from individuals and groups making choices about costs and price, and the benefits and satisfaction derived or expected from consumption.

Mathematically, value is written as the ratio of function to cost (Shillito and Marle, 1992).

$$value = \frac{function}{\text{cost}}$$

Based on the above equation, the value of a product or service could be theoretically increased either by:

- Increasing the function with the same cost;
- Decreasing the cost with the same function;
- Increasing the function with reduction of cost;
- Increasing the function significantly with slight addition of cost;
- Decreasing the cost significantly with slight reduction of function.

The equation only illustrates the relationship of value with cost and function, but cannot be really used to measure value due to the different units of function and cost. Cost can often be measured by the monetary amount paid by the customer/user, but function is hard to measure objectively due to its inherently subjective quality and value.

Value has been closely associated with the user's purpose, requirements and perception by a number of gurus of VM. Mudge (1976) defined value as "the lowest cost to reliably provide the required functions or services at the desired time and place and with the essential quality", where functions are explained as the specific purposes or uses intended for something. In order to stress the user's influence and reflect various features of value, SAVE international (2001) added "…and other performance factors to meet user requirements" to Mudge's definition. Fowler (1990) presented value as a ratio of worth to cost, where worth is the lowest cost to obtain the basic

functions. He also argued that measuring true worth of an item should reflect the perceptions of the actual users/customers.

$$value = \frac{worth}{cost}$$

Dell'Isola (1997) interpreted value as the relationship among function, quality and cost. Therefore, he defined value as follows: "value is the most cost effective way to reliably accomplish a function that will meet the user's needs, desires and expectations".

$$value = \frac{function + quality}{cost}$$

Ellegant (1989) further argued that it is most important to retrospect the user's requirements for defining and enhancing value. The total interlink between the definition of value and the end user requirements is supported by Stylianopulos (1989), who stated "… in all instances, value is determined by the owner/ user".

SAVE International (2007) gave a recent definition on value:

$$value \approx \frac{function}{resources}$$

where function is measured by the performance requirements of the customer and resources are measured in materials, labour, price, time, etc. required to accomplish that function.

From the above discussion, it can be summarised that value in VM is the relationship between the user-required functions and cost. Essentially, it is the ability of a product

or service to satisfy the user's requirements for the cost paid. In this respect, value is determined by the judgment, expectation and perception of the user.

2.2.2 VA, VE and VM

There is considerable and confusing terminology being used surrounding the management of the value process internationally. The terms 'value analysis' (VA), 'value engineering' (VE) and 'value management' (VM) are still largely used interchangeably in the literature and it is not possible to isolate one area for investigation without reference to the others.

Value analysis (VA)

Value analysis is a philosophy implemented by the use of a specific set of techniques, a body of knowledge, and a group of learned skills. It is an organized creative approach, which has for its purpose the efficient identification of unnecessary cost, i.e. cost that provides neither quality nor use nor life nor appearance nor customer features (Miles, 1972).

Value engineering (VE)

Value engineering is a proven management technique using a systematized approach to seek out the best function balance between the cost, reliability, and performance of a product or project (Zimmerman and Hart, 1982).

Value management (VM)

Value management is a structured, organized team approach to identifying the functions of a project, product, or service with recognized techniques and to providing

the necessary functions to meet the required performance at the lowest overall cost (SAVE International, 2001).

Apart from the above terminologies, numerous names for the process or sub-processes are listed below and represent those in common use by VM organizations and institutions:

- Value planning (VP)
- Value review (VR)
- Value methodology
- Value management reviews (VMR).

Over a two year period, a group of ten fellows of SAVE International worked individually and in teams to define, refine and finalize a glossary of value related terms. In this VM glossary, the definitions of these terms are summarized as Table 2.1.

Table 2.1 Definitions of VM terms

Terms	Definitions
VA	The application of value methodology to an existing project, produce or service to achieve value improvement.
VE	The application of a value methodology to a planned or conceptual project or service to achieve value improvement.
VM	The application of value methodology by an organization to achieve strategic value improvement.
Value methodology	A systematic process used by a multidisciplinary team to improve the value of projects through the analysis of functions. See Value Engineering, Value Analysis and Value Management.

VM is widely used as an all-embracing term for any application. VE, however, is increasingly being viewed as a subset of the VM process, where the focus is on improving value in the design and construction stages of a project (Male et al, 1998a). For example, 'value planning' is the term used to describe the front end of the VM process. VR is the term used to describe the post-project audit stage where the completed facility is assessed in terms of its fitness, as judged against the original brief and design. In this research, the main focus is given to the VM studies conducted at the early stage of projects when the design and construction has not been started.

2.3 The Background and History of Value Management

VM evolved from value analysis (VA), which was first developed by Lawrence Miles in the General Electric Company (GEC) during World War II. Due to the shortages caused by the war, GEC was forced to use substitute materials for many of their products. It was found that these substitutes often produced a result of reducing costs as well as improving the performance of products. Miles discovered the mechanism behind the phenomenon and finally established a formulated function-oriented systematic method named value analysis.

Encouraged by the significant effect on cost reduction and product performance improvement in GEC, VA was widely adopted by other industries after the War. In 1954, the Navy Bureau of Ships began to apply this technique. They took a more proactive approach and used it in the design and engineering stage. This differed from General Electric Company's original model, which focused on analyzing existing products (Zimmerman and Hart, 1982). Thus they changed the name from value

analysis to value engineering (VE) and the latter is presently more popular in North America.

Since the early 1960s, through its association with US companies, technology books, journals, seminars, symposiums and visiting studies, VE was spread beyond US to other countries. While the scope has expanded and the approaches to VE have developed continually, a number of terminologies have evolved, such as value control, value planning and value management. The term value management was first used by the General Services Administration in 1974 to reflect the fact that value techniques were not confined to technical issues but had evolved into management activities and company policy (Macedo et al., 1978). According to Norton and McElligott (1995), VM has become a blanket term that covers all value techniques whether they are called value control, value planning, value engineering or value analysis. The difference and relationship between VA and VE, VM will be clarified in Section 2.3.2. For the sake of simplicity and consistency, VM will be used as representative of them in this thesis.

VM has been used to improve the value of projects in government, the private sector, and the manufacturing and construction industries, and value concepts have spread worldwide. Concurrent with this growth, a number of other value improving tools, techniques, and processes emerged, many of which were complementary to and were integrated with the value concepts (SAVE International, 2007).

The first use of VM in the construction industry occurred in the Navy Facilities Engineering Commend in the USA in 1963 (Dell'Isola, 1982). The application of this

technique in the construction industry expanded quickly as it became a mandatory requirement in many public projects in USA. In particular, the required inclusion of VM in the work scope of construction management services further drove the application of VM in this industry. After VM entered the construction industry, approaches have been developed by the combined effort of academic research and practitioners in order to fit the unique characteristics of the industry.

2.4 Job Plan of VM

The VM job plan is a sequential approach to implementing the core elements of a value management study. It outlines sequential phases to be followed which support team synergy within a structured process, as opposed to a collection of individual opinions. (SAVE International, 2007). Dell'Isaola (1997) suggested that the job plan is an organized problem-solving approach, which distinguishes VM from other cost-cutting exercises. There are a variety of VM job plans, such as Charette, SAVE 40-hour Plan, VM audit, Contractor's Change Proposal, Truncated workshop, and Concurrent Study. The SAVE 40-hour Plan is the most widely accepted formal approach in the construction industry. Figure 2.1 illustrates the job plan process flow.

The workshop usually follows an organized and systematic job plan, which is strongly emphasized by VM methodology. Whilst the precise number of stages and specific names of these stages in the job plan often vary, the general process is always similar.

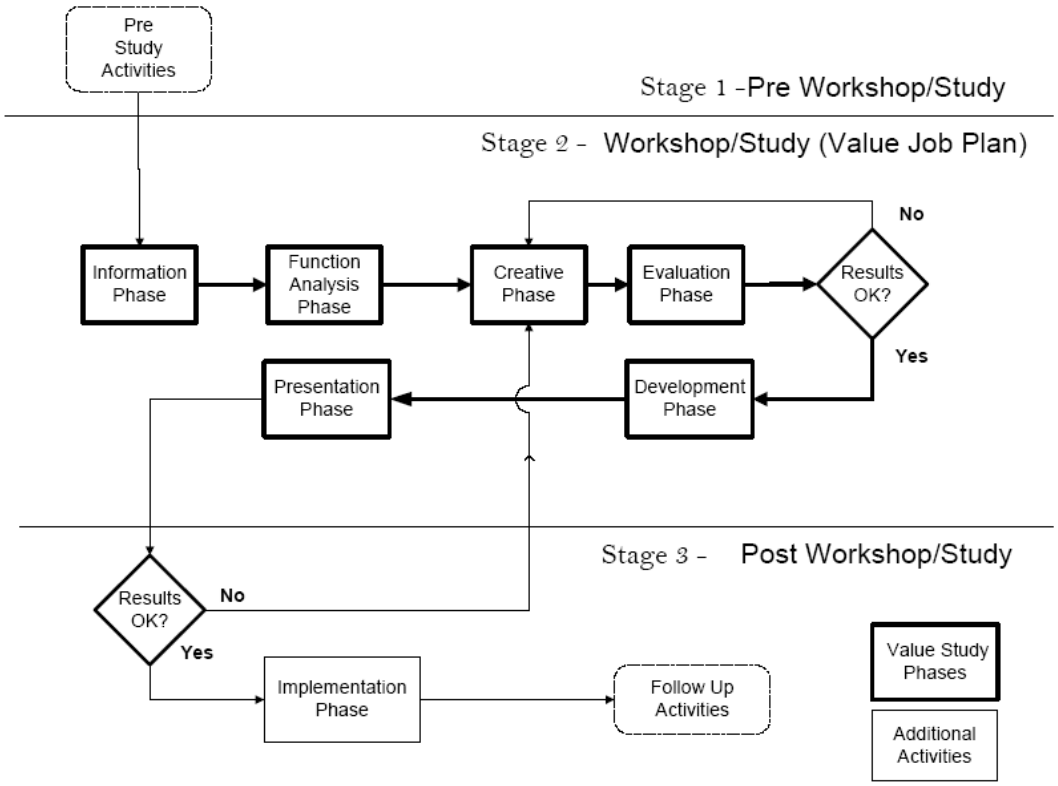

Figure 2.1 Value study process flow diagram [Source: SAVE International (2007)]

According to SAVE International (2007), a typical job plan comprises the following phases:

2.4.1 Pre-study stage

The pre-study phase aims to provide an opportunity for all parties to understand project issues and constraints, and therefore to give and receive information before VM workshops. The preparation tasks involve six areas:

- Collecting user/customer attitudes
- Completing the data files
- Determining evaluation factors
- Defining the scope of the study

- Building data models
- Determining team composition.

Clients can employ facilitators, usually VM facilitators, to organize and facilitate the briefing studies for them. Facilitators can also assist clients in defining the scope and objectives of the study. The standard (SAVE International, 2007) also draws up a list of information so as to ensure sufficient information is available for the studies.

2.4.2 Information phase

SAVE International (2007) states that the objective of the information phase is to complete the value study data package in order to produce an information base in VM studies. It also confirms the objectives, clarifies the assumptions and reviews the scope of the studies. As described in Yu (2007), this phase ensures that all members of the team fully understand the background, constraints, and limitations of the study so as to broaden their perspectives beyond their particular area of expertise. An introductory presentation is usually followed by a description of objectives for the project by a client representative, and then by descriptions of the project requirements and constraints by various stakeholders. Stakeholders involved should present their views in turn. Conflicting views are expected to occur and consensus is only arrived at after the analytical phase. In addition, the objectives of the study will also be finalized at the end of the information phase.

2.4.3 Analysis phase

According to SAVE International (2007), the objective of this phase is to develop the most beneficial areas for continuing study. In this phase, the functions of the project

are identified and analyzed. They may be represented in a hierarchical format and displayed on a function diagram. Liu (2003) suggested that the key questions asked during the analysis phase should be: “what is it?”, “what does it do?”, “what must it do?”, “what does the function cost (life cycle cost)?” and “what is the value of the function?”

2.4.4 Creativity phase

The objective of the creative phase (sometimes referred to as speculation phase) is to develop a large quantity of ideas for performing each function selected for study (Male et al, 1998a). This is a creative type of effort, totally unconstrained by habit, tradition, negative attitudes, assumed restrictions, and specific criteria. As suggested by Fan et al (2007), no judgment or discussion should occur during this activity. The quality of each idea will be developed in the next phase, from the quantity generated in this phase.

2.4.5 Evaluation phase

The objective of the evaluation phase is to explore ideas and concepts generated in the creativity phase, and to select those feasible ideas for development into specific value improvement. The collected ideas are examined according to both economic and non-economic factors, which are defined during the pre-study or evaluation phases, in order to highlight the best ideas for further studies (Norton and McElligott, 1995). Using the evaluation criteria established during the Pre-Study effort, ideas are sorted and rated as to how well they meet those criteria.

2.4.6 Development phase

The objective of the development phase is to select and prepare the “best” alternatives for improving value. It investigates the selected ideas in sufficient depth and develops them into written recommendations for implementation. The data package prepared by the champion of each of the alternatives should provide as much technical, cost, and schedule information as practical so that the designer and project sponsor(s) may make an initial assessment concerning their feasibility for implementation (SAVE International, 2007).

2.4.7 Presentation phase

The objective of the presentation phase is to obtain concurrence and a commitment from designers, project sponsors, and related stakeholders in order to proceed with the implementation of the recommendations. The recommendations are summarized in a final proposal and presented to all decision-making bodies and related interest parties for approval. Through the presentation and its interactive discussions, the team obtains either approval to proceed with implementation, or direction for additional information needed. The written report documents the alternatives proposed along with supporting data, and confirms the implementation plan accepted by management.

2.4.8 Post-workshop stage

The objective of the post-study phase is to assure the proper implementation of the approved value study change recommendations, as stated by Male et al (1998a). In this stage, the action plan is implemented and a report of the workshop is prepared and circulated. It is recommended that a post-evaluation be conducted for collecting

feedback about the study. The responsibility for ensuring the implementation of the action plan is allocated to an appropriate person.

Figure 2.2 illustrates the process of the VM studies which is introduced by Male et al. (1998a). The detailed tasks of each phase are specified in this model.

2.5 Review of Existing VM Frameworks

2.5.1 Three views on VM studies

Process view

According to the definition given by SAVE International (2007), VM is a systematic process used by a multidisciplinary team to improve the value of a project through the analysis of its functions. VM studies can be applied in any phases from the inception of a project to the completion of project (Male et al. 1998a). Therefore, VM studies are partial processes of the entire project management process.

Project view

VM has a systematic job plan which includes a pre-study phase, a value study phase and a post-study phase (SAVE International, 2007). It starts from the client's brief which calls for VM proposals and ends in the implementation of the alternatives recommended by the VM study. Time, money and other resources have to be assigned to conduct VM studies. Therefore, a VM study could also be considered as an entire project which aims to achieve the clients' objectives (Male et al., 1998a).

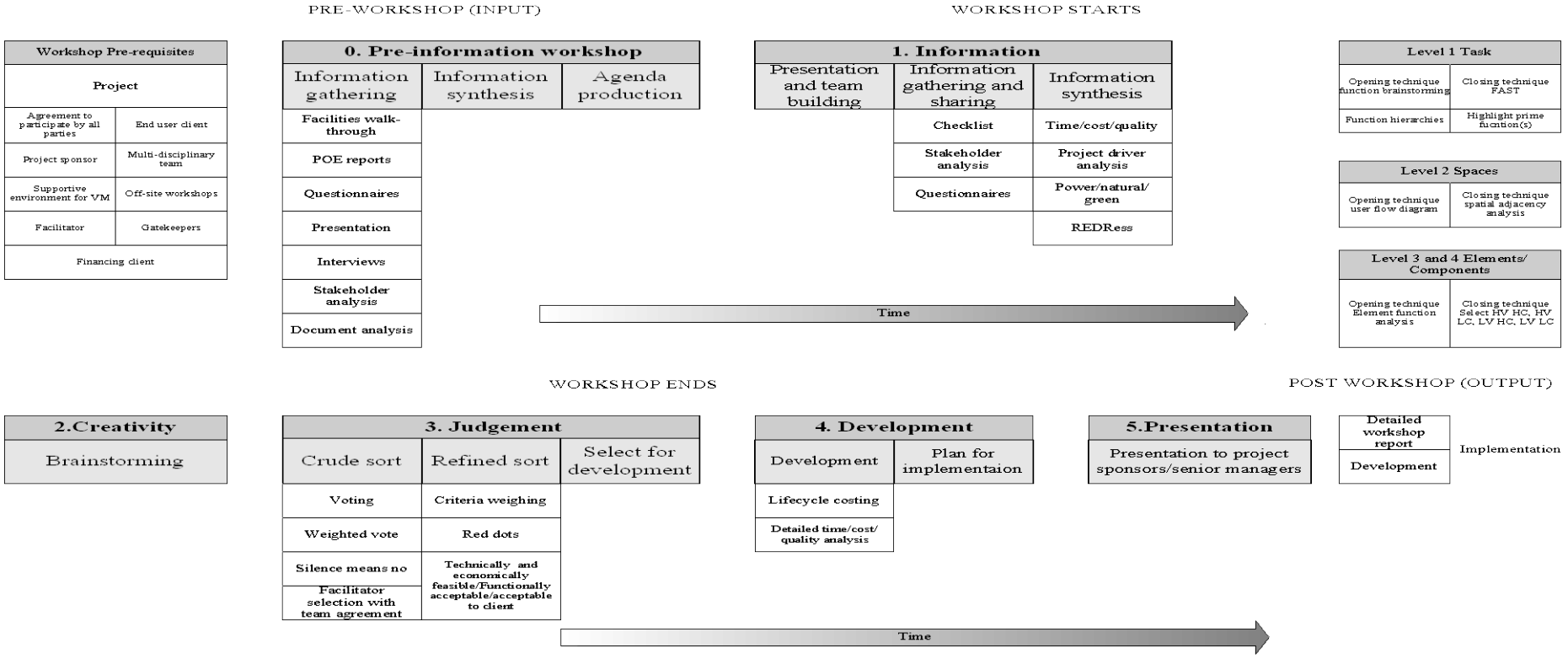

Figure 2.2 The Kelly and Male VM methodology [Source: Male et al. (1998a)]

Service view

VM studies are normally initiated by the clients and led by VM facilitators (Male et al. 1998a). VM facilitators are those who are trained to apply VM studies for value improvement (SAVE International 2007). Therefore, a VM study could be considered as a service provided to the clients who invest it by VM facilitators.

2.5.2 The nature of VM frameworks

A model for implementing VM can therefore be defined as a structure consisting of essential factors for guiding the implementation of a VM study. Normally, these factors are the key elements of a VM study which have major influences on the performance. Basically, a model should provide answers to four fundamental questions as follows (Yu, 2007):

- When will a VM study be carried out?
- Who should participate in the study?
- Where should the study be conducted?
- How should the study be processed?

2.5.3 Summary of publications for implementing VM

There is a long list of publications produced by academics, the practitioner community, governments, professional bodies and influential VM gurus in the form of guidance notes, standards, manuals, books and papers on the implementation of VM. Yu (2007) summarized the literature as follows:

- Value Engineering: The Search for Unnecessary Cost, the Chartered Institute of Building, Green and Popper, 1990.

- A SMART Methodology for Value Management, the Chartered Institute of Building, Green, 1992.
- Australian/New Zealand Standard – Value Management: AS/NZS 4183, Joint Technical Committee OB/6, 1994 (Revised and designated as AS 4183, 2007)
- Value Management in Construction: A Practical Guide, Norton and McElligott, 1995.
- Value Management Handbook, European Commission, 1995.
- Creating Value in Engineering: Design and Practice Guide, Institution of Civil Engineers, 1996.
- Value Management in Construction: A Client's Guide, Connaughton and Green, Construction Industry Research and Information Association, Special Publication 129, 1996.
- Fact Sheet on Value Management, Construction Industry Board, 1997
- Value from Construction – Getting Started in Value Management, Building Research Establishment, 1997.
- The Value Management Benchmark: A Good Practice Framework for Clients and Practitioners, Male et al., 1998.
- Value Methodology Standard, SAVE International, 2001 (Revised and designated as Value Standard and Body of Knowledge, 2007)
- European Standard – Value Management, European Committee Standardisation, 2000.
- British Standard: Value Management Practical Guidance to its Use and Intent, BS EN 12973, 2000.
- Value Engineering of Building Services, Building Services Research and Information Association, 1996.

Although these frameworks have many similar components, the variety of these models reflects the fact that the approach to the implementation of VM should be tailored according to different purposes, perspectives, users and contexts.

According to these frameworks, the essential factors for guiding the implementation of VM studies could be identified as follows:

- Clients
- Facilitators
- Participants
- Team and team dynamics
- Time and venue of VM studies
- Processes of VM studies
- Techniques used in VM studies
- Types of VM studies.

These factors, which comprise the body of knowledge of VM, should be carefully considered when measuring the performance of VM studies. This research focuses on the performance measurement of the typical six-phase VM workshops which are conducted at the early stage of construction projects.

2.6 Benefits and Critiques of VM in Construction

2.6.1 Benefits of VM in construction

The major reasons for choosing VM, according to Shen and Chung (2002), are to achieve cost saving, establish a clear project objective and provide creative thinking

for design improvement. Norton and McElligott (1995) listed a number of benefits of value management:

- Provides a forum for all parties involved;
- Provides an authoritative review of the entire project;
- Takes into account life cycle costs;
- Crystallizes the project's brief;
- Identifies project constraints, problems that may have been neglected.

Fong (2003) pointed out the early application of VM will deliver the following benefits:

- Recognize the strengths, weaknesses, opportunities and threats created by the "build" or "no build" options;
- Encourage the client's early commitment to the project;
- Clarify the client's needs versus wants;
- Enable the client to understand the problems it is attempting to solve;
- Formulate the real needs of the company;
- Improve the accountability, feasibility and thoroughness of the investigation as alternative options are considered and evaluated;
- Disseminate the briefing process of the problem to all concerned parties, to make sure that there is no misunderstanding or miscommunication;
- Discuss the problems thoroughly from all the participants' points of view;
- Safeguard the decision from any future auditing exercise, as an evaluation of alternative options has been made.

According to Yu (2007), the benefits of the VM process incorporate principles of stakeholder selection, knowledge creation and team learning. The VM process allows a “corporate dialogue” or “stakeholder dialogue”, which enables companies to have a proactive, open and co-operative discussion with representatives of stakeholders where issues of public concern are involved. Yu (2007) also pointed out that the team approach of VM involves an interactive pooling together of the knowledge of all the different stakeholders. Individuals in the VM team need to share information, knowledge and experience effectively and build on each other’s knowledge in order to create new knowledge or solutions and re-use existing proven knowledge to solve new problems/issues. In order to develop an understanding among the project stakeholders of the common or conflicting values, learning within the VM team must occur. Through the application of a proper VM job plan, a team learning environment is established which enhances the development of creative ideas and alternatives leading to value-added outcomes which are owned and learnt by the participating stakeholders as a team. In turn, this gained knowledge can be poured back into the larger organization, resulting in the whole organization learning together.

2.6.2 Critiques of VM in construction

Although VM has been applied in construction for about 40 years and has obtained a high reputation, critiques on it have never ceased. A number of articles such as “Too much value engineering” (Heitmann, 1989) in literature criticize and question the effect of VM exercises. Heitmann (1989) notes that the US Navy reported that failed VM studies make up about 2% of the total VM cases. Although it is only a small proportion, he suggested it should not be ignored. Problems in VM such as lack of

information, lack of participation and interaction were identified by Shen and Chung (2000). Typical critiques of VM in the construction industry include (Liu, 2003):

- The time consumption and interruptions to the flow of design work – The 40-hour workshop is regarded as a standard approach for implementing VM studies and is recommended by many VM organizations and societies. The main problem for implementing the 40-hour workshop is time. It is normally difficult to assemble key project participants for so long period and retain their attention from other things throughout this period of five days. Moreover, considerable time is needed by the design team for reviewing VM proposals and re-designing after the workshop. Sometimes the time for these processes is not allowed in a crowded design schedule (Kelly and Male, 1993).

- Many researchers have advocated that VM should be implemented as early as possible to maximize its results (Green, 1994; Dell'Isola, 1997). However, the most common point for VM intervention in practice is 35% of the way through the total design of a construction project since any changes to the original design are more easily introduced, costing data is more readily available in the form of the cost estimate, and savings can easily be identified (Kelly and Male, 1993). Kelly and Male (1993) claimed that this time seems too late to exert VM's influence on project concept formulation and on the feasibility study.

- The traditional VM practice (which is carried out at 35% of the way through the design by an external team) is essentially a design audit (Palmer et al., 1996). The adversative attitude of the original design team is not easily

eliminated. Many designers have argued that in a short period of time the VM team could not be expected to fully understand the project in comparison to the existing design team.

- The design liability of VM proposals is a thorny issue in VM applications. Whether the VM team or original team takes the design liability for any recommendations implemented is debatable, although the design team determines whether to accept or reject any proposals recommended by the VM team (Kelly and Male, 1993).

- A number of influential VM authors have given a strong emphasis to function analysis (Dell'Isola, 1982; Zimmerman and Hart, 1982). They considered that function analysis was an indispensable factor to the success of VM studies and made VM different from traditional cost reduction methodologies. SAVE International also embraced this view in its latest VM standard (SAVE International, 2007). However, there is not a clearly defined approach to function analysis in practice in North American VM (Palmer, 1992).

- How to structure the cost model is still a question. According to many guidance notes, the total cost should be broken down by the functions. However, the method may cause confusion when a component provides more than one function. For example, as the windows of housing contribute both ventilation and lighting, how much cost will be assigned to lighting and ventilation? (Yu, 2007)

The above items cannot display all critiques of VM in construction in literature, but they are listed to indicate the necessity to develop and perfect the traditional VM approaches.

2.7 Summary

VM originated in the US manufacturing industry during the Second World War, and was first used in the construction industry during the early 1960s. Since VM entered the construction industry, the approaches have been developed by the combined effort of academic researchers and practitioners in order to fit the unique characteristics of the industry. Value in VM has been defined as the relationship between the user-required functions and cost. However, analogous but confusing terminology VA, VE and VM are still largely used in the literature. VM studies conducted in the early stage of the projects are the main focus of this research. The standard three-stage process of pre-workshop, workshop and post-workshop; and six-phase workshop job plan are described. Three different views – process view, project view and service view – are described based on the different natures of VM studies. Essential factors, including clients, facilitators, participants, team and team dynamics, the technique used in VM studies, time and venue of VM studies, processes of VM studies and types of VM studies, have been extracted from the models for the implementation of VM studies. The value of VM in construction is still under debate, with some scholars such as Norton and McElligott (1995) enthusiastically shedding light on the benefits of VM, and others, such as Heitmann (1989), criticizing the effects of VM exercises.

This section gives a brief introduction to value management and reviews the literature in the field of VM. By understanding VM studies clearly, the research on the

performance measurement of VM studies can by conducted. In the next chapter, a review of performance measurement will be presented.

CHAPTER 3 PERFORMANCE MEASUREMENT OF VM STUDIES

3.1 Introduction

The overall aim of this study is to develop an appropriate framework for measuring performance in VM. In order to get some insight from previous studies in the field of performance measurement, the review is conducted in a hierarchical way, from generic performance measurement to measurement in construction, from measurement in construction projects to measurement in VM studies. This chapter concentrates on seven major areas of research: (1) background and history of performance measurement, (2) terminology and definitions, (3) performance measurement in construction, (4) performance measurement of VM studies, (5) existing approaches of performance measurement, (6) critiques of existing performance measurement frameworks, and (7) benefits of IT supported performance measurement.

3.2 Terminology and Definition

It is fundamental to clarify what exactly we mean by performance measurement. The language in the field of performance measurement complicates the subject because it is so confused (Neely et al., 2002). During the development of performance measurement many terms appeared which were frequently used by researchers, such as performance measurement, performance management, performance evaluation,

performance measures, key performance indicators, performance metrics, and critical successful factors, but few defining and distinguishing was done.

Neely et al. (2002) defined performance measurement as the process of quantifying the efficiency and effectiveness of past actions and a performance measure as a parameter used to quantify the efficiency and/or effectiveness of past action.

Bititci et al. (1997) gave a description of both performance management and measurement: the first '…is seen as a closed loop control system which deploys policy and strategy, and obtains feedback from various levels in order to manage the performance of the system', whereas a performance measurement system '… is the information system which is at the heart of the performance management process and it is of critical importance to the effective and efficient functioning of the performance management system'. Therefore, performance measurement is the process of '…determining how successful organizations or individuals have been in attaining their objectives'.

Critical Success Factors is defined by Sanvido et al. (1992) as those factors predicting the success of projects in the context of construction projects. Generally, CSFs could be defined as factors predicting success.

Performance evaluation is a synonym of performance measurement. Performance indicators and performance metrics are synonyms of performance measures. Key performance indicators are those parameters with importance when assessing the performance.

3.3 The Background and History of Performance Measurement

3.3.1 Deficiencies of traditional measurement based on financial accounting systems

It has been a long time since people first adopted performance measurement to assess the success of organizations. The research on performance measurement can be divided into two phases. The first phase was the time before 1980s, when attention was mainly paid to financial accounting systems. In the 1980s, a number of researchers (Kaplan, 1983; Johnson and Kaplan, 1987) found that it is insufficient to measure an organization's performance merely using traditional financial accounting systems, and hence a new generation of performance measurement based on multi-attitude measures was developed.

As in the traditional performance measurement methods, various indicators, such as return on investment, return on assets, productivity, cash flow and so on, were calculated exactly to measure the financial performance of an organization. Johnson (1983) pointed out that because of the increasing separation of ownership and management in an organization, measures of return on investment were applied so that owners could monitor the performance that managers were achieving.

As the world has developed from the industrial age to the information age, companies have had to meet with global competition and a rapid renewal of technique. However, performance measurement based on financial accounting failed to tell companies, especially in manufacturing industry, how to improve their competence in such a

severe competitive environment as stated by Neely et al (2002). Many deficiencies and limitations of traditional measures have been pointed out by researchers:

- They are historical in nature (Dixon et al., 1990). The financial reports of a company often tell the outcomes of previous months, quarters or years, which may be too old to make any decisions based on them. These measures are therefore called lagging measures.
- They give little indication of the relationship between works done in the present and performance in the future. Companies can not rely on traditional accounting systems to predict their future success because the assumption of the long production of a standard industry product, with unchanging characteristics and specifications, will not be relevant in the changing environment (Kaplan, 1983).
- They encourage focusing on short-term profits but not long-term strategies (Kaplan, 1986).
- They try to quantify performance and other improvement efforts solely in financial terms (Ghalayini et al., 1997). Many efforts, such as reducing defects in products and training employees, are difficult to evaluate in dollars but they will play important roles in achieving success.
- They hinder innovation (Skinner, 1986). Placing too much emphasis on cost reduction and productivity makes managers set all the Dos and Don’ts for workers, which inhibits workers from taking the initiative.
- They are internally rather than externally focused, with little regard for competitors and customers (Kaplan and Norton, 1992).

3.3.2 Revolution of performance measurement during the late 1980s and early 1990s

As a result of a continuous loss in practitioners' practices and an awareness of the limitations of traditional accounting systems among academia, a revolution of performance measurement broke out both in academia and industry, primarily in the manufacturing industry. Eccles (1991) predicted that 'Within the next five years, every company will have to redesign how it measures its business performance.' Terms other than financial indicators were added to the performance measurement systems to make the systems more comprehensive and appreciated. More attention was paid to total quality and delivery time in the 1980s, and in the 1990s more attention was paid to customer satisfaction.

Several integrated performance measurement frameworks were developed in the late 1980s and early 1990s, among which the following three frameworks were most influential: the strategic measurement analysis and reporting technique (SMART) system (Cross and Lynch, 1988); the performance measurement questionnaire (PMQ) (Dixon et al., 1990); and the balanced scorecard (BSC) (Kaplan and Norton, 1992).

The SMART systems by Cross and Lynch (1988) can be seen as a four level performance pyramid: corporate vision/strategy, business unit market and financial objectives and measures, business unit operational objectives and measures, and departmental level operational measures.

PMQ was designed by Dixon et al. (1990) to help managers get a clear idea of what improvements of their organizations should be achieved to assure the their business success, to what extent the existing measurement systems support the improvements, and how to establish an agenda for the evolution of the performance measurement systems.

BSC, which was initiated by Kaplan and Norton (1992), became popular and was adopted by many companies soon after its birth. This framework for performance measurement takes consideration of four perspectives: financial, customer, internal business process, and learning and growth.

All of these frameworks emphasize that both financial and non-financial measures should be considered in the measurement of all levels of the organizations. Each framework answers parts of the limitations mentioned above and each has its strengths. However, each also has its relative weaknesses. The SMART system does not explain how to identify key performance indicators. The PMQ is a method for determining the important measures of a company and evaluating existing systems rather than a comprehensive integrated framework. Both SMART and PMQ lack a concept of continuous improvement (Ghalayini et al., 1997). BSC does not mention all the relevant stakeholders such as end-users, regulators, and local communities, etc., which can have a massive impact on the organization and on its ability to perform (Neely et al., 2002).

Though these frameworks are not perfect and can not serve as a panacea for improving performance measurement, they provide a new concept of performance measurement apart from traditional accounting systems.

3.3.3 Rapid development of research on performance measurement

Between 1994 and 1996, some 3,615 articles on performance measurement were published, and in 1996 new books on the subject appeared at a rate of one every two weeks in the USA alone (Neely, 1999). Many other frameworks and models were developed not only for the manufacturing industry but also for specific industries to answer distinct problems.

EFQM Excellence Model (EFQM, 2003) is a non-perspective framework based on nine criteria, which takes a wider view of stakeholders. Bititci (1997) developed an Integrated Performance Measurement System (IPMS) which emphasizes the provision of a proactive closed loop control system which deploys policy and strategy, and obtains feedback from various levels in order to manage the performance of the business. Benchmarking methods are also widely used to compare operations, compensation, and financial performance with those of other similar operations, both internally and externally (Neely et al., 2002). KPI Report (CBPP, 2002) is an instance of benchmarking.

On the basis of previous frameworks and models, some frameworks with a more comprehensive conception emerged. Bourne (2003) considered that performance measurement developed from multi-dimensional frameworks (such as BSC, Kaplan

and Norton, 1992) to multi-stakeholder frameworks (such as the Performance Prism, Neely et al., 2002) and Strategy Maps (Kaplan & Norton, 2000). The Performance Prism consists of five perspectives: stakeholder satisfaction, stakeholder contribution, strategies, processes and capabilities. These five perspectives comprise a comprehensive and integrated framework for thinking about organizational performance (Neely et al., 2002). Strategy Maps, which is based on BSC, shows how an organization converts its initiatives and resources – including intangible assets such as corporate culture and employee knowledge – into tangible outcomes (Kaplan & Norton, 2000).

3.4 Performance Measurement in Construction

3.4.1 Statistics of papers related to performance measurement in construction

In view of the large number of tests and the amount of literature on the subject of performance measurement, this section includes a review of the well-known texts and most cited publications in refereed journals to map the development of performance measurement in the last two decades.

Articles from the last eight years from seven major construction management journals were considered to map the development of performance measurement in construction. The journals used for the literature review included: Construction Management and Economics (CME), the ASCE Journal of Construction Engineering and Management (CEM), Engineering Construction and Architectural Management (ECAM), the ASCE Journal of Management in Engineering (JME), the International Journal of Project Management (IJPM), Automation in Construction (AIC) and Building

Research and Information (BRI). The selection of journals was based on the study of Chau (1997), who found that these journals had the highest scores for quality. Chan et al. (2002, 2004) and Li et al. (2000) adopted a similar methodology in their studies to identify the critical success factors of construction projects, design/build projects, and partnering projects. Keywords for searching included performance, measure (measurement, measuring), evaluate (evaluation, evaluating), assess (assessment, assessing), critical success factors, and key performance indicators. These words are known to have been used in papers on performance measurement in construction.

The procedures for retrieving papers related to performance measurement were as follows:

1. The titles, keywords and abstracts were scanned for the keywords. There were more than 800 articles that contained at least one of the keywords in the default areas. These articles include "genuine" papers which focus on performance measurement in construction, closely related papers, and less related papers.
2. A review of the abstracts of these papers was conducted to filter out the less related papers. For instance, some papers had just a small part on performance measurement, and could not be considered related papers (e.g., Pietroforte and Stefani 2004). Some other papers devoted to measuring the performance of materials were also excluded (e.g. Kerali and Thomas, 2004).
3. After filtering, 324 articles with pertinent content with respect to performance measurement in construction were left for analysis.

There are admittedly many other articles on performance measurement that have been published in other journals. However, the scope of the study is on determining a valid

research methodology. Thus, instead of including all publications on performance measurement in this review, some are simply cited where appropriate.

There have been few papers published in refereed journals that are closely related to the subject of measuring the performance of VM studies in construction. To supplement the literature search, some texts about VM studies in general were also taken into consideration (Miles, 1972; Dell'Isola, 1982; Kelly and Male, 1993; Male et al., 1998a, 1998b).

Table 3.1 provides the number of papers published in each journal. CME, CEM, and BRI published the most papers on performance measurement. Volume 27 Issue 4/5 of BRI is a collection of nine papers on the Green Building Challenge (GBC), which focuses on measuring the performance of building environments. Volume 29 Issue 2 of BRI includes five papers on "assessing building performance in use", which make up a series. In order to better reflect the trend of performance measurement research in construction, these two special issues are judged as two papers. (Modified numbers of papers are shown in parenthesis).

Table 3.1 Number of papers related to performance measurement

Journal title	Number of papers
Journal of Construction Engineering and Management	68
Construction Management and Economics	57
Building Research and Information	59 (47)
Automation in Construction	43
International Journal of Project Management	43
Journal of Management in Engineering	28

Engineering Construction and Architectural Management	26
Total	324 (312)

Notes: The number in parentheses is the number after modification.

There is a growing interest in the area of performance measurement in construction. Papers are categorized by year of publication in Figure 3.1. The number of papers during last decade has increased significantly. Growing interest in performance measurement in construction can be attributed to a number of reasons. First, the boom in research on performance measurement in construction is a continuation of the rapid development of performance measurement in other sectors during the 1990s. The second reason is the increasing complexity of construction projects that require appropriate measurement tools to improve performance. The development of construction project management as well as building technology is another reason for growing interest on performance measurement.

Table 3.2 lists the number of papers classified under performance measurement on the organizational level, the project level, or both levels. The number of papers focusing on measuring project level performance is much greater than those focusing on organizational-level performance because of the project-based nature of the construction industry. Although the measurement of organizational performance shares some common ground with that of project performance, they differ a great deal with regard to different perspectives. The following two sections will separately give more detailed reviews of both levels of measurement.

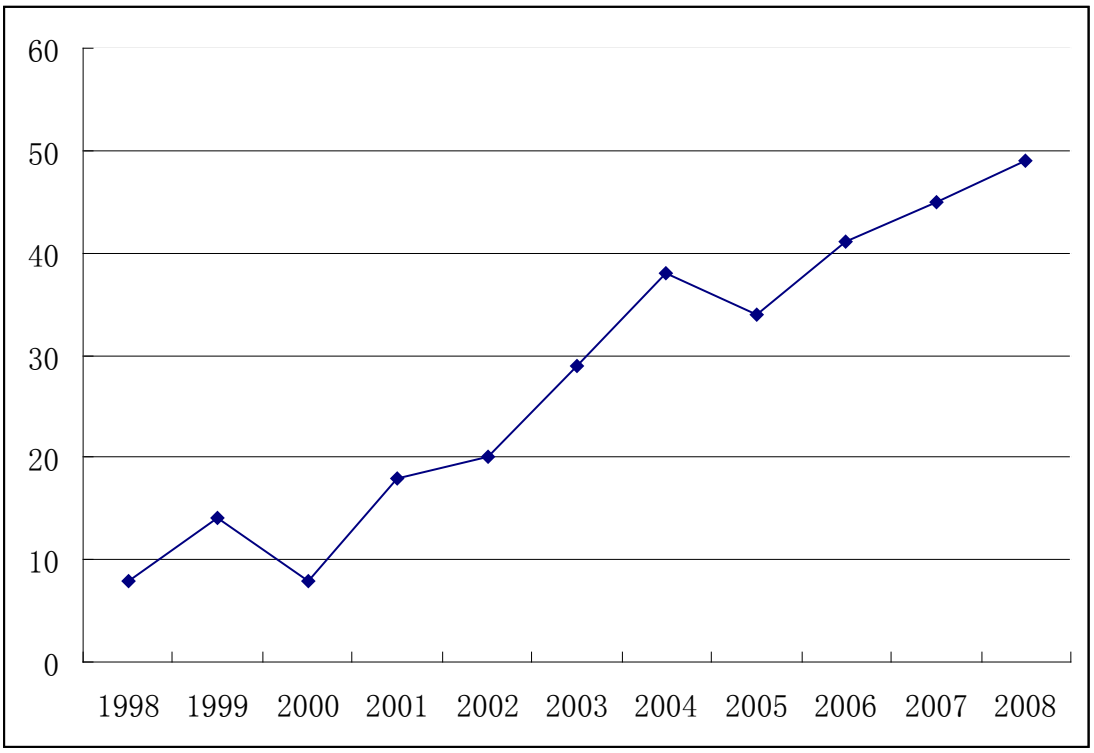

Figure 3.1 Number of papers published in selected journals

Table 3.2 Number of papers classified by different levels of measurement

Category	Number of papers	Percentage
Organizational level	85	26%
Project level	197	61%
Both levels	42	13%
Total	324	100%

All of the selected papers are to some extent related to performance measurement in the construction industry, but they focus on different aspects of performance measurement. Some papers focus on the overall performance and the others pay attention to a certain facet, such as safety performance, quality performance,

environmental performance, and so on. Table 3.3 shows the numbers of papers categorized by different scopes of research. About one third of the papers are on the overall performance of a construction organization or project, while the others examine various aspects of performance.

Table 3.3 Number of papers classified by different scopes of research

Category	Number of papers	Percentage
Overall performance	110	34%
Partial performance	214	66%
Total	324	100%

There are so many different facets that it is hard to give a thorough list of areas of focus. Table 3.4 lists areas with more than five papers, classifying the remainder as "others". The number of papers focusing on environmental performance assessment and human resource performance are the largest. The measurement of procurement performance, technology innovation, safety performance, and design performance also constitute a large proportion of the sample. These papers do not reflect all of the academic work being carried out in this research field because of the limited searching scope. However, they reflect the research hotspots in performance measurement in construction. Each specific area of the construction industry has its own method of measurement that emphasizes the distinctive characteristics of that area, which will help us to better understand the issue of performance measurement in construction. Only a few papers related to the performance measurement of VM studies in construction have been published in the selected journals (Shen and Liu, 2003; Lin and Shen, 2007; Fan et al 2007). This reflects the lack of research on performance measurement in the context of VM studies in construction.

Table 3.4 Number of papers focusing on partial performance

Focus	Number of papers	Percentage
Environmental performance	33	15%
Human resource performance	30	14%
Procurement performance	25	12%
Technology innovation	24	11%
Design performance	15	7%
Safety performance	13	6%
Cost performance	12	6%
Quality performance	11	5%
Time performance	7	3%
Post-occupancy evaluation	7	3%
Maintenance	5	2%
Thermal and air-conditioning	5	2%
Participant's satisfaction	5	2%
Others	22	10%
Total	214	100%

3.4.2 Measuring organizational performance

Entering into the 1990s, the construction industry was facing significant new changes including increased competition, higher standards for competitive success, and dwindling resources (Thompson and Sanders, 1998). Reports on the performance of the construction industry have pointed out the areas of improvement and emphasized the need for performance measurement (Latham, 1994; Egan, 1998; CIRC, 2001).

For measuring the organizational performance, benchmarking is a widely accepted approach. The KPI framework developed by The CBPP in the late 1990s and the CII Benchmarking & Metrics developed by the CII are two frameworks now used by many construction organizations. Garnett and Pickrell (2000) claimed that it was feasible to use a benchmarking method in construction. Several benchmarking studies were conducted to benchmark organizational performance at the organizational level, national level, and international level (Ramirez et al., 2004; Winch and Carr, 2001). Measuring performance with the benchmarking method, based on a macro-perspective, assists in identifying a company's position among the peer organizations.

Some frameworks as BSC and the EFQM Model, which were developed generically, have been adopted and adapted to for use in the construction industry. Kagioglou et al. (2001) developed a conceptual Performance Measurement Process Framework (PMPF) on the basis of BSC, adding "project" and "supplier" perspectives which are tailored to the needs of the construction industry. Both Bassioni et al. (2004) and Beatham et al. (2004) have explained the feasibility and usefulness of using EFQM Model in construction. Beatham et al. (2004) has stated that an integrated business improvement system (IBIS) is being developed that utilizes the EFQM Model criteria. These frameworks and adaptations focus on multiple aspects of a single organization.

Several papers focus on the performance of contractors for the purpose of helping organizations select contractors. Hutush and Skitmore (1997) investigated the relationship between contractor selection criteria (CSC) and project success factors

(PSFs). Yamasis et al. (2002) introduced a contractor quality performance (CQP) evaluation model that can be used in a contractor prequalification/selection system. They claimed that the quality of the construction process and levels of customer satisfaction will improve if the quality performance of the contractor is evaluated. Alarco'n and Mourgues (2002) developed a framework for evaluating contractors for future work and proposed a selection system that incorporates the contractor's performance prediction as one of the criteria for selection. Measurements of the performance of contractors are used for selection, so most of the measurements are based on the previous performance of the contractors.

3.4.3 Measuring project performance

The business unit in construction is project based (Liu and Walker, 1998), so that the measurement of project performance is as important as that of organizational performance. However, the measurement of project performance is different from the measurement of organizational performance. Many papers have focused on measuring the performance of a project, from the performance of one aspect to overall performance. Here, papers that discuss the measurement of overall performance are reviewed.

Each project is unique in feature (Bassioni et al., 2004). Because of the uniqueness of construction projects, it is difficult to develop a generic framework to measure the performance of various projects. Besides, such a framework would receive different assessments when judged from the standpoint of different participants in the project such as the client, designer, or contractor. A method does not yet exist to aggregate the behaviour, performance, and perceptions of all participants over all tasks and

throughout the duration of the project (Liu and Walker, 1998). Liu and Walker (1998) considered a temporary multi-organization and a shifting multi-goal coalition as two fundamental characteristics that complicate the evaluation of a project.

The traditional approach to evaluating the performance of a project relied on three indicators: cost, time, and quality (Ward et al., 1991; Kagioglou et al., 2001). However, a project's performance should be measured in a more comprehensive manner. Kagioglou et al. (2001) argued that the three traditional indicators are "lagging" and fail to provide a balanced view when measuring. Kumaraswamy and Thorpe (1996) added client satisfaction, project team satisfaction, technology (transfer), environment (friendliness), and health and safety to the criteria of success. The KPI framework (KPI working group, 2000) chose time, cost, quality, client satisfaction, change orders, business performance, and health and safety as the seven key performance indicators.

Many researchers have focused on determining the CSFs to a construction project. Chan et al. (2004) reviewed 43 articles selected from seven major management journals in the construction industry, and listed 44 factors in five categories that affect the success of a project. Research on the critical success factors of a project is considered a method of improving the effectiveness and efficiency of the project (Chan et al. 2004). Getting to know the causal relationship between CSFs and KPIs will help researchers and practitioners to better measure the performance of projects.

Several models, systems, and frameworks have been developed to meet the need to measure the performance of projects. The KPI framework (KPI working group, 2000)

which uses benchmarking methodology can also be adopted to measure the performance of project by choosing indicators that are project based. Westerveld (2003) developed the Project Excellence Model, which was adapted from the EFQM model. This model linked success criteria and critical success factors. Cheung et al. (2004) developed a web-based Construction Project Performance Monitoring System to help project managers monitor and assess project performance.

3.5 Performance Measurement of VM Studies

VM is adopted in many projects to cope with challenges such as budget constraints, safety issues, environmental impact, and after all, value for money. However, VM studies often face pressure from limited time and resources (Shen and Liu, 2003). A proper measurement of the performance of VM studies will improve the allocation of limited time and recourses to achieve better output.

Performance measurement of VM studies focuses on cost savings and improved functions, especially on the savings achieved by implementing the proposals of VM studies in the past decades. The website of SAVE international provides a lot of cases which saved money by using the VM methodology. The research works in this area, such as Kelly and Male (1993) and Palmer et al. (1996), have been introduced in detail in Section 3.4.1. However, merely focusing on cost reduction appears to be insufficient when measuring the effect of VM studies (Shen and Liu, 2003; Lin et al., 2004). Many researchers have criticized the finance-focused measurement and have claimed that many other aspects, such as the clarification of client's objectives, improving the communication of stakeholders and the acceleration of

decision-making should be considered (McElligott, 1995; Palmer et al., 1996; Shen and Liu, 2003). As explained in the introduction section, the process-related performances are seldom considered in the measurement of VM studies, which hinders VM practitioners from knowing the relationship between the processes and outcomes.

The identification of CSFs which describe how an objective of VM studies can be measured and achieved is important in performance measurement. After a benchmarking study, Male et al. (1998a) highlighted 10 CSFs for VM. Shen and Liu (2003) reviewed the literature about factors affecting the success of VM studies and identified 15 CSFs (as shown in the Table 3.5) in four clusters: 'value management team requirements', 'clients' influence', 'facilitator competence', and 'relevant department's impact'. They evaluated the importance of these CSFs by surveying experienced VM practitioners. But they did not identify performance indicators which link to these CSFs at an operational level. The causal relationship between CSFs and KPIs, once identified, will help in measuring the performance (Chan et al., 2004).

Table 3.5 Ranking of critical success factors for VM studies [Source: Shen and Liu (2003)]

Factors	Ranking
Client's support and active participation	1
Clear objective of VM study	2
Multidisciplinary composition of VM team	3
Qualified VM facilitator	4
Control of workshop	5
Preparation and understanding of related information	6

Plan for implementation	7
Function analysis	8
Timing of study	9
Interaction among participants	10
Professional experience and knowledge of participants in their own disciplines	11
Personalities of participants	12
Adequate time for VM study	13
VM knowledge and experience of participants	14
Cooperation from related departments	15

Benchmarking is also adopted by researchers to measure the performance of VM studies. Male et al. (1998b) developed a benchmarking methodology for VM which takes into consideration both objective indicators and subjective indicators to indicate the performance of a VM process. The case study analysis in the research program eliminated the majority of the performance indicators. The research team concluded that client satisfaction would be a good indication of the performance of VM applications and that data related to the project collected after the application of VM could be added to give an overall indication of the performance of VM undertaken in practice. However, these indicators were discussed earlier in this chapter as “lagging indicators”; they tell little about how the performance is achieved and how to improve the performance. Moreover, measures such as workshop time, the background of the participants, function analysis and so on, which are related to the CSFs identified by Shen and Liu (2003), did not receive adequate recognition. Table 3.6 list the issues addressed by Male et al.’s (1998a, 1998b) research.

Table 3.6 Issues addressed by Male et al.'s research [Source: Liu (2003)]

Issues	Explanations
The global development of VM	Mainly concerning the process of VM diffusion from manufacturing to construction.
Terminology and definitions	Clarifying the terminology related to VM.
Value opportunities	Six value opportunity points recommended by the research team
The process at each value opportunity point	Including: • VM pre-requisites • Senor management and participant support • VM team characteristics • Types of participants • The role of the facilitator • The selection of the facilitator • The number of facilitators • Large and small team facilitation • Pre-workshop issues.
Workshop issues	Including: • The job plan and variants • Function analysis and objectives hierarchies • Workshop environment.
Post-workshop issues	Concluding that a post workshop study stage of implementation should be included as part of the VN workshop process
Individual value opportunity workshop structures	Introducing objectives, pre-requisites, timing, participants, duration and deliverables for the six recommended individual workshops in the project life cycle. The workshops are: • The pre-brief workshop • The briefing design workshop • The concept design workshop • The Charette • The detail design workshop • The operational study. The implementation workshops following each of above workshops are specially stressed to ensure the implementation of the produced recommendations.
The influences of the market place on the provision of VM service	Identifying the influence of clients of VM service on VM applications
Qualifications, standards and legislation	Discussing the influence of the certification of facilitators. Legislating for the use of VM and the development of standards.
The prospect of a new profession – the VM facilitator.	This issue relates to the definition of a profession, VM knowledge base, VM professional associations and professionalism, and education and training.

Fong et al's study (2001) is to develop an analytical framework for benchmarking value management. The framework consists of some common key characteristics and CSFs perceived to be applied to different work processes, regardless of the type of industry or organisation. It was based on a review of the literature on VM, particularly the studies of Male et al. (1996, 1997a, b, 1998a, b) and the VM process suggested by Webb (1993a, b). It is noted that key characteristics are major segments of the VM process, in which they represent a small part but have a larger effect (Mitchell, 1995; Vaziri, 1992). As a result, some common key characteristics, CSFs and related performance metrics are identified, as depicted in Table 3.7. The proposed framework provides a foundation for researchers to undertake further research on benchmarking value management.

Table 3.7 An analytical framework for benchmarking value management [Source: Fong et al. (2001)]

Key characteristics	CSF of VM process	Performance metric
Orientation involves:		
1. Management approval for the benchmarking project	1. Management support	1. Perception of management support*
2. Project team formation	2. Project team formation	2. Perception of team members' capability*
3. Budget setting	3. Budget setting	3. Cost variance/budget of VM
Information and analysis involves:		
4. Information gathered by the facilitator	4a. Facilitator efficiency in gathering information	4a. Time involved in gathering information compared with other projects
4b. Facilitator's skills	4b. Perception of the previous experience of the facilitator*	
Speculation involves:		
5. Ideas/solutions generated within a time limit	5. Ideas' cost or value	5a. Number of ideas generated/number of people involved
	5b. Number of ideas generated/number of hours	
	5c. Number of feasible ideas/number of ideas generated	
6. Brainstorming	6. Brainstorming group effectiveness	6. Number of ideas generated/number of people

		involved
Evaluation involves:		
7. Screening of ideas	7. Skills of screening	7. Perception of the accuracy of the techniques employed for analysis*
8. Gaining acceptance from top management	8. Management commitment to the new best practice	8. Perception of the level of management commitment*
Implementation involves:		
9. VM plans implementation	9. VM performance	9. Actual savings/proposed savings
10. Quality for customers	10. Customer satisfaction	10. Customer satisfaction level on a proved measuring scale*
11. Surveillance maintenance.	11. Surveillance regularity.	11. Deviation from the number of surveillance checks scheduled per year.

Note: * Measured by Likert-type scale

The Hong Kong Institute of Value Management (HKIVM) developed a feedback form for both the clients and facilitators (HKIVM, 2008). The form includes nine indicators:

1. Client preparation,
2. Client management of process,
3. Attitude of participants,
4. Number of key stakeholders present,
5. Objectives of workshop achieved,
6. Appropriateness of the length of workshop,
7. Client's expectation met or exceeded,
8. Suitability of venue,
9. Refreshments quality.

This form covers several aspects of the performance of VM workshops. However, indicators such as refreshments quality have no direct relationship with the

performance of VM studies. The form missed some important indicators to the performance of VM studies such as ‘improvement of communication among stakeholders’, ‘quality of VM report’. It is used to produce a quick record of the workshop but is not suitable to measure the performance.

The investigation of performance measurement is far from meeting the management requirements. Each VM study is unique according to the uniqueness of the target project, which calls for a flexible measurement. Meanwhile, the measurement framework should be prompt and cost-efficient because of the time and resource limitations of VM studies. The existing literature shows that different researchers (SAVE International, 2008; Male et al., 1998b; Palmer et al., 1996; Fong, 2003) embrace different concepts on the performance measurement of VM studies. It appears no rigorous performance measurement framework has been developed specifically for VM studies in construction. For example, there is no measurement framework which aggregates features such as flexibility, promptness and economy without reducing the accuracy of the measurement in VM literature.

3.6 Approaches of Performance Measurement for VM Studies

3.6.1 Single-criterion measurement approach

Single-criterion measurement approach means that only one indicator is used to measure the performance of VM studies. Normally, cost savings is the performance indicator used in a single-criterion approach.

The previous measurements on the performance of VM studies have focused on reducing costs and enhancing the functions of projects, especially on the savings achieved by implementing the proposals of VM studies. “Value management is a … team approach to … providing the necessary functions to meet the required performance at the lowest overall cost” (SAVE International, 2008). Highway and transportation departments saved U.S. taxpayers $1 billion in 2000 by applying VM studies to construction projects. State transportation departments spent more than $6 million to administer VM programs and realized a return on investment of $121 for every dollar spent (SAVE International, 2008). This amount of savings was used to measure the success of the VM studies. Kelly and Male (1993) investigated several VM studies in the construction industry in the United States and argued that the main concern when judging whether a VM study is successful is the percentage of savings a study can achieve. Palmer et al. (1996) analyzed 55 studies in this field, and calculated the proposed savings as well as the implemented savings, and categorized the savings by discipline and by type.

Norton and McElligott (1995) listed the major characteristics of VM studies, including systematic process, multidisciplinary approach, function analysis and value improvement, which differentiate them from cost-reduction techniques. Palmer et al. (1996) made a holistic appraisal of value engineering in construction in the United States and claimed that there are a multitude of factors that appear to have a direct effect on whether or not a VE study is successful. Shen and Liu (2003) claimed that the size and complexity of the projects that are subjected to VM studies are continually increasing. Therefore, as well as reducing costs, the purpose of

implementing VM studies is to clarify project objectives, improve communication between different parts, and enhance the function of project.

3.6.2 Multi-criteria measurement approach

In the multi-criteria measurement approach, more than one indicator, even several sets of indicators, are used to measure the performance of VM studies. These indicators focus on different aspects of VM studies and the integration of them could provide a comprehensive view of the performance of VM studies. For example, Shen and Liu (2003) identified 15 CSFs and categorized them into four aspects without linking these CSFs to specific KPIs. Chang and Chan (2004) developed a framework for measuring the performance of VE studies using factor analysis and the Analytic Hierarchy Process (AHP). However, their emphasis is on VE studies and the data are based on Taiwan. The literature on the multi-criteria measurement of VM studies is too limited to form a solid foundation of appraisal. Therefore, multi-criteria measurement approaches used for the performance of other management practices and for the project performance are also discussed.

3.6.2.1 Multi-criteria measurement of VM studies

The identification of CSFs, which describe how an objective of VM studies can be measured and achieved, is important in performance measurement. Many studies have been conducted to identify the CSFs of VM studies. After a benchmarking study, Male et al. (1998a) highlighted 10 CSFs for VM. Shen and Liu (2003) reviewed the literature about factors affecting the success of VM studies and identified 15 CSFs in four clusters: ‘value management team requirements’, ‘clients’ influence, facilitator competence’, and ‘relevant department’s impact’. They evaluated the importance of

these CSFs by surveying experienced VM practitioners. But they did not identify performance indicators that link to these CSFs at an operational level. The causal relationship between CSFs and KPIs, once identified, will help in measuring performance (Chan et al. 2004).

Proper indicators are the fundamental elements in developing a measurement framework. It is hard to determine whether an indicator is useful considering the feasibility of data collection. Based on the research of Male et al. (1998b) and Shen and Liu (2003), Lin et al. (2004) have developed a list of potential indicators for measuring performance of VM studies. The indicators identified by Lin et al. (2004) have been classified into eight categories which cover different aspects of VM studies. They also proposed a conceptual framework which integrates the process and outcome measurement. Chang and Chen (2004) applied a statistics method (Factor Analysis) and Analytic Hierarchy Process (AHP) to analyze a questionnaire survey distributed to experienced VM practitioners in Taiwan. Based on the data collected from the survey, they developed a model for the performance measurement of VM studies which includes four sub-aspects and 23 measurement indicators.

3.6.2.2 Multi-criteria measurement in VM studies

The concept of multi-criteria measurement has been integrated into the VM methodology since the infancy stage of VM. Multi-criteria measurement is conducted to select the best ideas or recommendations in the evaluation phase of VM studies (Miles, 1972).

Green (1992) developed a Simple Multi-Attribute Rating Technique (SMART) which could be used to help in decision-making. This approach creates a learning environment within which stakeholders can reach a shared understanding of the broad, strategic objectives of a project and express them in a clear and structured manner (Green and Moss, 1998). Kulshrestha and Deshpande (2002) developed a Multiple Criteria Decision Support System (MCDSS) for value management implementation in construction projects. They presented some concepts of Multiple Criteria Decision Theory (MCDT) and established an analogy between the decision environments of VM and MCDT.

A Performance Measures Process was developed by Stewart (2004) in conjunction with the California Department of Transportation as a means of developing a better understanding of the effects that recommendations developed in VM studies have on project performance. This process seeks to measure performance by:

- Identifying and defining key performance attributes;
- Determining the relative importance of performance attributes in meeting a project's purpose and need;
- Developing measurement scales to quantify (or qualify) performance levels;
- Comparing performance to cost ratios (i.e., value) of multiple design concepts.

3.6.2.3 Potential multi-criteria measurement tools

The measurement frameworks and tools discussed in this section are used to measure other things rather than VM, with the purpose of presenting a comprehensive review of potential measurement tools.

Multi-criteria measurement approaches are widely used in measuring the performance of many other management tools. Numbers of models and frameworks have been developed to fulfil various measurement requirements. The concepts and techniques of these models and frameworks, which are in line with the characteristics of VM, could be adapted for measuring the performance of VM studies. The strengths and weaknesses of some existing frameworks used for performance measurement are discussed in this sub-section.

Total quality management (TQM) has been widely used in the construction industry for decades. Within the construction industry, each party involved in a project, including the owner, constructor, and designer, plays the role of customer and supplier of services. The owner supplies the requirements to the designer, the designer supplies the plans and specifications to the constructor, and the constructor supplies the built facility to the owner (Juran, 1988). Based on this concept, Russell et al. (1994) pointed out that a principal focus of TQM is for each supplier of services to identify and satisfy or exceed their customer's needs in terms of cost, quality, and time. Hence, measurement of programme performance is a key aspect of a TQM programme which includes tabulating quantitative costs and benefits arising from TQM, such as dollar and schedule savings, as well as recognizing qualitative effects such as higher quality and increased customer satisfaction. Kano and Koura (1991) developed a list of quantitative, tangible effects of a quality program that may be measured as shown in Table 3.8.

Table 3.8 Measures for tangible effects of TQM activities [source: Kano and Koura (1991)]

Project objective	Measure
	Cost
Cost reduction	Cost reduction amount
	Rate of defect cost
	Degree of achieving target cost
	Schedule
Delivery date	Delivery date achievement rate
	Late delivery
	Delivery troubles
	Quality
Finished product inspection	Acceptance rate of inspection by QA Department
	Acceptance rate of outgoing inspection
User demerit	Customer complaints
	Defective rate of incoming inspections of products delivered to customers
	Compensation work cost
	Rate of complaints at customer's line
	Complaints from market
	Annual failure rate
User merit	Comparison of market quality evaluation
	User satisfaction
	Comparison with international level
	Change in contents of quality problems
	Customer cost reduction
	Extension of guarantee period
	Safety/Human Resources
Safety	Number of accidents
	Accident rates
	Severity rates
Human resource development	Number of completed QC circle themes
	Number of suggestions
	Number of qualification obtained
	Absenteeism
	Number of employees receiving QC education

Derived from TQM awards, the EFQM and Baldrige models have gained much popularity in the field of performance measurement (EFQM, 2003). Figure 3.2 presents the basic concept of EFQM model. The EFQM model provides a perspective

to integrate result areas (lagging indicators) and organization areas (leading indicators) in one model which can be adopted when measuring the performance of a VM study.

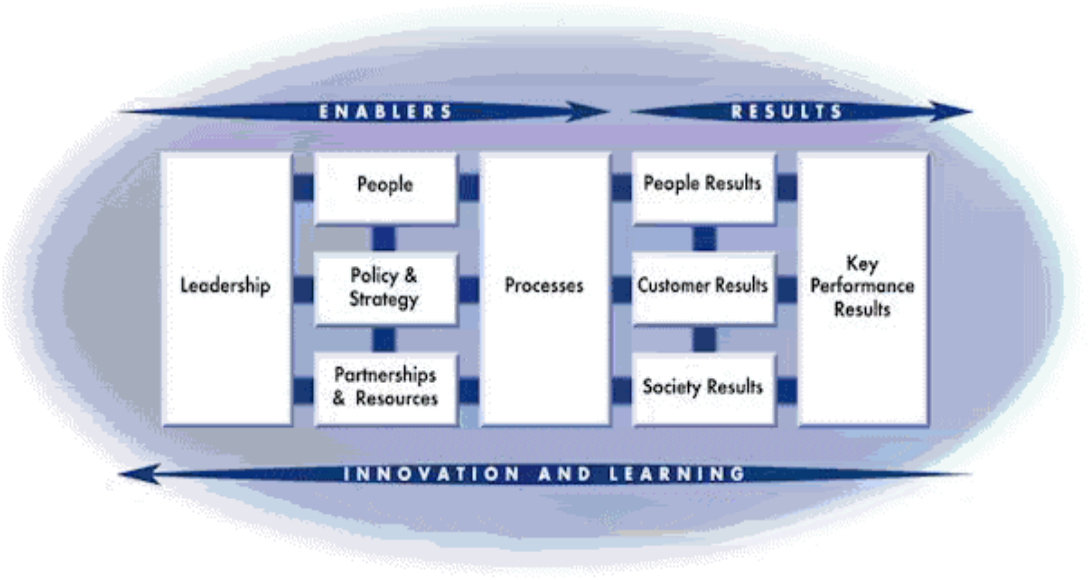

Figure 3.2 Concept of EFQM model [Source: EFQM (2003)]

The Balanced Scorecard (BSC) has been one of the most popular frameworks used for measuring organizational performance since its birth in the 1990s. It was developed by Kaplan and Norton (1992) and has been considered an excellent contribution to performance measurement. The concepts of BSC are illustrated in Figure 3.3. However, the four perspectives of the BSC have been considered insufficient by many researchers (Neely et al., 2002; Kagioglou et al., 2001).

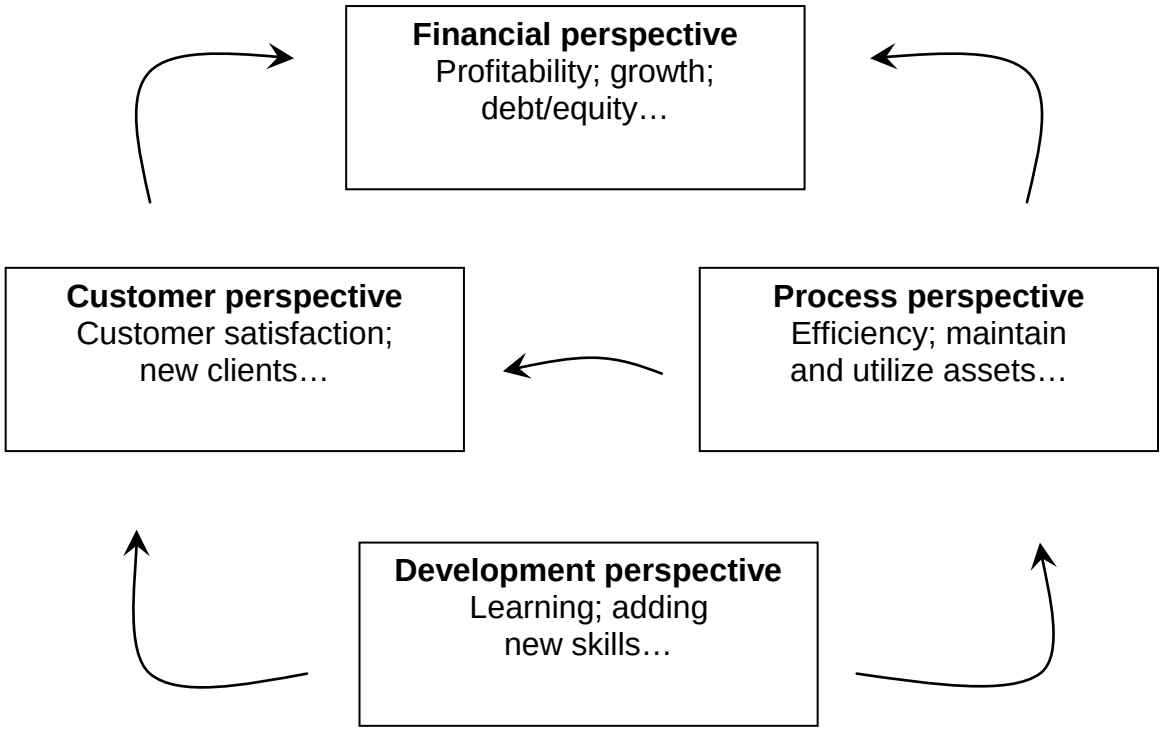

Figure 3.3 Basic BSC with examples of typical contents for each perspective [Source: Olve et al. (2003)]

Constructability programmes are defined as the application of a disciplined, systematic optimization of the procurement, construction, test, and start-up phases by knowledgeable, experienced construction personnel who are part of a project team. ("Constructability" 1991). It shares some common features with VM such as a systematic and team approach. There is also a need for developing a measurement framework so that the constructability performance may be documented and compared among projects and organizations (Russell et al., 1994). To meet this need, Russell et al .1994) developed a simplified framework for identifying and quantifying the costs and benefits stemming from implementing constructability at the project level. They divided the constructability benefits into quantitative and qualitative benefits, as shown in Table 3.9. Some of these quantitative and qualitative benefits, such as reduced cost, reduced schedule duration and reduced disruption to current

production, could also been adopted as indicators for measuring the performance of VM studies. However, most of these indicators are lagging indicators which could only be used to measure the benefits of VM studies to the project. Russell et al. (1994) also pointed out that accurately quantifying the benefits may not be possible when considering the qualitative benefits listed in Table 3.9. These qualitative benefits are difficult to measure due to the many interrelated factors that contribute to the final performance. It is difficult to identify and separate the impact of VM studies on the project. Other factors such as project management capabilities may affect the overall performance of the project.

Table 3.9 Quantitative and qualitative constructability benefits [Source: Russell et al. (1994)]

Constructability benefits	
Quantitative	Qualitative
Reduced engineering cost	Increased problem avoidance
Reduced schedule duration	Improved site accessibility
Reduced construction cost (labour, material, and equipment	Reduced disruption to current production
	Improved safety
	Reduced amount of rework
	Increased focus on a common goal
	Increased understanding of purpose/effect of individual's involvement
	Increased commitment from team members
	Increased communication
	Enhanced team building and cooperation
	Increased construction flexibility
	Reduced maintenance cost
	Protected equipment
	Smoother start-up
	Shortened offsite leasing

	Reduced amount of material handling of inventories
	Improved production efficiencies
	Accounted for future expansion on site
	Accounted for future expansion of building
	Sales tool for constructor to receive additional work

3.6.3 Benchmarking approach

Benchmarking is a technique used by researchers to measure the performance of VM studies. Male et al. (1998b) developed a benchmarking methodology for value management, which takes into consideration both objective indicators and subjective indicators to indicate the performance of a VM study. The construction best practice program (CBPP) developed a KPI framework in the late 1990s, which is now used by many European construction organizations. It provides a tool to benchmark activities both at a strategic level and at an operational level (KPI Working Group, 2000). The Construction Industry Institute (CII) also developed a benchmarking programme called CII Benchmarking & Metrics (CII, 2006), which helps member companies with statistical measurements that can improve the effectiveness of a capital project. The data collected for benchmarking could also be used for statistical studies. For instance, Lee et al. (2004) measured the value of best practices based on data taken from the CII Benchmarking and Metrics database.

These different approaches of performance measurement have their own characteristics. In order to develop a suitable performance measurement framework for VM studies, the chosen approach for measurement has to be in line with the nature of VM studies. Considering a VM study as a project or a service, the major factors influencing the performance have been identified in the last chapter. Considering a

VM study as a process of construction project management, the following factors will be important when measuring:

- Project
- Post project evaluation (PPE)
- Post occupancy evaluation (POE).

Meanwhile, two major issues relating to performance measurement should also be considered:

- Critical success factors (CSFs)
- Key performance indicators (KPIs).

These five factors, added to the eight factors identified in Section 2.5.2 as essential factors for guiding the implementation of VM studies, are the major factors influencing the performance measurement of VM studies in construction. They will be discussed in detail in Section 5.3.

3.7 Benefits and Critiques of Existing Measurement Frameworks

As mentioned above, many frameworks and models have been developed to measure the performance of organizations and projects. This section discusses the benefits and critiques of these existing frameworks in the context of VM and what lessons could be learned from these frameworks to measure the performance of VM studies.

The Balanced Scorecard (BSC) has been an excellent contribution to performance measurement, but it is not complete or comprehensive. The four perspectives of the BSC have been considered insufficient by many researchers (Neely et al., 2002;

Kagioglou et al., 2001). The four perspectives appear to be especially limited when measuring various kinds of VM studies. The BSC provides a valuable perspective to measure performance according to a multi-criteria principle that should be adapted to measure the performance of VM studies. However, months are required before the outcomes of implementing the BSC can be seen and the BSC focuses on strategy perspectives, so it is not suitable for VM studies, which last only a few days. The BSC was developed at a strategic rather than operational level, and each BSC will be different to meet the needs of specific organizations. It is inefficient to develop a specific BSC system for a specific VM study.

The EFQM and Baldrige models have gained much popularity in the field of performance measurement. The EFQM model provides a perspective to integrate result areas (lagging indicators) and organization areas (leading indicators) in one model, which can be adopted when measuring the performance of a VM study. However, studies have to be conducted to identify the proper criteria that meet the unique requirements of VM studies. The criteria of the EFQM model are fixed because of their similarity to organizational performance. This feature limits flexibility when measuring VM studies that are different from each other. Bassioni et al. (2004) listed the limitations of the overviewed performance measurement frameworks and excellence models after a general critique of their deficiencies:

1. Limited/non comprehensive performance criteria/perspectives;
2. No relation among criteria, or if relations exist, they are simple and do not simulate actual complexities;
3. No measurements of development or design processes;

4. Lack of implementation guidelines and long-term maintenance of the framework to adapt to changing environments; and

5. Little consideration for existing performance systems and their interaction with the model/framework.

The Project Excellence Model (Westerveld, 2003), which was developed from the EFQM model, uses five different project types to describe the project, giving guidance to the application of the model. This method could be adapted when measuring the performance of different types of VM studies. VM studies could also be classified as several types according to the different characteristics (Male et al., 1998a). The framework developed for measuring the performance of VM studies should be flexible to meet the needs of various types of VM studies (Lin et al., 2004). Guidance should be provided to explain the differences in applying performance measurement to different types of VM studies.

The KPI framework has also been considered problematic by some researchers. Kagioglou et al. (2001) pointed out that a) the indicators offer little indication from a business point of view, b) the framework lacks a holistic viewpoint on the relationship between the different indicators, c) none of the indicators are designed to measure the performance of suppliers, and d) none of the indicators deals with the “innovation and learning perspective.” Neely et al. (2002) figured out that benchmarking activities are for short-term improvement initiatives. Moreover, the KPI framework gives no explanation of the cause and effect between best practices and project processes. According to these problems and the uniqueness of VM studies, the benchmarking method is not suitable for measuring the performance of VM studies. However, the

benchmarking method could be implemented to collect and compare the values of indicators to identify the best practices.

Specifically, Table 3.10 shows the advantages of these popular frameworks.

Table 3.10 A Critical Comparison of Several Popular Frameworks

Frameworks or models	Multiple perspectives	Flexibility	Continuous measurement	Real-time feedback	Accessibility of data
Balanced Scorecard	√	√	√		
The European Foundation for Quality Management Excellence Model	√			√	√
The Malcolm Baldrige National Quality Award	√			√	√
Key Performance Indicator Framework	√		√	√	√

Major barriers to using these existing measurement frameworks have also been identified (Bititci and Carrie, 1998; Bourne and Neely, 2000). Because many existing performance measurement tools use historical data, they actually measure past performance, and there is a lack of immediacy between measurement and improvements. These tools often require cumbersome and time-consuming procedures of data collection, sorting, maintenance, and reporting. The value and usefulness of these tools have been seriously undermined because of the short durations of the VM studies. There is also a lack of appropriate models to effectively take into

consideration the non-financial and less tangible factors in relation to the processes of the VM studies. To overcome these deficiencies, an appropriate framework needs the following features:

1. The framework should measure not only the final outcomes but also the processes of VM studies.
2. The data collection and processing methods of the framework need to be prompt to provide timely feedback for corrective measures.
3. Indicators such as client's satisfaction and improved communication between stakeholders which is non-financial but critical to the success of the VM studies should be included in the measurement framework.

3.8 Benefits of IT Supported Performance Measurement

3.8.1 Difficulties in measuring the performance of VM studies

The measurement of VM studies is difficult when considered comprehensively. The reasons why the performance of VM studies is hard to measure are explained as follows:

Various types of VM studies

VM studies can be applied at any stage of a project. The objectives and processes of the studies are quite different (Male et al., 1998). For instance, the major objectives of VM studies applied in the briefing stage are to systematically identify and clearly define the client's requirements and to improve the understanding of various stakeholders' objectives, while the major objective of that applied in the detailed design stage is to seek the alternatives to save money and enhance the functions. Starting from these different objectives, the measures should be tailored. What is

more, each project is unique in features (Bassioni et al., 2004), so each VM study linked to a project is unique. The time requirements, budget constraints, focuses of VM studies are various. Special indicators should be designed to measure the performance of the unique aspects.

Time limitation

Normally, VM studies last for several weeks, including pre-workshop, workshop, and post-workshop phases (Norton and McElligott, 1995; Male et al., 1998). The workshops, however, often only last for several days, even one day in some cases (Male et al., 1998). Such a short period of time requires the measurement of the processes of VM studies to be very prompt (Lin et at., 2004). Otherwise, the benefit of real-time feedback is likely to be sharply reduced. On the other hand, the clients expect to have the performance report on the completion of the workshop, which assures them of the outcomes of the workshop. They will not wait until the completion of project construction for the measurement. Therefore, the time for collecting the relevant information to measure the performance of VM studies is quite limited.

Difficulties in data processing

It is critical to collect the right and accurate data to conduct the measurement (Kaplan and Norton, 1996). Partly because of the inaccessibility of the data, it is difficult to develop an appropriate and rigorous framework for measurement. The traditional way to collect objective data is to assign a secretary to record the processes and interim outcomes of the VM workshops. The subjective data is obtained by a survey after the workshop or is sometimes neglected (Liu, 2003). The facilitators have to

spend their time sorting through and analyzing the data after the workshop to measure the performance. This whole data collecting, sorting and analyzing process is time-consuming and ineffective.

Intangible performance

Apart from the tangible performances, such as the duration of the workshop, the number of ideas generated, the amount of cost savings and so on, there are also many intangible performances which are difficult to measure. Some of these intangible performances, such as the interaction among participants, the activity of participants and the participants' satisfaction, are critical to the success of VM studies (Shen and Liu, 2003). Judging by facilitators or surveying the participants after the workshop is the traditional way to measure the intangible performance, either subjective or lagging.

3.8.2 Potential benefits of utilizing IT in the performance measurement of VM studies

IT emerged as a key enabler to change the way business is conducted. Significant productivity improvements experienced by a wide range of industries have been associated with IT implementation (Stewart and Mohamed, 2004). The importance to and the need for IT in the construction industry have been recognized back to the 1980s (Barton, 1985; Meuller, 1986). The value that IT adds to construction organizations and projects, such as improved availability of information, better and faster decision making and quicker response to queries etc., has been reported by literature from the beginning of the implementation of IT in construction (Parker et al., 1988; DeLone and McLean, 1992; Priest et al., 1995; Cronk and Fitzgerald, 1998; Stewart and Mohamed, 2001).

The performances of the organizations and projects should be measured and managed in the rapidly developing market (Kagioglou et al., 2001). Therefore, integrating the measurement frameworks into computer-aided toolkits which make the measurements faster, smarter and easier is necessary in meeting the challenges. A lot of performance measurement and management software has been developed and widely applied to measure and monitor the performance of the organizations and projects. In many companies, significant improvements in performance measurement were achieved by using performance management software. It is anticipated that benefits such as time savings and easy data recording could be obtained by utilizing IT to facilitate performance measurement in VM studies. Some of the potential benefits of utilizing IT in the performance measurement of VM studies are discussed as follows:

Increased accuracy

The collection of data conducted manually, as in the traditional workshops, is criticized as being inaccurate (Davidson and Skibniewski, 1995). It is common to find some errors when checking the reports of previous VM studies. During the workshop, especially in the creativity phase, ideas are generated by the participants continuously, which leads to an incorrect record of ideas or even the missing of some ideas. This inevitable problem within the traditional data collection method in VM studies could be easily overcome by applying IT. Most of the data is collected and processed without human intervention, which could minimize the possibility of errors occurring (Navon, 2005).

Time-saving

Traditional measurement methods are based on manual data processing, which is time-consuming (Davidson and Skibniewski, 1995). The materials and documents yielded from the traditional face-to-face workshop are often complex and not in the required format. It may take the facilitators several days to retrieve the useful data from these tangled materials to conduct the measurement. This is probably why many clients and facilitators perform intuitive and infrequent measurements. By using IT systems, the collection, sorting and analysis of the data becomes effortless, for most of the work could be completed by the computer automatically (Shen and Chung, 2002). Therefore, the clients and facilitators could pay more attention to performance control and improvement.

Real-time feedback and control

Because current data collection methods are performed off-line, they do not enable corrective measures to be taken in time to mitigate the damage to an ongoing workshop. Corrective measures can be effective in ongoing workshops if they are taken in real-time or shortly after a deviation occurs. IT provides the ability of real-time feedback and control based on high-quality data which is essential to identify discrepancies between desired and actual performances (Navon, 2005). Such control enables timely corrective measures to be taken when needed and, consequently, a reduction in damages caused by the discrepancies.

Ease of benchmarking

The clients and facilitators use various methods to record the processes and outcomes of the VM studies and prefer different kinds of performance measurements.

Consequently, the reports of the studies are often in diverse formats and contain different information, which makes the benchmarking of these VM studies difficult. Facilitators have to make an effort to compare the studies with the historical ones to investigate the areas for improvement (Male et al., 1998; Liu, 2003). By applying IT, the data of previous VM studies could be stored in a database and be organized in a similar format. These data could be used at any time they are needed, especially while conducting a real-time comparison during the workshop.

3.9 Summary

Performance measurement has received increasing attention from organizations due to fierce competition in a global scope. Performance measurement models which merely focus on financial accounting are being replaced gradually by multi-perspective frameworks. Performance measurement in the construction industry has received more attention in the recent years. According to the review:

1. 61% of the papers related to performance measurement focused on the project level rather than the organization level;
2. 34% papers focused on overall performance;
3. Environmental performance and human resource performance received most attention.

The traditional performance measurement of VM studies, which focuses on cost reduction, was demonstrated to be insufficient. Many perspectives other than cost reduction should be considered seriously when measuring.

Three approaches, including a single-criterion measurement, multi-criteria measurement and benchmarking for measuring the performance of VM studies, have

been reviewed and discussed. The multi-criteria measurement approaches, not only for VM studies but also for other management tools and the whole project, are critically appraised. Previous research has identified the CSFs of VM studies and further research should be done to link CSFs to KPIs. Factors influencing the performance of VM studies based on the project view are summarized, including project, PPE and POE. CSFs and KPIs are two important issues which should be carefully considered when measuring. It is not suitable to adopt the existing popular measurement frameworks to measure VM studies. However, perspectives like multi-attitude measurement and could be adapted to develop a performance measurement framework for VM studies.

The implementation of IT in the performance measurement of VM studies helps to overcome the difficulties encountered by traditional manual measurement. The benefits of applying IT in the measurement of VM studies include improved accuracy, time-saving, real-time feedback and control, and continuous benchmarking.

This chapter provides a review of performance measurement which investigates the strengths and weaknesses of existing frameworks. The approaches for measurement have been summarized and factors influencing the performance of VM studies have been supplemented. This literature review is of great importance to the research as a whole in that it sets the scene for the research methodology and the theoretical framework that follow.

CHAPTER 4 RESEARCH METHODOLOGY

4.1 Introduction

The choice of research methodology should depend on the features and scope of the research. Research design is the plan which explains the overall scheme or programme of the research (Emory and Cooper, 1991). This research aims to develop a framework for measuring the performance of VM studies in construction. It is necessary to undertake a holistic exploration of the research methodology that relates to this research because of the complexity of the research. This chapter explains the research methods used in this research including interviews, questionnaire surveys, case studies and action research. “What are these methods?” “Why choose these methods?” and “How are they conducted?” are presented.

4.2 Qualitative interviews

The qualitative interview can be defined as a conversation that has the following characteristics: it is elicited by the interviewer; interviewees are selected on the basis of a data-gathering plan; a considerable number of subjects are interviewed; it has a cognitive objective; it is guided by the interviewer; it is based on a flexible, non-standardized pattern of questioning (Corbetta, 2003). The qualitative interview does not simply involve recording information; it is a process of social interaction between two individuals.

According to Corbetta (2003), qualitative interviews can be classified as one of three types. In structured interviews, all respondents are asked the same questions with the same wording and in the same sequence (the questions are predetermined both in

content and in form, as in a questionnaire with open questions). In semi-structured interviews, the interviewer does not pose pre-written questions, but refers to an 'outline' of the conversation (only the content, not the form, of the question is predetermined). In unstructured interviews, the interviewer's only task is to make sure that predetermined topics that are dealt with during the conversation, according to forms and modes that he feels are most adequate in the particular interviewing situation.

4.2.1 Interview 1

At the early stage of this research, semi-structured interviews allow researchers to obtain first-hand information from practitioners on the use of performance measurement models in assessing VM studies in construction, the content of the proposed measurement framework, and the desired functionalities of the computer-aided toolkit. The objective of these interviews is to help the researchers collect as much useful information in this area as possible. Without pre-written questions, semi-structured interviews allow the researchers to explore these issues in depth by communicating with VM experts, while a list of questions related to the research are prepared to ensure the direction of the interviews.

4.2.2 Interview 2

Structured interviews are also used in this research when validating the developed framework to provide the researchers with direct feedback about the research findings. The objectives of the interviews are:

1. To seek the generic opinions of the experts on this framework as to whether it solves the problems that occur in VM;

2. To refine the KPIs identified by the previous questionnaire and the issues raised in the focus group meeting;
3. To refine the data collection methods including data providers, the weightings of KPIs and the definition of the scorings.

Therefore, the questions are all pre-determined to focus on the validity of the framework.

The selection of individuals for Interview 2 was done with regard to practical issues such as location and availability. Because the author is based in Hong Kong, the interviewees were also selected in Hong Kong. The works departments under the Development Bureau of Hong Kong SAR including the Architectural Services Department, the Civil Engineering and Development Department, the Drainage Services Department, the Water Supplies Department and the Highways Department under the Transport and Housing Bureau are the major clients conducting VM studies in their public projects. Therefore, representatives of these departments who had experience were selected as interviewees. In practice, the governmental departments normally outsource the VM studies to construction consultant companies in Hong Kong. These consultant companies help the government manage the whole VM processes. Representatives from these consultant companies were targeted. The certificated VM facilitators listed in the Hong Kong Institute of Value Management were also targeted interviewees as they have first hand experience with VM studies. In all, twelve interviews were conducted. Ten interviewees were from the governmental sector and two from consultant companies. Two of the interviewees are certificated VM facilitators who have facilitated lots of VM studies initiated by the Hong Kong government. Five interviewees from the governmental sector are the

contact officers in works departments who are in charge of VM issues in their departments. The other interviewees from the governmental sector have performed as the client's representatives in previous VM studies.

All interviews were approximately 45 minutes. They were conducted at the interviewees' office or in an adjacent room. A background paper was sent to each interviewee before the interview to help them understand the framework. The interviews started with a brief introduction of the framework developed by the authors. Following this were the generic questions about their opinions of the framework. The questions are shown in Table 4.1. These questions validates whether the framework solves the problems that occur in the implementation of VM studies. The interviewees were also asked whether they would use this framework to measure the performance of VM studies in the future.

Table 4.1 Generic questions for Interview 2

To what extent do you agree with the following statements about the framework	**5**	**4**	**3**	**2**	**1**
This framework can ensure you about the returns of VM studies.					
The measurement results of this framework can help the development of VM methodology.					
This framework can achieve real-time management of the performance of VM studies.					
This framework fulfils your measurement requirements of VM studies.					

Note: *(5: Strongly Agree 4: Agree 3: Neutral 2: Disagree 1: Strongly Disagree)*

The second part is the discussions on the three performance perspectives and associated KPIs. Regarding each perspective, the interviewees were asked to answer four questions:

1. Is the list of KPIs completed? Interviewees were asked to check the initial list of KPIs to see whether there were any other KPIs missing from the list or any KPIs in the list which are not important in their opinion. The reason why a KPI should be added or deleted was also asked.
2. Who should score the indicators? Interviewees were asked to determine the appropriate people to score the KPIs. Why they made such decisions was also asked.
3. How should the indicators be ranked? Interviewees were asked to conduct a pair-wise comparison exercise of the KPIs associated with this measurement perspective. The example form for the exercise is shown as Table 4.2.

Table 4.2 Form for pair-wise comparison exercise to predicting indicators

KPIs	A	B	C	D	E	F
A. *Clear objectives of workshop*						
B. *Client's participation*						
C. *Client's support*						
D. *Disciplines of participants*						
E. *Qualification of facilitator*						
F. *Relevant departments' support*						

4. How should the scores be defined? Interviewees were asked to give a definition to the scorings of each KPI from five to one where five means the

best performance and one means the worst performance. Due to the time limitation, the answers for this question were collected after the interviews via email.

4.3 Questionnaire survey

In questionnaire survey, the respondents are asked the same questions in the same circumstances. Careful piloting is necessary to ensure that all the questions mean the same to all respondents. Information is gathered by means of self-completion questionnaires. The aim is to obtain answers to the same questions from a large number of individuals to enable the researcher to not only describe but also to compare, to relate one characteristic to another and to demonstrate certain features that exist in certain categories (Bell, 2005). Bell (2005) Pointed out that the questionnaire surveys can provide answers to the questions 'What?' 'Where?' 'When?' and 'How?', but it is not so easy to find out 'Why?'. A causal relationship can rarely be proved with the survey method. The main emphasis is on fact-finding.

The questionnaire survey is used to identify the KPIs of the measurement framework in this research by asking VM experts all over the world to rate the importance of each potential indicator. The reason for selecting a questionnaire to identify the KPIs is because this method could collect more data for analysis which makes the findings more objective. By the collection of a number of data relating to the importance of the indicators from the questionnaire survey, it is possible to conduct a factor analysis to investigate the interrelationship of these KPIs.

The respondent was required to tick the weighting of each potential indicator on a scale ranging from: (0) useless; (1) least important; (2) slightly important; (3) somewhat important; (4) important; and (5) very important. Open questions are given in the questionnaire to collect the indicators which are considered to be important by the respondents but not included in the potential indicators. The questionnaire also contains questions on the background of the survey respondents.

The questionnaire was sent to 285 VM practitioners. Qualified VM facilitators, architects, engineers, surveyors, consultants and government officers were carefully selected from the list of delegates attending the international conferences on VM hosted by SAVE International and The Hong Kong Institute of Value Management from 2005 to 2007, and were found by searching the lists of delegates. These experts are either VM clients or practitioners who are active in the construction industry, which ensures that the indicators identified focus on VM studies in construction. This method has been used by Shen and Liu (2003) and was shown to be reliable.

4.4 Focus group meeting

A focus group is a form of qualitative research in which questions are asked in an interactive group setting where participants are free to talk with other group members. It allows the researchers to study people in a more natural setting than a one-to-one interview. Focus groups have a high apparent validity – since the idea is easy to understand, the results are believable (Marshall and Rossman, 1999).

The disadvantages of focus group meetings are that the researcher has less control over a group than in a one-on-one interview, and thus time can be lost on issues irrelevant to the topic; the data are tough to analyze because the talking is in reaction to the comments of other group members; observers/moderators need to be highly trained, and groups are quite variable and can be tough to get together. A fundamental difficulty with focus groups is the issue of observer dependency: the results obtained are influenced by the researcher, raising questions of validity (Walvis, 2003).

In order to ensure the reliability and validity of the developed performance measurement framework for VM studies in construction, a focus group meeting was conducted to further investigate the KPIs identified by the questionnaire survey. Focus group meetings enable us to obtain valuable views and insights from VM practitioners and clients. During these meetings, we can ask and adapt questions as necessary, ensure that questions and responses are properly understood by repeating or rephrasing them and pick up non-verbal cues from the respondents.

Eight participants attended the focus group meeting, including one facilitator, four government representatives, two VM researchers and the author. The facilitator is a world famous VM facilitator who has more than 20-years' experience in VM. The four government representatives each have more than 10-years' working experience in construction-related departments and have attended VM studies in their departments. Two of them are VM experts in the governmental sector. The private developers and quasi-governmental organisations were also invited to attend the focus group meeting. No representative from these two parts accepted the invitation. The reasons maybe that the private developers in Hong Kong seldom use VM in their

projects in recent years so there is limited motivation for them to spend time in this area.

The focus group meeting was conducted at the Royal Garden Hotel in Hong Kong and lasted for two hours. The focus group meeting was divided into three parts. The first half an hour was spent sharing the information among the participants about VM practices as well as the performance measurement of VM studies in their work. Afterwards, a brief introduction to the development of a performance measurement framework for VM studies in construction was presented. General opinions of the participants on the framework were collected after the presentation. Finally, the KPIs identified by the previous survey were discussed in detail.

4.5 Case study

A case study approach can be particularly appropriate for individual researchers because it provides an opportunity for one aspect of a problem to be studied in some depth (Bell, 2003). The objectives of using case studies are to identify the common and unique features, to identify or attempt to identify the various interactive processes at work, and to show how they affect the implementation of systems. These processes may remain hidden in a large-scale survey but could be crucial to the success or failure of systems. Yin (1994) pointed out that the more a study contains specific propositions, the more it will stay within reasonable limits. Critics of the case study approach draw attention to a number of problems such as the difficulty in cross-checking information, selective reporting and distorted results (Bell, 2003).

In this research, the case studies are used to gain a comprehensive and in-depth understanding of performance measurement of VM studies in practice. The feasibility and validity of the framework and the computer-aided toolkit are confirmed by the case studies focusing on specific aspects of the framework. It allows the researchers to find the problems and advantages of the developed framework in practice.

Due to the confidential issues and limited numbers of VM studies conducted, it is difficult to use real-life VM studies for case studies during the research period. Alternatively, experimental VM studies conducted by construction practitioners who attend the VM courses in Hong Kong Polytechnic University were used. These practitioners are from the construction industry of Hong Kong, including quantity surveyors, architects, government officers and project managers. They are the potential participants of real-life VM workshops in construction and have adequate exposure to both VM methodology and the construction industry. They can conduct the VM studies based on the real-life projects approximate to the real-life studies when acting as relevant VM team members. The disadvantage of using experimental VM studies includes that the participants are not real stakeholders of the projects. Their opinions are not given based on solid knowledge background. This may undermine the results of VM studies. However, this research is to use case studies to test the performance measurement framework, the results of VM studies do not affect a lot to the testing.

4.5.1 Case Study 1

4.5.1.1 Objectives of Case Study 1

This study goes beyond the initial development of the framework perspectives and indicators by presenting two VM workshops, which allows for an investigation of the feasibility and validity of the framework. Because the framework starts from the objectives of the workshops, the first hypothesis is:

H1: VM studies which have clearer objectives will lead to better outcome performance.

The leading indicators which represent the process could predict the outcomes of the workshops. Better process performance should lead to better outcome performance. Therefore, the second hypothesis is:

H2: VM studies which have better scores in leading indicators will have better scores in lagging indicators.

It should be noted here that the objective of this study is not to investigate the full measurement process introduced in the detailed framework. That task is beyond the scope of this study since it would require the record of the completion of a project over a period of several years. However, this case study investigates the period from the start of the study to the end of the workshop, which is regarded as the key period of a VM study.

4.5.1.2 Design of Case Study 1

Two experimental studies were carried out to implement the performance measurement framework. The participants of the two studies are practitioners in the

construction industry who were attending a VM course at The Hong Kong Polytechnic University. Each VM study had 17 participants and was prepared independently. A task based on the information of a real public project was used in these two studies. The same difficulty level of the task made the results of the two workshops comparable. The participants acted as the key stakeholders of the real project in the VM study. The two groups choose different methods to conduct the workshops. One chose the traditional face-to-face approach and the other chose the computer-aided approach. A period of three weeks was given to the groups to prepare for the workshops and a one and a half day workshop was conducted by each group. Two colleagues attend the workshops as observers. The relevant data were collected by the observers without interrupting the process of the workshops. The computer-aided toolkit entitled “Interactive Value Management System” also automatically recorded some objective data in one of the workshops. Figure 4.1 and Figure 4.2 show the two workshops in progress.

In order to test H1 and H2, no corrective measures were conducted during the processes of the workshops. Because no corrective measures were needed, the data of some leading indicators which are subjective were collected with a questionnaire at the end of the workshops to avoid interruptions of the workshops.

Figure 4.1 Traditional face-to-face workshop

Figure 4.2 Computer-aided workshop

4.5.2 Case Study 2

4.5.2.1 The background of the experimental study

The primary objective of the study was to investigate the differences between the traditional performance measurement methods of VM studies and the IT supported

performance measurement. Consequently, these two studies were conducted similarly. The two studies were carried out by two groups of construction professionals who were taking the subject "Value Management in Construction and Property" in the Hong Kong Polytechnic University. Both of the groups had 19 participants including the facilitator and a tutor to help them organize the VM studies. All of them attended a lecture on how to conduct a one day VM workshop. Participants of VM Study B who used the IVMS were given an extra lecture on the implementation of the system and each participant was assigned a computer to use in the workshop. The participants of both VM studies were asked to conduct a one day workshop. The difficulty of the tasks of these two studies was similar for both groups. In order to record the required data for measurement, a performance evaluator who did not join the discussion of the task was assigned to VM Study A.

4.5.2.2 Factors used for validation

IT provides great advantages in speed of operation, consistency of data generation, accessibility and exchange of information etc. (Stewart and Mohamed, 2004). Great efforts have been made by the researchers to investigate the performance improvement resulting from IT implementation (DeLone and McLean, 1992; Priest et al., 1995; Stewart and Mohamed, 2001 and 2004). DeLone and McLean (1992) divided those factors that contribute to information systems success into six categories: system quality, information quality, use, user satisfaction, individual impact and organization impact. Stewart and Mohamed (2001) reviewed previous research in this field and developed a framework to assess the success of IT implementation. The framework was tested and refined by their following research (Stewart and Mohamed, 2004).

This research focuses on the benefits IT adds to the performance measurement of VM studies. Therefore, several related factors have been adapted from the framework developed by Stewart and Mohamed:

- Response time (time-saving)
- Feedback (time-saving, real-time feedback and control)
- Decision making (increase accuracy, time-saving, ease of benchmarking)
- More satisfied participants (general)

Table 4.3 lists the factors related to the success of IT implementation in measuring VM studies. The values of the measures could be directly obtained from the VM workshops.

Table 4.3 Factors to validate the use of IT in measuring VM studies

Factors	Key aspects	Measures
Response time	IT system reduces the time for data collection and processing	– Time taken for idea collection
		– Time taken for idea categorization
		– Time taken for questionnaire survey (including data analysis)
Feedback	IT system enhances the real-time control of the VM study	– Time of feedback
		– Time taken for feedback
Decision making	IT system improves the quality and accessibility of the performance report.	– Mistakes in the report
		– Satisfaction of decision maker to the performance report
		– Time taken to provide the performance report to the decision maker

More satisfied participants	The participants of the workshop are satisfied with the performance measurement and management throughout the study	– Satisfaction of participants with the performance measurement of the VM study

4.6 Action research

Action research is a reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems. It is an iterative inquiry process that balances problem solving actions implemented in a collaborative context with data-driven collaborative analysis or research to understand underlying causes enabling future predictions about personal and organizational change (Reason and Bradbury, 2001).

Action research involves the researchers as part of the situation under exploration, and all individuals involved in the study are contributing actors in the research (Gabel, 1995). This is very appropriate for examining the real effect of using the proposed framework in VM studies.

The primary objective of action research is to investigate the application of the preliminary performance measurement framework in a VM workshop to find the advantages and disadvantages which will be borne in mind to develop the detailed framework. It also tries to validate whether real-time feedback could improve the performance of the VM study.

The scenario of the VM study is adopted from governmental documents, described as follows:

The residential development at the existing site No.15 Wylie Path Kowloon is 40 years old. The last renovation works were carried out in 1996. A recent building survey reported that there was a lot of spalling concrete in the buildings and the conditions of the lifts, electrical and fire services installations, and drainage were poor. Structural cracks were found at the two carport levels and the swimming pools on the podium.

There are five blocks of 20-storey buildings at the existing site. Three blocks (A, B and C) are Government accommodation and two blocks (D, E) are the purchaser's accommodation. The Government leased the land for Block D and E to Win Hin Development Co. Ltd. (WH) for 75 years starting from 1 April 1963 on condition that WH should construct Block A, B and C for the Government's accommodation at no cost to the Government. The lease condition has not been expired yet.

It was assumed that the Government wholly owned blocks A, B & C and possessed 60% of the shares of the common areas and facilities. WH had 50% of the shares of blocks D & E and 20% of the common areas. The individual owners of blocks D & E (the Incorporated Owners of Block D & E) held the remaining 50% of the shares of blocks D & E and 20% of the common areas.

The Architectural Services Department (ArchSD) was requested by the Government Property Agency (GPA), called the 'Client' below, to carry out an evaluation study to

optimize the use of the existing site and to explore other uses of the land. The proposed options may have included renovation of the existing buildings, demolition of the existing buildings and development of new buildings which may be for residential buildings, offices, social or recreational facilities, etc.

Based on the aforesaid scenario, the experiment was carried out with the cooperation of a group of construction practitioners who were taking the subject 'Value Management in Construction and Property' at the Hong Kong Polytechnic University. These construction practitioners are the same as the targeted participants who are from the works departments of the Government, contractors, construction consultant companies and architectural companies in the real life VM studies in Hong Kong. They attended a lecture on the application of VM in the briefing process and were provided with a briefing guide titled 'A Guide to Value Briefing'. These 19 participants were instructed to act as a team of professionals including VM facilitators, client's representatives and other key stakeholders in order to conduct this VM study, which included preparing and attending a one day workshop and production of the VM report for the project. The researcher attended the whole process of the VM study as an observer and scored the potential indicators. Real time feedback was given by the researcher after each stage of the VM study, lasting for three to five minutes. Follow-up questionnaires were given to the participants to seek their opinions of the feedback.

4.7 Summary

Research methods including interviews, questionnaire surveys, a focus group meeting, case studies and action research have been used in this research. Interview 1 is a semi-structured interview which was conducted at the early stage of this research to obtain first-hand information from VM practitioners. Interview 2 is a structured interview which was conducted after the development of the measurement framework to refine and validate the developed framework. A questionnaire survey was used to identify the KPIs by collecting the opinions of 285 VM practitioners. A focus group meeting was conducted to further investigate the KPIs identified by the questionnaire survey. Both Case Study 1 and Case Study 2 are comparison studies. Case Study 1 was conducted to prove:

1. Whether clearer objectives lead to better outcome performance,
2. Whether better scores in leading indicators lead to better scores in lagging indicators.

Case Study 2 was conducted to investigate the differences between the traditional performance measurement methods of VM studies and the IT supported performance measurement. Action research investigated the application of the preliminary performance measurement framework in a VM workshop to find the advantages and disadvantages which will be borne in mind to develop the detailed framework. It also tried to validate whether real-time feedback could improve the performance of the VM study.

The research methods explained in this chapter provide a logical route for the development and validation of the developed framework and computer-aided toolkit. The following chapters introduce how a performance measurement framework for

VM studies in construction and its relative computer-aided toolkit are developed step by step.

CHAPTER 5 THEORETICAL FRAMEWORK FOR THE MEASUREMENT FRAMEWORK

5.1 Introduction

Verma and Beard (1981) pointed that the importance of theory is to help the researcher summarize previous information and guide the future course of action. Sometimes the formulation of a theory may indicate missing ideas or links and the kinds of additional data required. They also claimed that theory is an essential tool of research in stimulating the advancement of knowledge still further. According to Miles and Huberman (1994), a theoretical framework is an explanatory device which explains, either graphically or in narrative form, the main things to be studied including the key factors, constructs or variables, and the assumed relationships among them. This chapter first explains the linkage of the different views of VM and different measurement approaches. Based on the thirteen factors extracted from the literature and interviews, the theoretical structure and the theoretical framework for this research are then established.

5.2 Linkage of Different Views of VM studies and Different Measurement Approaches

5.2.1 Understanding the different views of VM studies

The performance measurement rationale to VM studies is based on the way of seeing and representing VM studies. This sub-section further discusses the three views of VM studies which have been introduced in Chapter 2: seeing a VM study as an interim process of the whole project management process (process view), seeing a VM study as an entire project (project view), and seeing a VM study as a service

provided to the investor (service view). These different views affect the adoption of the performance measurement approaches in practice.

According to the definition given by (AS/NZS 4183, 1994), VM is a structured and analytical process that seeks to achieve value for money by providing all of the necessary functions at the lowest cost consistent with required levels of quality and performance. It has been introduced into the construction industry as a useful tool for project managers to cope with challenges (Shen et al., 2005). VM studies can be applied at any phase from the inception to the completion of a project (Male et al. 1998a). Based on this process view, the performance of a VM study should be indicated by the benefits brought by applying the study to the whole project. These benefits include cost saving, time saving on construction, reduction of rework, etc. (Kelly and Male, 1993; Liu, 2003). However, the cost, construction time and other variables which can be obtained at the completion of the project may be affected by some other internal or external factors. It is difficult to identify the impact arising from the VM studies.

VM has a systematic job plan which includes a pre-study phase, a value study phase and a post-study phase (SAVE International, 2001). It starts from the client's brief which calls for VM proposals and ends in the implementation of the alternatives recommended by the VM study. Time, money and other resources have to be assigned to conduct VM studies. Therefore, a VM study could also be considered as an entire project which aims to achieve the clients' objectives (Male et al., 1998a). Based on the project view, the performance measurement should focus on VM study itself. The performances of VM studies could be categorized as outcome performance and

process performance (Shen et al., 2005). Outcome performance includes the number of recommendations, the time and money used for conducting the VM workshop, the quality of VM report, etc. (Lin et al., 2004). The values of the indicators which could indicate the outcome performance are often obtained after the completion of VM studies. Process performance includes clarification of functions, interaction between participants, etc. (Lin et al., 2004). The value of these process indicators could be obtained while a VM study is ongoing. Real-time feedback and control based on process-related performance measurement is essential to identify discrepancies between desired and actual performances. Such control enables timely corrective measures to be taken when needed and, consequently, a reduction in damages caused by the discrepancies (Lin et al., 2005).

VM could also be considered as a service provided to the client who invests on it. This service brings together a multidisciplinary team of stakeholders to review the project, and develops alternative recommendations under the direction of a professional facilitator who follows the job plan. Based on the service view, the satisfaction of the stakeholders of VM studies, namely the client, the VM facilitator and the VM team members, are important indicators. A most important measure in any measurement of a service's performance is whether it satisfies the client's requirements and what clients think and feel about it. Performance is oftentimes more difficult to quantify and is often subjective in nature (Stewart, 2004). The satisfaction of stakeholders with the performance of VM studies could indicate the performance of VM studies in a simple format. Male et al. (1998b) developed a benchmarking study for value management. The research team concluded that client satisfaction would be

a good indication of the performance of VM applications by eliminating other objective indicators.

5.2.2 The links between the views and approaches

By understanding the different views of VM studies and reviewing the different approaches to measure the performance, the building of the links between the views and approaches will help researchers better understand the principles for measurement. Figure 5.1 presents the relationship between the views and some performance measurement approaches in the context of VM. Each view of VM studies can be embraced in several approaches. For instance, the process view of VM studies could be found in approaches such as focusing on the single-criterion of cost saving, a multi-indicator approach, and the EFQM model. Conversely, each approach may represent one or more views of VM studies. An approach that focuses on the single-criterion of cost saving emphasizes the cost reduction to the project and therefore takes the VM studies as an interim process of a project. However, approaches such as the EFQM model and BSC contain more than one view. In these approaches, different views of VM studies are considered holistically to procure a better performance measurement.

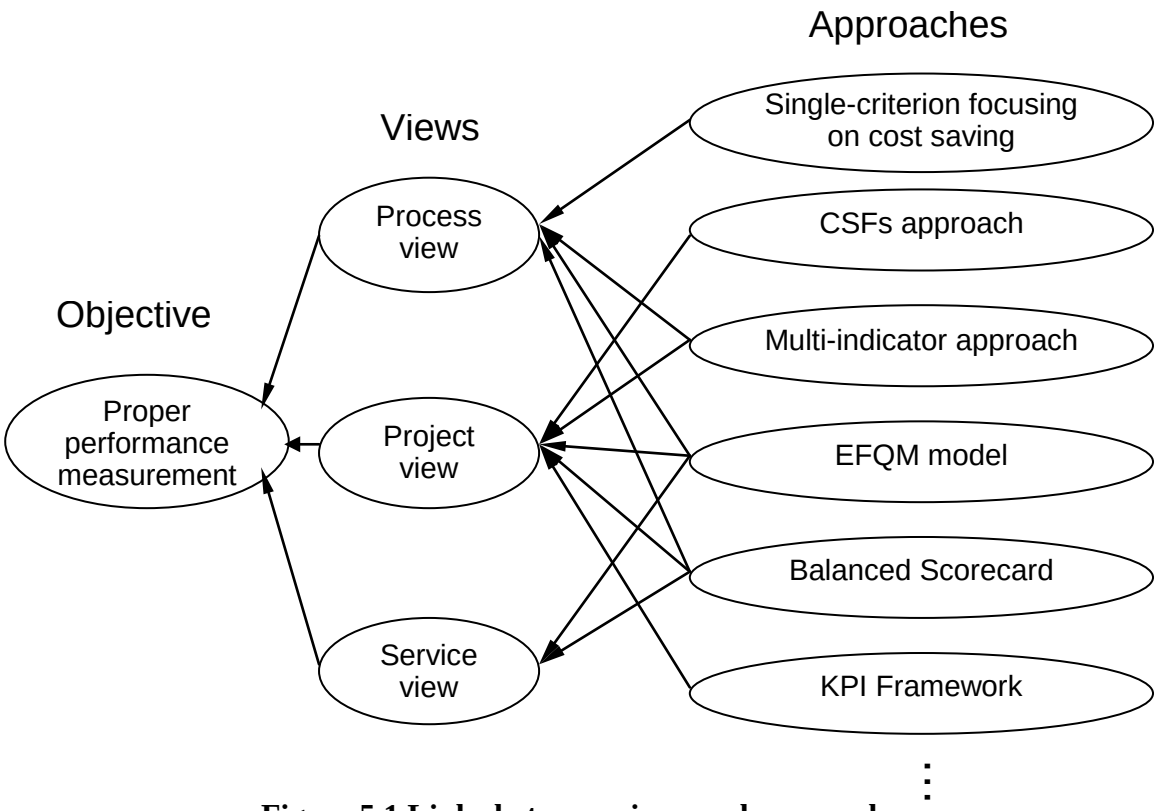

Figure 5.1 Links between views and approaches

The process view of VM studies requires that the performance measurement reveal the benefits to the project of conducting VM studies. The returns on the investment in VM can be identified by this kind of performance measurement. The performance measurement based on the project view of VM studies can reveal the advantages and disadvantages of the way that a VM study has been conducted. Thus, areas for improvement could be identified and corrective measures could be taken. The service view of VM studies matches the performance measurement to the client's objective. This kind of performance measurement highlights to what extent the client's objectives have been achieved in the VM studies. Hence, a combination of different views of VM studies will lead to a better performance measurement than one based on an isolated view.

5.3 Thirteen Factors Influencing the Performance of VM Studies

An in depth investigation of the factors which have an influence on the performance of VM studies is necessary to establish the theoretical foundation of the research. Based on these factors identified from the nature of VM studies, the overall processes of projects, and the principle of performance measurement, the research foundation can be established. Thirteen major factors which have an impact on the performance of VM studies are listed and briefly described as follows:

1. Projects
2. Clients
3. Facilitators
4. Participants
5. Team and team dynamics
6. Techniques used in VM studies
7. Time and venue of VM studies
8. Process of VM studies
9. Types of VM studies
10. Critical Success Factors (CSFs)
11. Key Performance Indicators (KPIs)
12. Post Occupancy Evaluation (POE) and
13. Post Project Evaluation (PPE).

Projects

A project, as defined in the field of project management, consists of a temporary endeavour undertaken to create a product or service (PMI, 2004). In this research, the

term project is used to represent construction project, which could be building a house, a public facility, or even remodelling or upgrading a building. Although the types of projects differ, they do have at least four traits in common:

1. Each project is unique and not repetitious;
2. A project works against schedules and budgets to produce a specific result;
3. The construction team cuts across many organizational and functional lines that involve virtually every department in the company;
4. Projects come in various shapes, sizes, and complexities.

Based on the process view, VM studies are one of the processes which constitute the overall construction project activities. They could also be seen as mini-projects in themselves according to the project view. Therefore, VM studies have similar traits as projects. Attention should be paid to the characteristics of a project when measuring the performance of VM studies.

Clients

The definition of a client in the construction industry is a person or group of people dealing with the effects of change, who is in a building environment, and who is in need of professional assistance. According to Yu (2007), the client type can be categorized according to three parameters: size (large or small), sector (public or private) and project interest (development or owner occupation). It is of key importance to ensure the clients' support of and the adequate representation of client groups in the VM studies to clarify the objectives of VM as well as to implement the suggestions of a VM study completely. The client's satisfaction with the VM study has been considered by many researchers as one of the key performance indicators to measure the performance of VM.

Facilitators

The VM facilitator controls and leads a group of individuals working together to reach the objectives of the study. In the context of a value management exercise, a skilled facilitator can efficiently manage a temporary team so that maintenance behaviour is minimized and task behaviour maximized. It has been recognized that the VM facilitator performs a vital role in the VM process and is a significant attribute in the degree of success achieved (SAVE International, 2001).

Participants

The participants of VM studies are those who make the decisions about and add value to the target project through the systematic approach of VM studies. The professional experience, knowledge and personalities of participants were claimed as critical success factors by Shen and Liu (2003). Essentially, participants should include all relevant disciplines and stakeholders to fully cover the issues in the study. The choice of the participants for the study is an important factor that should be borne in mind in the measurement according to Shen and Liu (2003).

Team and Team Dynamics

A team is defined by Cook et al (1997) as “a type of group with complementary skills, competencies and knowledge, who are committed to a common purpose, set of performance goals and approach for which they will hold themselves mutually accountable”. Kelly et al (2004) claimed that the characteristic of VM as a facilitated team activity is one part of the formula that makes VM unique as a management technique.

Techniques Used in VM Studies

In the context of VM, 'techniques' means those tools used in the process of a VM study to facilitate the study. Techniques such as function analysis in the analysis phase and brainstorming in the creativity phase make the VM methodology different from other management methodologies. Using appropriate techniques in line with the characteristics of a unique VM study will maximize the function of the VM approach. Dallas (2006) summarized the VM techniques as follows:

1. Function analysis
2. Function analysis system technique
3. Cost/worth
4. Multifunctionality
5. SMART methodology
6. Value drivers
7. Value profiling (or value benchmarking)
8. Option selection
9. Weighting techniques
10. Generating ideas for adding value (creative techniques)
11. Selecting the best ideas (evaluation)
12. Developing implementation proposals
13. Scenarios
14. Target costing
15. Function performance specification

The list of techniques used in VM studies is still growing. It is necessary to investigate the efficiency and effectiveness of the techniques used in VM when measuring the processes performance of a VM study.

Time and Venue of VM Studies

Kelly and Male (1993) claimed that VM should be performed as early as possible to exert its potential for value enhancement. However, VM studies are in reality conducted in different time slots of the project. Attention needs to be paid to the time when VM study is applied in the measurement, especially when doing comparisons or benchmarking. A good venue, which is quiet, pleasing and inspiring, will help the participants concentrate on the study and generate more outcomes.

Process of VM studies

According to Yu (2007), the process of VM uses structured, team-oriented exercises that make explicit and appraise existing or generated solutions to a problem. Pre-workshop phase, six major phases in the workshop, namely information phase, analysis phase, creativity phase, evaluation phase, development phase and presentation phase, and post-workshop phase in the process of VM studies are introduced in Chapter 2. Real-time feedback from each phase is critical to conduct a prompt measurement to effectively direct the right way of VM study.

Types of VM Studies

There are different types of VM studies which have different characteristics. Section 2.5.2 lists the existing frameworks for implementing VM. According to Kelly and Male (1993), most American projects adopt the 40-hour job plan with less than 10

participants, while Hong Kong practitioners prefer to complete the workshop in one or two days with more than 10 participants (Fong and Shen, 2000). Performance indicators will be different considering the types of VM studies. This research focuses on a typical VM study which has six phases in the workshop stage and is conducted at the early stage of a project. The frameworks for measuring the other types of VM studies could be developed based on the prototypal measurement framework developed in this research.

Critical Success Factors (CSFs) and Key Performance Indicators (KPIs)

CSFs are the statements of how improved business practice must be achieved if an organization is to be able to attain its mission. KPIs are the means by which an organization can measure the progress being made to ensure that the critical success factors are being achieved. A CSF is not a KPI. CSFs are elements that are vital for a strategy to be successful. KPIs are measures that quantify objectives and enable the measurement of strategic performance. Previous researchers identified many CSFs for VM studies (Male et al., 1998b; Shen and Liu, 2003), each of which should have a few KPIs that can be measured and quantified.

Post Occupancy Evaluation (POE) and Post Project Evaluation (PPE)

POE is defined as the 'examinations of the effectiveness for human users of occupied design environments' (Zimring and Reizenstein, 1980). PPE is the process of assessing the impact of a project after it has come to an end. It is an essential aid to improving project performance, achieving the best value for money from public resources, improving decision-making and learning lessons. POE and PPE can provide "lessons learned" that can be applied to future projects to reduce cost and

enhance building quality. Successes, failures and past experiences of what does and does not work well could be used to demonstrate the effectiveness of VM studies and to inform better implementation of VM studies.

5.4 Theoretical Structure for the Measurement Framework

Figure 5.2 shows the theoretical structure for the proposed performance measurement of VM studies. This framework is expected to measure both processes and outcomes performance which are derived from the integration of process indicators and outcome indicators. These factors will serve as the foundation of indicators, making them reasonable and invulnerable.

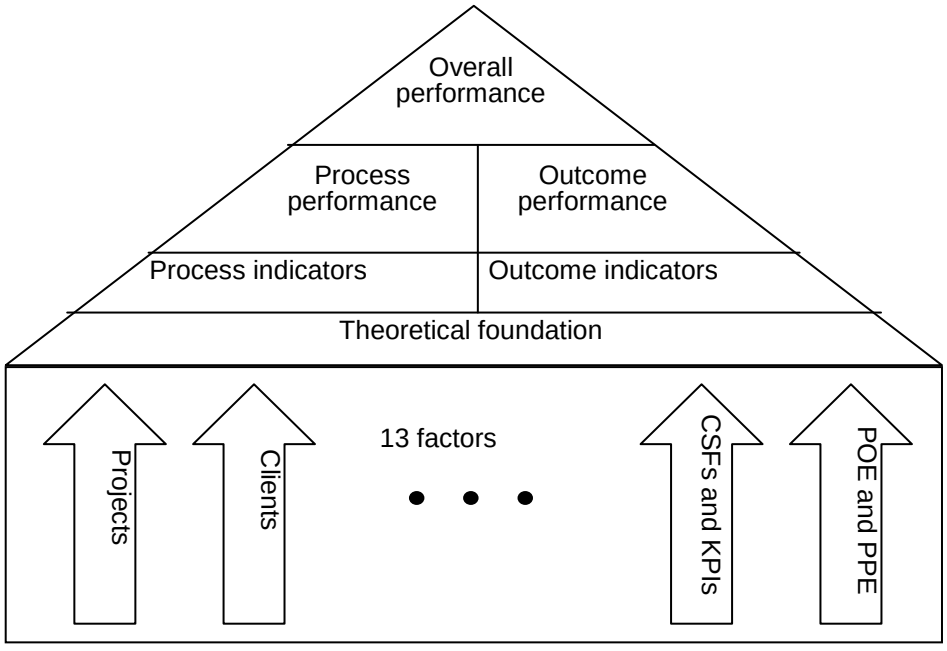

Figure 5.2 Theoretical structure for performance measurement

5.5 Theoretical Framework for the Measurement Framework

Figure 5.3 portrays a theoretical framework for performance measurement of VM studies and shows how the factors relate to one another. The facilitator, client and participants constitute the human resources of VM studies. Participants from relevant disciplines and client representatives form the team which is facilitated by the facilitator in the process of VM studies. A positive team dynamic is expected to add value to the project. These human resources, as well as the duration, venue, and the techniques used in VM studies are seen as the inputs which may affect the performance of VM studies.

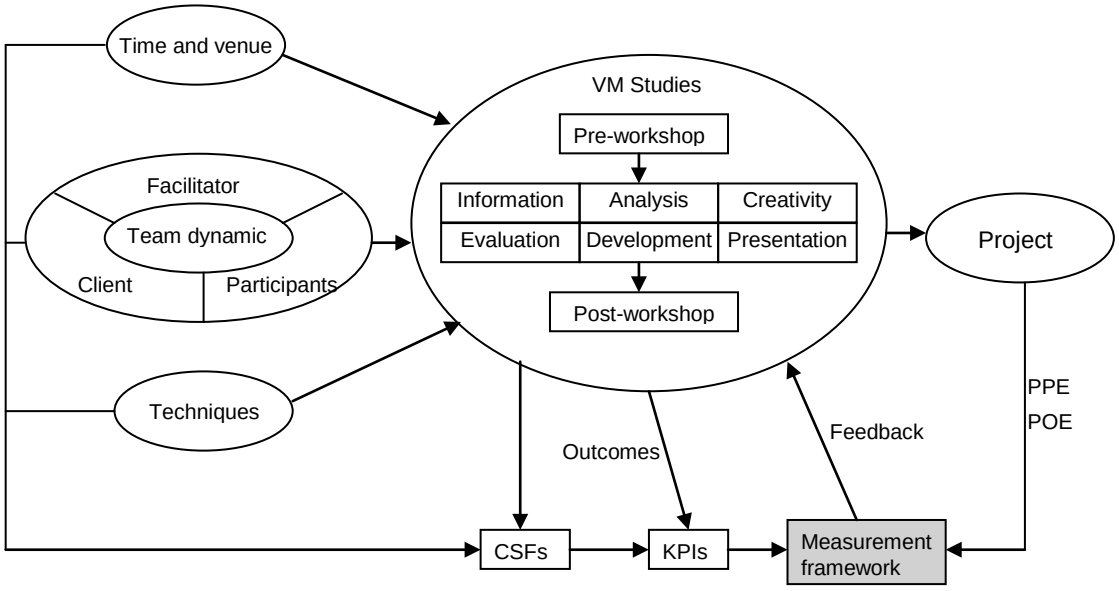

Figure 5.3 Theoretical framework for performance measurement of VM studies [Source: Shen et al. (2005)]

A VM study is a systematic approach which consists of a pre-workshop, a six-phase workshop and a post-workshop. Each phase requires the input of previous phases and yields output for the subsequent phases. The performance of each phase could be measured and integrated to form the process performance of VM studies. The whole

process of a VM study is integrated into the project management process to add value to the project.

Measuring the performance of a VM study will stem from the objectives of the study. Each objective should be linked to one or more CSFs which are identified according to the inputs and processes of the VM study. Each CSF should have a few KPIs that can be measured and quantified. The outcomes of the VM study will include issues such as the quality of decisions, the time to reach decisions, and the satisfaction with the outcomes, which will also be linked with relevant KPIs.

The KPIs with their relevant weightings make up the core of the measurement framework. The feedback of the measurement could be used to improve the performance of the VM study and guide the following VM activities. Results from POE or PPE could be used as an addition to measure the performance of VM studies, though they may be influenced by many internal or external factors of the project. On the other hand, these results could be used to demonstrate the usefulness of VM studies.

5.6 Summary

In this chapter, three views of VM studies and their implications for performance measurement have been further analyzed. The links between different views and approaches are discussed. Each view is embraced by several approaches and each approach may have one or more views linked to it. The performance measurement based on a combined view will be more effective than that of one based on an isolated view.

Thirteen factors are identified as having major impacts on the performance of VM studies according to the literature review. A theoretical foundation was established based on these thirteen factors. The interrelationships of these factors are introduced as the theoretical framework. This theoretical framework explains how the factors interact with each other and where the performance measurement framework will be in this theoretical foundation. Based on the theoretical foundation, further research will be conducted to develop a coherent framework which can fulfil the measurement requirements of VM studies.

CHAPTER 6 DEVELOPMENT OF A PERFORMANCE MEASUREMENT FRAMEWORK FOR VM STUDIES IN CONSTRUCTION

6.1 Introduction

Chapters 2 to 4 covered the literature review and the theoretical analyses, leading to the development of a performance measurement framework for VM studies in construction. This chapter introduces the development of this measurement framework in detail. The desired features of the measurement framework are summarized, followed by the development of a preliminary framework which meets these requirements. The identification of the KPIs by a questionnaire survey is presented sequentially. The detailed framework is then developed based on the preliminary framework and the identified KPIs.

6.2 Desired Features of the Measurement Framework

6.2.1 Desired features

The desired features of the framework should be clarified based on the investigation of existing approaches and the theoretical foundation before developing the performance measurement framework for VM studies.

Specific value (through specific goals) guides performance towards successful project outcomes through subsequent implementation of project management (Leung and Liu, 2003). Therefore, the performance measurement should start with the objectives of VM studies. However, VM studies are unique because of the uniqueness of each

project (Lin et al., 2004). This means that the objectives of individual VM studies will vary from each other. Therefore a coherent but flexible measurement framework should be established to meet the requirements of different VM studies.

Besides cost savings, other benefits arising from the implementation of VM studies, such as improved communication between project stakeholders and better clarification of clients' objectives, should been taken into consideration in the measurement framework (Lin, 2006). Indicators such as clients' satisfaction and improved communication between stakeholders, which are critical to the success of VM studies, should be included in the measurement framework. Hence, the measurement framework should be multi-criteria so as to provide a comprehensive measurement. Both objective and subjective indicators, tangible and intangible factors, as far as they can indicate the performance of VM studies, should be taken into consideration.

One of the purposes of performance measurement is to realize performance management and performance control (Lin, 2006). Taking immediate corrective measures will be possible if any areas for improvement have been identified during the processes of VM studies. In order to achieve this real-time measurement and control, methods for collecting and processing the data of the indicators should be prompt and succinct.

6.2.2 Different levels of interactions

If there is no measure, there will be no improvement (Neely, 2002). One of the objectives of measuring the performance of VM studies is to improve and advance the development of VM. Thus, the process and result of measurement should be dynamic,

not static. The measurement of VM tells where the methodology can be improved. Meanwhile, the improved VM needs new measurement techniques. There should be some positive interactions between measurement and performance to ensure the continuous improvement of performance.

The first interaction is at the level of a single VM study. The measurement of the process of a specific VM study could provide valuable information on whether this study was conducted properly. The generic process to implement a VM workshop is shown in Figure 5.1. The performance of the previous phase will influence the performance of later phases. Therefore, the timely and proper measurement of the performance of each phase can provide indications to the following phases. For example, whether enough information about the project has been collected in the pre-study phase will affect the decision making process in the value study phase. More useful information should be collected if the real time measurement indicated that the information is not complete. In the case that the real time measurement provides information that there are some participants who are not participating actively in the brainstorming process, the facilitator can try to encourage these participants to be active to accomplish efficient team synergy. Most of the VM studies last for a few days or are even completed in one day due to tough time schedules, which means the interaction should be prompt and accurate. The interactive measurement process is illustrated in Figure 6.1.

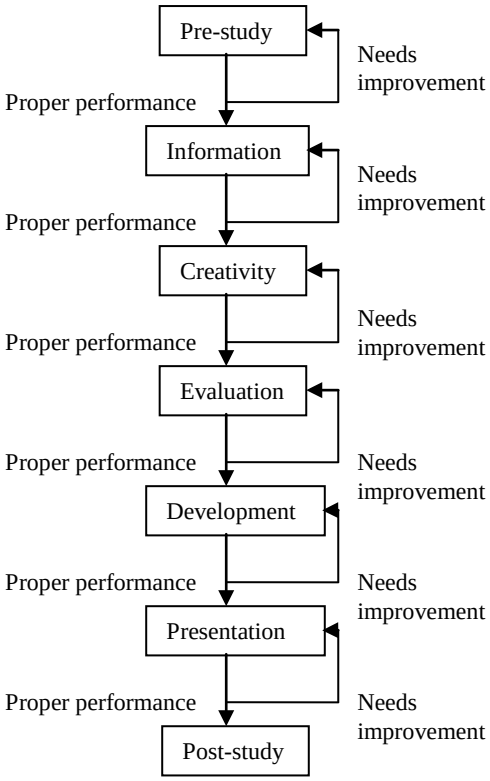

Figure 6.1 Generic process to implement a VM workshop

The second interaction is at the multiple VM studies level. The measurement of the outcomes of previous VM studies could show how to implement a successful VM study or why a VM study failed, which is important information for subsequent VM studies. Meanwhile, these data could be used in the subsequent measurement to improve efficiency and effectiveness. Analysis of the data collected from a number of VM studies may reveal the deficiencies of VM methodology in general, which is of significance to the evolution of VM methodology. The evolution of VM is the result of continuous measurement and improvement. Figure 6.2 shows the interaction at the level of multiple VM studies.

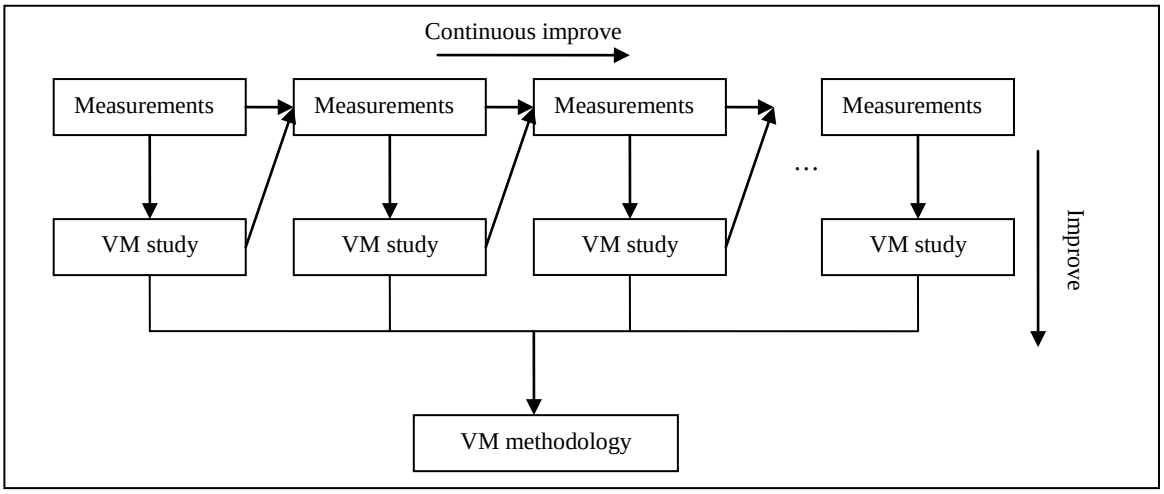

Figure 6.2 Continuous improvements of performance measurement in VM studies

6.3 Development of a Preliminary Measurement Framework

Based on the desired features of the performance measurement framework, a preliminary framework has been developed. As shown in Figure 6.3, leading indicators are used to measure the process performance of VM studies while lagging indicators are used to measure the outcome performance. It is possible to measure and improve promptly when acquiring and comparing leading indicators to historical results. Choosing proper indicators to measure a specific VM study makes this framework flexible. A comprehensive measurement of a VM study can be achieved by integrating the measurement results of previous VM both in terms of process performance and outcome performance. Meanwhile, the measurement results of overall performance will be added to the database as historical results, which can benefit subsequent VM studies and enable this framework to grow continuously.

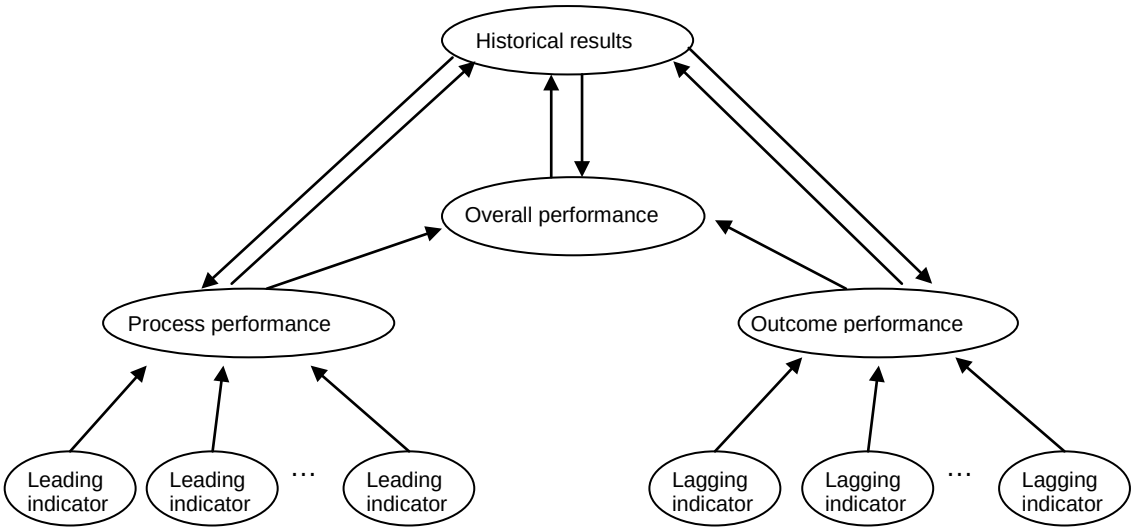

Figure 6.3 A conceptual framework for performance measurement in VM studies

6.4 Selection of Performance Indicators for the Measurement Framework

6.4.1 Potential indicators

Proper indicators are the fundamental elements in developing a measurement framework. It is hard to determine whether an indicator is useful and the feasibility of its data collection. Many researchers have investigated the performance indicators of VM studies (Male et al. 1998; Fong et al. 2001; Kulshrestha and Deshpande 2002; Chang and Chen 2004; Stewart 2004). However, it would appear that no previous research has comprehensively covered the key aspects of a VM study in a measurement framework.

According to the research work of Male et al. (1998b) and Shen and Liu (2003) as well as the review of the thirteen factors, a list of potential indicators is first drafted. Some other indicators which should be investigated need to be included in the research. In order to establish a complete list of indicators, interviews with the VM

facilitators as well as Hong Kong government officers who have experience in VM were conducted to enrich the potential list.

Totally 47 potential indicators are identified after the interview. Based on the theoretical framework, the indicators collected were divided into five major categories: *inputs of the VM study*, *pre-workshop stage*, *workshop stage*, *post-workshop stage* and *outcomes of the VM study*. Each major category is divided into several sub-categories indicating a specific area. This classification covers all the key factors derived from the theoretical foundation which have an influence on the performance of VM studies in construction. The full lists of potential indicators are shown in Table 6.1.

Table 6.1 Potential indicators identified

Potential indicators related to the inputs	
Time	i1 Satisfaction of the time when the VM workshop will be conducted
Venue	i2 Satisfaction of venue
Participants	i3 Disciplines of participants
	i4 Authority of key stakeholder participants
	i5 Years of professional experience of participants
	i6 VM knowledge of participants
Facilitator	i7 Years of experience of facilitator
	i8 Numbers of VM workshops facilitated
	i9 Qualification of facilitator
Clients	i10 Client's support
	i11 Client's participation
	i12 Clear objectives of workshop
Relevant departments	i13 Relevant departments' support
Potential indicators related to the pre-workshop stage	
Information collection	i14 Time spent on preparation before workshop
	i15 Background information collected
Pre-workshop	i16 Number of pre-workshop meetings held

activities	i17 Number of site visits
	i18 Number of related documents analyzed
Potential indicators related to the workshop stage	
All phases	i19 Duration of each phase
	i20 Time keeping of each phase
	i21 Satisfaction of the techniques used in each phase
	i22 Interaction among participants in each phase
Information phase	i23 Client's objectives clarified
	i24 Project givens/assumptions clarified
Analysis Phase	i25 Primary functions identified
Creativity Phase	i26 Total number of ideas
	i27 Average numbers of ideas generated by each participant
	i28 Equal contribution of participants
	i29 Efficiency of idea generation
Potential indicators related to the post-workshop stage	
VM report	i30 Duration to complete the report
	i31 Quality of the report
Action plan	i32 Percentage of action plan carried out
Potential indicators related to the outcome of VM studies	
Finance	i33 Proposed change on project investment
	i34 Proposed change on life-cycle cost
	i35 ROI of VM study, i.e. proposed savings /cost of VM
Time	i36 Proposed change on design schedule
	i37 Proposed change on construction schedule
Function	i38 Reducing the difficulty of construction, i.e. rework times
	i39 Improving the project quality
	i40 Improving the project appearance
Communication	i41 Identifying and clarifying the client's requirements
	i42 Accelerating the decision-making
	i43 Improving communication and understanding among stakeholders
	i44 Deliberating the alternatives
Satisfaction	i45 Client's satisfaction
	i46 Participants' satisfaction
	i47 Facilitator's satisfaction

6.4.2 Respondent profiles

In order to further refine the list of indicators and identify the KPIs, a follow-up questionnaire was developed and disseminated, with the aim to achieve the following objectives:

- Quantifying the relative importance of indicators;
- Calculating the interdependence of indicators;
- Ranking indicators and identifying the KPIs.

A total of 89 positive returns were received, representing an average response rate of 31.2%. Two questionnaires were eliminated due to missing data, leaving a final sample size of 87 (i.e. adjusted response rate of 30.5%).

The respondents are from 7 countries and regions including Hong Kong, U.S.A, U.K., Canada, Australia, Germany and Korea. Most respondents are from Hong Kong and U.S.A. Of the 87 respondents: 38 (44%) are VM facilitators; 24 (28%) are VM clients and 25 (29%) are VM participants. Seventeen respondents out of 24 clients are internal VM facilitators of construction organizations or governmental departments. The years of experience with VM of these respondents are shown in Table 6.2. 95% of the VM facilitators and 83% of the VM clients have more than five years experience with VM. However, only 12% of the VM participants have more than five years experience with VM. Considering the numbers of VM studies facilitated, 82% of the VM facilitators have facilitated more than 10 VM studies. The results show that most VM facilitators and VM clients have experience with VM (because many VM clients are also VM facilitators) while most of the VM participants only have a limited experience of VM.

Table 6.2 Years of experience in VM

Years of experience	VM facilitators	VM clients	VM participants
< 1 year	0 (0%)	1 (4%)	7 (28%)
1-5 years	3 (5%)	3 (13%)	15 (60%)
6-10 years	14 (**26%**)	7 (**29%**)	2 (**8%**)
> 10 years	38 (**69%**)	13 (**54%**)	1 (**4%**)
Total	55 (100%)	24 (100%)	25 (100%)

6.4.3 Key performance indicators

Considered to be the most important component of the questionnaire survey, this section asked respondents to weigh each potential performance indicator related to one of the processes of VM studies in the list. The mean value and standard deviation for the 47 indicators are detailed in Table 6.3. The mean values range from 4.58 for i10: *Clients' support*, to 2.44 for i27: *Average number of ideas generated by each participants*. The mean value for all indicators listed in the questionnaire is 3.70 indicating that the respondents weighted the indicators on average as important. There are 18 indicators that have means higher than the four which means they are considered to be extremely important according to the responses. The remaining 29 indicators are not identified as KPIs in this questionnaire survey. Some of these indicators may be important to a specific VM study. A further discussion of these indicators will be given in the validation process.

Table 6.3 Means and standard deviation of the scores

Num.	**KPIs**	**Means**	**StDev**
i10	*Client's support*	**4.58**	0.73
i45	*Client's satisfaction*	**4.57**	0.71
i12	*Clear objectives of workshop*	**4.53**	0.66
i41	*Identifying and clarifying the client's requirements*	**4.46**	0.76

i23	*Client's objectives clarified*	**4.38**	0.86
i31	*Quality of the report*	**4.37**	0.92
i11	*Client's participation*	**4.35**	0.86
i25	*Primary functions identified*	**4.35**	0.86
i43	*Improving communication and understanding among stakeholders*	**4.33**	0.72
i22	*Interaction between participants in each phase*	**4.26**	0.90
i39	*Improving the project quality*	**4.23**	0.84
i42	*Accelerating the decision-making*	**4.14**	0.74
i13	*Relevant departments' support*	**4.11**	1.05
i24	*Project givens/assumptions clarified*	**4.11**	0.84
i9	*Qualification of facilitator*	**4.07**	0.92
i3	*Disciplines of participants*	**4.04**	1.13
i32	*Percentage of action plan carried out*	**4.03**	1.08
i15	*Background information collected*	**4.02**	0.94
i34	*Proposed change on life-cycle cost*	3.97	0.93
i38	*Reducing the difficulty of construction, i.e. rework times*	3.96	0.90
i44	*Deliberating the alternatives*	3.89	0.87
i7	*Years of experience of facilitator*	3.88	1.02
i46	*Participants' satisfaction*	3.87	0.70
i33	*Proposed change on project investment*	3.81	0.92
i21	*Satisfaction of the techniques used in each phase*	3.75	1.06
i4	*Authority of key stakeholder participants*	3.70	1.19
i1	*Satisfaction of the time when the VM workshop will be conducted*	3.59	1.19
i35	*ROI of VM study, i.e. proposed savings /cost of VM*	3.58	1.13
i37	*Proposed change on construction schedule*	3.58	1.05
i8	*Number of VM workshops facilitated*	3.51	1.02
i40	*Improving the project appearance*	3.49	1.04
i14	*Time spent on preparation before workshop*	3.43	1.15
i36	*Proposed change on design schedule*	3.33	0.97
i47	*Facilitator's satisfaction*	3.28	0.98
i30	*Duration to complete the report*	3.24	0.93
i29	*Efficiency of idea generation*	3.21	1.35
i2	*Satisfaction of venue*	3.19	1.11
i26	*Total number of ideas*	3.14	1.08
i19	*Duration of each phase*	3.12	1.10
i28	*Equal contribution of participants*	3.04	1.33
i18	*Number of related documents analyzed*	3.02	1.19
i5	*Years of professional experience of participants*	2.95	1.21

i16	*Number of pre-workshop meetings held*	2.89	1.17
i20	*Time keeping of each phase*	2.88	1.09
i17	*Number of site visits*	2.86	1.20
i6	*VM knowledge of participants*	2.60	1.29
i27	*Average numbers of ideas generated by each participants*	2.44	1.25

According to their characteristics, the 18 KPIs were then divided into three groups. This is shown in Table 6.4. The KPIs in Group 1 are those leading indicators which can predict the performance of VM studies. However, the scores of these KPIs do not indicate the performance of VM studies. For example, a score of five for i3 means that the VM team consists of all stakeholders of the project, which ensures a holistic view of the tasks of the VM study. The score is an indicator of factors conducive to a successful workshop but a high score itself can not guarantee workshop success. The KPIs of Group 2 are also leading indicators. The difference between Group 2 and Group 1 is that the KPIs of Group 2 can indicate the processes performance of VM studies. The KPIs of Group 3 are the lagging indicators which indicate the outcome performance of the VM studies, including both tangible and intangible issues.

Table 6.4 Groups of the KPIs

Group 1 **(Predicting indicators)**	**Group 2** **(Process performance indicators)**	**Group 3** **(Outcome performance indicators)**
i3 *Disciplines of participants*	i15 *Background information collected*	i31 *Quality of the report*
i9 *Qualification of facilitator*	i22 *Interaction between participants in each phase*	i32 *Percentage of action plan carried out*
i10 *Client's support*	i23 *Client's objectives clarified*	i39 *Improving the project quality*
i11 *Client's participation*	i24 *Project givens/assumptions clarified*	i41 *Identifying and clarifying the client's requirements*
i12 *Clear objectives of workshop*	i25 *Primary function identified*	i42 *Accelerating the decision-making*
i13 *Relevant departments' support*		i43 *Improving communication and understanding among stakeholders*
		i45 *Client's satisfaction*

The 12 KPIs of Group 2 and Group 3 were subjected to a principal component factor analysis followed by a varimax rotation using SPSS V12.0 in order to seek their relationship. They are the indicators which measure the critical performance of the VM studies. The Bartlett test of sphericity is 299.935 and the associated significance level is 0.000, suggesting that the population correlation matrix is not an identity matrix. The value of the Kaiser-Meyer-Olkin measure of sampling adequacy is 0.697, which is higher than 0.5 and hence considered acceptable. The results of this test show that the sample data is appropriate for factor analysis. Three principal components with eigenvalues greater than one are extracted by the analysis. The components matrix after varimax rotation is presented in Table 6.5. Each of the KPIs loads to only one of the components, with the loading exceeding 0.5. The rotation sums of squared loadings of the principal component analysis are shown in Table 6.6. The three components extracted account for 63.874% of the variance. Therefore, the components represent the three dimensionalities of the data well. Component one, 1 which consists of the KPIs of Group 2, accounts for one out of three of the total variance, which reveals the importance of the process performance.

Table 6.5 Components matrix after varimax rotation

KPIs	**Component**		
	1	**2**	**3**
i24 *Project givens/assumptions clarified*	0.868		
i23 *Client's objectives clarified*	0.860		
i25 *Primary function identified*	0.841		
i22 *Interaction between participants in each phase*	0.814		
i15 *Background information collected*	0.714		
i42 *Accelerating the decision-making*		0.805	
i43 *Improving communication and understanding among stakeholders*		0.773	

i41 *Identifying and clarifying the client's requirements*	0.760	
i45 *Client's satisfaction*	0.725	
i32 *Percentage of action plan carried out*		0.730
i31 *Quality of the report*		0.637
i39 *Improving the project quality*		0.515

Table 6.6 The rotation sums of squared loadings

Component	Eigenvalues	% of Variance	Cumulative %
1	3.813	31.772	31.772
2	2.587	21.561	53.333
3	1.265	10.541	63.874

6.4.4 Interpretation of components

Component 1 (Process performance)

The five extracted KPIs significant for Component 1 are: i15 *Background information collected* which belongs to the category *Pre-workshop stage*; i22 *Interaction between participants in each phase*, i23 *Client's objectives clarified*, i24 *Project givens/assumptions clarified* and i25 *Primary function identified* which belong to the category *Workshop stage*. These are all KPIs from Group 2. Therefore, Component 1 represents the process performance of the VM studies.

Component 2 (Intangible outcome performance)

Component 2 consists of i41 *Identifying and clarifying the client's requirements*, i42 *Accelerating the decision-making*, i43 *Improving communication and understanding among stakeholders*, and i45 *Client's satisfaction*. These four KPIs are all lagging indicators which indicate the outcomes of the workshop. The identification of i41, i42 and i43 as KPIs is consistent with the previous research results of the authors (Lin and

Shen, 2007) that the purposes of implementing VM studies include clarifying project objectives, improving communication between different parts, and enhancing the function of a project. The identification of i45 is also in line with the research of Male et al. (1998b) which identified client satisfaction as a key indication of the performance of VM studies. All these four KPIs indicate the intangible outcome performance of the VM studies.

Component 3 (Tangible outcome performance)

This component consists of i31 *Quality of the report*, i32 *Percentage of action plan carried out* and i39 *Improving the project quality*. These three indicators indicate the tangible outcome performance of the VM studies. A well-written report will help the clients grasp the processes and output of the VM study. It also guides the client's decision making if any recommendations of the VM study are conducted. The benefits of the VM study to the entire project can be realized only if the follow-up actions recommended by the study are carried out. 'Improving the project quality' but not 'cost savings' as one of the KPIs differentiates VM from cost reduction techniques.

The results show that these KPIs include process indicators, tangible outcome indicators and intangible outcome indicators. The measurement framework including these KPIs can take into consideration of intangible performance which is underestimated by previous frameworks.

6.5 Development of the Detailed Measurement Framework

A detailed performance measurement framework is developed from the preliminary framework and the selected KPIs.

6.5.1 Measurement processes

As shown in Figure 6.4, the identified KPIs are put in a systematical order along with the processes of the VM studies. The measurement starts from the objectives and the other inputs of the VM study. Each stage of the VM study has several indicators linked to its performance. These KPIs should be included to measure all kinds of VM studies while the other indicators in the potential list are optional in measuring different kinds of VM studies. This ensures the flexibility of the framework. The indicators cover most aspects of a VM study to map the performance in a holistic way. Both subjective indicators and objective indicators are considered in the framework. The indicators before the end of VM workshop are leading indicators which indicate the process performance. Corrective measures could be conducted during the process of the VM study whenever the values of these leading indicators turn out to be problematical. Data about the project collected after the application of VM and to the completion of the project could be added to give an overall indication of the performance of VM studies.

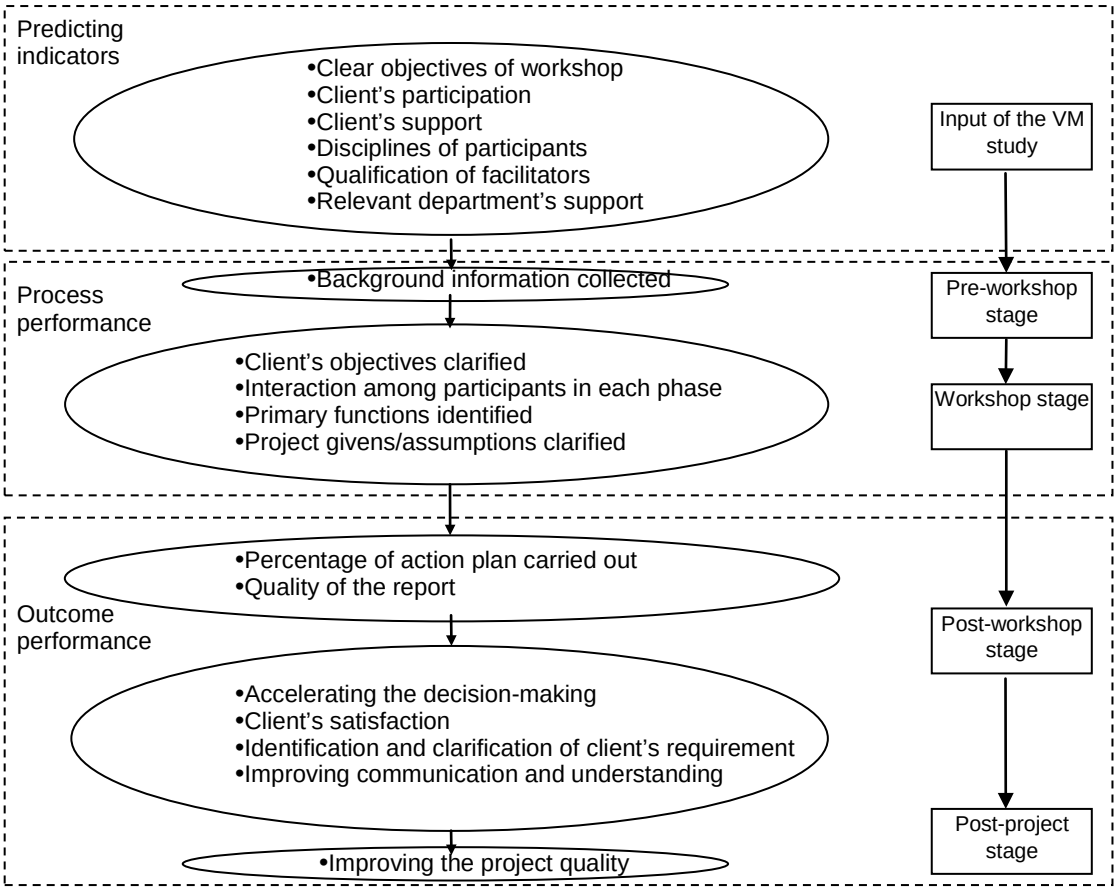

Figure 6.4 KPIs for measuring the performance of VM studies

6.5.2 Data providers

The authors have interviewed many VM practitioners in construction and their opinions differ. Three dominant opinions on this issue are that the client, the VM facilitator or the client together with the VM facilitator should take the responsibility for the performance measurement of VM studies. In the authors' opinion, all the stakeholders, including the clients, facilitators and participants of the VM studies, should take part in the measurement process. However, not all the stakeholders provide data for each KPI. The data of each KPI should be provided by the appropriate parties. Taking *Client's support* as an example, the data of this KPI should be provided by facilitators and participants but not clients. This can avoid risk of bias if the clients provide the data, and ensure the validity of the data. Table 6.7 lists the proposed data providers for the three groups of KPIs.

Table 6.7 Data providers for the KPIs

KPIs	Numbers of answers		
	Facilitator	Client	Participant
Predicting indicators (Group 1)			
Clear objectives of workshop			√
Client's participation	√		
Client's support	√		√
Disciplines of participants	√		
Qualification of facilitator		√	
Relevant stakeholders' support	√	√	
Process-related performance indicators (Group 2)			
Background information collected			√
Client's objectives clarified			√
Interaction among participants in each phase	√		
Primary functions/processes identified			√
Project givens/assumptions clarified			√
Outcome-related performance indicators (Group 3)			
Percentage of action plan without uncertainty carried out		√	
Quality of the report		√	
Accelerating the decision-making		√	
Client's satisfaction		√	
Identifying and clarifying the client's requirements		√	√
Improving communication and understanding among stakeholders		√	√
Improving the project quality		√	

6.5.3 Weightings of the KPIs

In order to simplify the calculation and distinguish the difference among the performances, the weightings of the KPIs are standardized based on the questionnaire results. The formula for standardization is as follows:

$$W_i = \frac{(M_i - 2.44)}{(4.58 - 2.44)} \times 10$$

Where W_i = calculated weightings of the indicators. M_i = original means of the weightings according to the questionnaire.

The calculated weighting of each KPI is rounded to an integral number to form the standard weighting. The results are listed in Table 6.8. However, the weightings calculated by this method are not good enough to differentiate the importance of the KPIs. A further investigation of the weightings will be explained in Section 7.4.

Table 6.8 Weightings of KPIs

Num.	KPIs	Means	Weightings
i10	*Client's support*	4.58	10
i45	*Client's satisfaction*	4.57	10
i12	*Clear objectives of workshop*	4.53	10
i41	*Identifying and clarifying the client's requirements*	4.46	9
i23	*Client's objectives clarified*	4.38	9
i31	*Quality of the report*	4.37	9
i11	*Client's participation*	4.35	9
i25	*Primary functions identified*	4.35	9
i43	*Improving communication and understanding among stakeholders*	4.33	9
i22	*Interaction between participants in each phase*	4.26	9
i39	*Improving the project quality*	4.23	8
i42	*Accelerating the decision-making*	4.14	8
i13	*Relevant departments' support*	4.11	8
i24	*Project givens/assumptions clarified*	4.11	8
i9	*Qualification of facilitator*	4.07	8
i3	*Disciplines of participants*	4.04	7
i32	*Percentage of action plan carried out*	4.03	7
i15	*Background information collected*	4.02	7

6.5.4 Definition of the scorings of each KPI

Given that a data collection method should be succinct and prompt without impairing accuracy to meet the desired features of the measurement framework, a five-point scale method has been adopted to score the KPIs. To mitigate the subjectivity of scoring, the meaning of each point to each KPI is clearly defined. The definitions of the KPIs are presented as follows:

i3 *Disciplines of participants*

5 — All of the senior managers of the stakeholders are included in the VM team;

4 — All of the senior managers of the key stakeholders and most of the representatives of the stakeholders are included in the VM team;

3 — Most of the senior managers of the key stakeholders and the representatives of the other key stakeholders and stakeholders are included in the VM team;

2 — All the representatives of the key stakeholders and some representatives of stakeholders are included in the VM team;

1 — A representative from any of the key stakeholders is missing.

i9 *Qualification of facilitator*

5 — World-famous qualified VM facilitator;

4 — Qualified VM facilitator with more than 10 years experience and who has facilitated more than 10 VM studies in the past two years;

3 — Qualified VM facilitator with more than five years experience and who has facilitated more than five VM studies in the past two years;

2 — Qualified VM facilitator who has facilitated at least two VM studies;

1 – Qualified VM facilitator who has facilitated less than two VM studies or not qualified VM facilitator.

i10 *Client's support*

5 – Full support from the top management of the client organization;

4 – Support from most of the senior management of the client organization;

3 – Support from at least one of the senior management of the client organization;

2 – Support from the middle level management of the client organization;

1 – The VM study is conducted just to obey regulations.

i11 *Client's participation*

5 – Decision maker of the client organization participates in the entire process of the VM study;

4 – Decision maker of the client organization participates in the VM workshop stage and a senior manager participates in the other stages;

3 – Senior manager participates in the entire process of the VM study;

2 – Senior manager participates in the VM workshop and client representatives participate in the other stages;

1 – No senior manage participates in the VM workshop.

i12 *Clear objectives of workshop*

5 – All the objectives of the workshop are clearly addressed with interpretive documents from the inception of the study;

4 — The major objective of the workshop is clearly addressed with interpretive documents;

3 — The objectives are addressed before the start of VM workshop;

2 — The major objective is addressed before the start of VM workshop;

1 — Conducting the workshop without regard for objectives or outcomes.

i13 ***Relevant departments' support***

5 — Full support from all relevant departments;

4 — Full support from the important relevant departments;

3 — Support from most of the relevant departments;

2 — Support from some important relevant departments;

1 — No support from any relevant department

i15 ***Background information collected***

5 — Plenty of information containing the critical background information is collected and well-documented in various formats such as graphs, pictures and tables which can facilitate the VM team to understand the study;

4 — Plenty of information containing the critical background information is collected;

3 — The critical background information is collected with some other supplementary information;

2 — The critical background information is collected;

1 — Any critical background information is missing.

i22 ***Interaction among participants in each phase***

5 — The interaction among participants is enthusiastic throughout the workshop;

4 — The interaction among participants is positive in most of the phases, no participants perform dominantly or silently;

3 — The interaction among participants is positive in most of the phases but some participants perform dominantly or silently during the workshop;

2 — The interaction among participants is positive in the information phase, function analysis phase and creativity phase;

1 — The interaction among participants is limited.

i23 ***Client's objectives clarified***

5 — Consensus of the client's objectives by all the VM team members is obtained after clarification;

4 — Most of the VM team members understand the client's objectives after clarification;

3 — Most of the VM team members understand the client's major objectives after clarification;

2 — Different understanding of some of the client's objectives still remains;

1 — Client's objectives are not clarified.

i24 ***Project givens/assumptions clarified***

5 — All the project givens/assumptions are clarified and well-documented for reference during the workshop;

4 — Most of the project givens/assumptions are clarified;

3 — The critical project givens/assumptions are clarified;

2 — Some of the project givens/assumptions are clarified but a lot are missing;

1 — Project givens/assumptions are not clarified.

i25 ***Primary function identified***

5 — All the functions are identified and get the consensus of the VM members; a FAST diagram is drawn for reference during the workshop;

4 — All the functions are identified and a FAST diagram is drawn, but a few team members have different views;

3 — All the primary functions and some of the secondary functions are identified;

2 — Primary and secondary functions are listed but team members still have different views;

1 — Primary function are not identified.

i31 ***Quality of the report***

5 — The report is well-organized with information about all the processes and outcomes of the study in it, and is submitted to the client soon after the workshop;

4 — The report contains all the important information of the study but is not organized so well;

3 — The report contains the outcomes of study and brief information about the processes;

2 — The report briefly summarizes the study but lots of useful information is missing;

1 — The report misses any important outcomes of the study or it is not submitted to the client after the workshop.

i32 ***Percentage of action plan carried out***

5 — All the actions listed in the action plan are one hundred percent completed and reported;

4 — All the actions are followed-up but some are not completed;

3 — Most of the actions are followed-up;

2 — Some of the actions are follow-up;

1 — The action plan is just a document on a shelf.

i39 ***Improving the project quality***

5 — The project quality is highly improved in a lot aspects including primary functions by conducting the recommendations of the VM study;

4 — The project quality is improved in a lot aspects including primary functions;

3 — The project quality is improved in the primary functions;

2 — The project quality is slightly improved;

1 — The project quality is not improved or decreased.

i41 ***Identifying and clarifying the client's requirements***

5 — All the client's requirements about the projects discussed in the study are identified and clarified, consensus of all the stakeholders of the project on the client's requirements is obtained.

4 — Most of the requirements are identified and clarified after the study;

3 — Most of the requirements are identified but some are not clarified;

2 — Some of the requirements are identified and clarified, but a lot are not;

1 — The misunderstanding on the client's requirements is still serious.

i42 ***Accelerating the decision-making***

5 — Decisions can be made immediately according to the outcomes of the VM study;

4 — The outcomes of the study are important supports to the decision-making;

3 — The outcomes of the study are useful to the decision-making;

2 — The outcomes of the study slightly influence the decision-making;

1 — The outcomes of the study have no influence on the decision-making;

i43 ***Improving communication and understanding among stakeholders***

5 — All the key stakeholders of the project build up a positive relationship after the VM study;

4 — Most of the key stakeholders build up a positive relationship after the VM study;

3 — Most of the key stakeholders improve understanding between each other;

2 — Some of the key stakeholders improve understanding between each other;

1 — The communication and understanding does not improve at all.

i45 ***Client's satisfaction***

5 — Highly satisfied;

4 — Satisfied;

3 — Quite satisfied;

2 — Slightly satisfied;

1 — Not satisfied.

6.6 Summary

The desired features for the measurement framework are identified. A coherent but flexible framework should be established in order to meet the requirements of different VM studies. It should be multi-criteria so as to provide a comprehensive measurement and allow for prompt and succinct data collecting and processing methods. The dynamic feature desired for measuring is further introduced as two levels of interactions: study level and methodology level. A preliminary framework is developed based on the features desired which gives a brief concept of how the measurement is conducted.

Totally 47 potential indicators are collected from previous research and interviews. A questionnaire survey of facilitators, clients and participants identifies eighteen KPIs from the list of potential performance indicators according to their scores, which are measured in accordance to the views of VM practitioners. The respondent profiles show that most of these practitioners have significant experience in VM studies. The findings of the study are consistent with the previous research. The KPIs are divided into three groups according to their characteristics, namely predicting indicators, process performance indicators and outcome performance indicators. By conducting the principle component factor analysis, the KPIs of process and outcome performance indicators are grouped into three components. Component 1 is a

combination of five process related KPIs which indicates the process performance of the VM study. Component 2 represents the intangible outcome performance of the VM study. Component 3 consists of three lagging indicators which indicate the tangible outcome performance of the VM study. The detailed measurement framework which follows the processes of VM studies is developed according to the preliminary framework and the identified KPIs.

This chapter describes the development of the performance measurement framework for VM studies in construction. The detailed measurement framework includes measurement processes, data providers, weightings of KPIs and a definition of the scorings of KPIs. The investigation of the feasibility and validity of this framework will be presented in the next chapter.

CHAPTER 7 VALIDATION OF THE PERFORMANCE MEASUREMENT FRAMEWORK FOR VM STUDIES IN CONSTRUCTION

7.1 Introduction

Validation is commonly referred to as the process of checking if something satisfies a certain criterion. The validation here is checking whether the developed framework could properly measure the performance of VM studies in construction. This chapter presents the results and discussion of Case Study 1, the action research, the focus group meeting and Interviews 2 which are used to validate the framework developed in Chapter 6.

7.2 Results and Discussion of Case Study 1

The objectives and design of Case Study 1 are introduced in section 4.5.1. According to the observation, the processes of the two workshops were controlled well. The activities listed in the agenda were completed smoothly. Minor deviation from the agenda existed in both workshops, but the major cause was the late attendance of several participants. Generally, the two workshops were conducted under active and innovative atmospheres. All the participants in these two workshops made their contribution though a few of them seemed reluctant to express their ideas during the creativity phase.

Some of the research claimed that more ideas generated in the creativity phase does not indicate a better performance (Male et al., 1998). However, it is also believed that with an increased quantity of ideas, there is more possibility of quality ideas being generated. Table 7.1 listed the numbers of ideas generated in these two workshops and some relevant data. The number of ideas generated in the computer-aided workshop is about twice of that in the face-to-face workshop. This is in line with the previous research work (Fan et al., 2005; Fan et al., 2006). Both workshops had some silent participants in the creativity phases, but no participant dominated the discussion because the best contributor just generated about 10% of the ideas. The levels of equal contribution of participants in two workshops are about the same in the creativity phase. This is in line with the observations in the other phases of workshops.

Table 7.1 Numbers of ideas generated by two workshops

	Face-to-face	**Computer-aided**
Total number of ideas generated in the creativity phase	92	188
Minimum number of ideas generated by a participant	2	2
Maximum number of ideas generated by a participant	10	22
Average number of ideas generated by each participant	5.41	11.06
Standard deviation	2.06	4.10
Significance (T-test)	P=0.004<0.05*	

Note: * means the significant at 0.05 level

The statistical results of the questionnaire are listed in Table 7.2. Generally, the computer-aided workshop received higher scores than the traditional face-to-face workshop. The face-to-face workshop only performed better in “The client

participated in the VM workshop process" and "Adequate background information has been collected". However, there are only two indicators of the computer-aided workshop which are statistically larger than those of face-to-face workshop, namely "This VM workshop has clear objectives" and "Client's requirements have been identified and clarified". Considering the scores in a holistic way, the computer-aided workshop still leads in both leading indicators and lagging indicators. The scores of lagging indicators of computer-aided workshop are statistically larger than face-to-face workshop. Therefore, hypothesis 1 has been proved valid in this study. However, the scores of the leading indicators of the computer-aided workshop are not statistically larger. Hypothesis 2 is not fully supported in this study.

Limitations in this case study include the following. First, the participants were not real stakeholders in the task project. They did a good job in role-playing, but they could not fully represent the real stakeholders. However, it is hard to test a framework in a real-life workshop in Hong Kong because most of the workshops are confidential. Experimental studies are alternatives under this circumstance. Second, the samples are too limited. The study will be more valid if more samples and solid data can be obtained through experimental studies. If applicable, the implementation of the framework in real-life VM studies would be more valuable. Third, the feature of

Table 7.2 Subjective indicator statistics

	Face-to-face (mean)	Computer-aided (mean)	Significance (T-test)
This VM workshop has clear objectives.	4.41	4.76	0.029*
The client supported the implementation of the VM	4.12	4.35	0.299

workshop.			
The client participated in the VM workshop process.	4.41	4.29	0.668
Adequate background information has been collected.	4.47	4.35	0.543
Interaction among the VM team was active in each phase.	4.29	4.65	0.055
Client's objectives have been clarified in the information phase.	4.35	4.59	0.104
Project givens/assumptions have been clarified in the information phase.	3.94	4.00	0.791
Primary functions have been identified in the function analysis phase.	4.00	4.29	0.172
Leading indicators	**4.25**	**4.41**	**0.148**
Communication and understanding among key stakeholders have been improved.	4.00	4.35	0.083
Client's requirements have been identified and clarified.	4.06	4.53	0.002*
The workshop expedited the decision making process.	4.12	4.35	0.299
You are satisfied with the performance of the workshop.	4.35	4.59	0.163
Lagging indicators	**4.13**	**4.46**	**0.021***

Note 1: 5 Strongly agree, 4 Agree, 3 Neutral, 2 Disagree, 1 Strongly disagree

Note 2: * means the significance at 0.05 level

real-time control, which is inherent to this framework, was not used and tested in this study due to time limitations.

7.3 Results and Discussion of Action Research

The objectives and design of this action research are introduced in Section 4.6. The mean score of each indicator for the input of the workshop is indicated in Table 7.3.

Table 7.3 Mean score of the indicators for the input of the workshop

Category	Indicator	Mean score
Time	i1 Satisfaction of the time when the VM workshop will be conducted	4.1
Venue	i2 Satisfaction of venue	4.5
Participants	i3 Disciplines of participants	5.0
	i4 Authority of key stakeholder participants	1.0
	i5 Years of professional experience of participants	1.0
	i6 VM knowledge of participants	2.0
Facilitator	i7 Years of experience of facilitators	1.0
	i8 Number of VM workshops facilitated	1.0
	i9 Qualification of facilitator	1.0
Clients	i10 Client's support	5.0
	i11 Client's participation	4.3
	i12 Clear objective of workshop	4.4
Relevant departments	i13 Relevant departments' support	3.0

Time

The workshop was conducted on 17th April, 2005 (Sunday). The choice of this date was to make sure that all the participants could be free and to allow them to concentrate on the workshop. Most of the participants were satisfied with the time according to the result of the questionnaire.

Venue

The workshop was conducted at the Management Laboratory of the Department of Building and Real Estate, Hong Kong Polytechnic University. The size of the laboratory is adequate and the facilities in it fulfil the requirements of the workshop. Therefore, all the participants were satisfied with the venue.

Participants

Disciplines of participants

The participants were asked to act as the key stakeholders of this project. The list of stakeholders was discussed by the facilitators and clients so that these roles formed a multi-disciplinary team which fulfiled the requirements of the workshop.

Authority of key stakeholder participants

The participants acting as key stakeholders did not have real authority.

Professional experience of participants

All the participants were practitioners in the construction industry. However, most of them were quantity surveyors so they had little experience in the field of their roles.

VM knowledge of participants

The participants registered for the course "Value Management in Construction and Property" so they were equipped with some basic concepts of VM. However, none of them had participated in any VM studies in their real-life work.

Facilitator

Years of experience of facilitators

The facilitators were acted by the students who had no experience in facilitation and had never facilitated a VM workshop before.

Number of VM workshops facilitated

This was the first workshop facilitated by the facilitators.

Qualification of facilitators

None of the facilitators had any qualification.

Clients

Client's support

The clients were assumed to fully support the workshop in this case.

Client's participation

Three representatives (acted by students) from client's department had attended the workshop. All of them attended the initial meeting and pre-workshop meeting. They performed actively in this study.

Clear objectives of the workshop

The primary objective of the workshop was to carry out an evaluation study to optimize the use of the existing site and to explore other uses of the land which had been clearly addressed in the briefing material. Most of the participants accepted that they were clear about the client's objectives.

The mean score of the indicators for the pre-workshop phase is indicated in Table 6.4.

Table 7.4 Mean score of the indicators for pre-workshop phase

Category	Indicator	Mean score
Information collection	i14 Time spent on preparation before workshop	5.0
	i15 Background information collected	4.0
Pre-workshop activities	i16 Number of pre-workshop meetings held	5.0

i17 Number of site visits	1.0
i18 Number of related documents analyzed	3.0

Information collection

Time spent on preparation before workshop

The information collection started on 31st March and ended on 16th April. According to Kelly et al. (2004), a typical strategic briefing workshop should take between four and seven days to complete. Concerning the size and complexity of the project and its sensitivities, the duration for collecting information was adequate.

Background information collected

The students made an effort to collect relevant information such as the lease and site conditions.

Pre-workshop activities

Number of pre-workshop meetings held

An initial meeting was held with the facilitators and group leaders to explain the process and the requirements of the workshop. A pre-workshop meeting was held with all the participants to introduce and clarify the background information of the project, and the objective of the strategic briefing workshop.

Number of site visits

No site visit activity was conducted before the workshop.

Number of related documents analyzed

Several project-related documents such as the lease conditions, the site plan and the block plan were analyzed. However, little analysis was given to the documents of similar projects because of a lack of information.

The mean score of the indicators for the workshop phase is indicated in Table 7.5.

Table 7.5 Mean score of the indicators for the workshop phase

Category	Indicators	Mean score
All phases	i19 Duration of each phase	3.5
	i20 Time keeping of each phase	4.0
	i21 Satisfaction with the techniques used in each phase	4.2
	i22 Interaction among participants in each phase	4.2
Information phase	i23 Client's objectives clarified	4.2
	i24 Project givens/assumptions clarified	4.2
Analysis phase	i25 Primary functions identified	4.0
Creativity phase	i26 Total number of ideas	3.0
	i27 Average number of ideas generated by each participant	1.5
	i28 Equal contribution of participants	4.0
	i29 Efficiency of idea generation	2.0

All phases

Duration of each phase

The duration of each phase is deliberated by the facilitator before the workshop. Therefore, it was reasonable. However, the overall time for the workshop was limited.

Time keeping of each phase

The process of the workshop was controlled well by the facilitator. Most of the items were completed according to the agenda. Minor deviations from the agenda occurred but the workshop was completed half an hour earlier than expected.

Satisfaction of the techniques used in each phase

Various techniques had been used in different phases of the workshop. They made the process of the workshop more organized. The results of the questionnaire showed that the participants were satisfied with these techniques.

Interaction among participants in each phase

The workshop was conducted in an active atmosphere in which all the participants communicated freely with each other. They indicated that they had good interactions in the questionnaire.

Information phase

Client's objectives clarified

According to the observation, the facilitator spent only two minutes introducing the objectives of the workshop and no questions were raised regarding the objectives. The objectives might be discussed and clarified during the pre-meeting. Most of the participants agreed that the client's objectives had been clarified.

Project givens/assumptions clarified

The givens/assumptions were mentioned in the introduction to the scenario in the briefing material of the study. No specific time was assigned to clarify

givens/assumptions during the workshop. However, most of the participants considered that they were clear about the givens/assumptions.

Creativity phase

Total number of ideas

Subsequent to the thorough overview of project constraints and analysis of the functions of the project, twenty-two innovative ideas and options were generated. Valuable ideas may come out from the large number of ideas. Twenty-two options were judged as not being developed enough for evaluation in this strategy briefing workshop.

Average number of ideas generated by each participant

The average number of ideas generated by each participant is about one, which was not so good.

Equal contribution of participants

According to the observation and the numbers of opinions raised by each participant, all participants contributed to the idea generation. No one dominated the discussion and no one was silent. They achieved good synergy in the group discussion.

Efficiency of idea generation

The team assigned half an hour to conduct the idea generation. However, fifteen participants generated only twenty-two ideas in this period. The average number of ideas generated by one participant in an hour was less than three. It is evident that the generation of ideas was not so efficient.

The mean score of the indicators for the outcomes of the workshop is indicated in Table 7.6.

Table 7.6 Mean score of the indicators for the outcome of the workshop

Category	Indicators	Mean score
VM report	i31 Quality of the report	4.0
Communication	i41 Identifying and clarifying the client's requirements	4.3
	i42 Accelerating the decision-making	4.0
	i43 Improving communication and understanding among stakeholders	4.4
	i44 Deliberating on the alternatives	4.2
Satisfaction	i45 Client's satisfaction	4.5
	i46 Participants' satisfaction	4.2
	i47 Facilitator's satisfaction	3.5

VM report

Quality of brief

The report of the workshop was basically the strategic brief of the project. It describes all the relevant information and requirements, and records all the options and decisions made. The brief was considered comprehensive and well structured.

Communication

Identifying and clarifying the client's requirements

Through the use of issue analysis, the concerns of the client were elicited. The needs and wants of the client were also identified and clarified in the subsequent function

analysis. The REDReSS analysis (Kelly et al, 2004) finally captured any missing requirements.

Accelerating the decision-making

The systematic group process sped up the briefing process and reduced the time required to arrive at a justified 'decision to proceed' and thus to obtain the optimum solution.

Improving communication and understanding among stakeholders

Through presentation, listening and active discussion, the participants were able to understand the client's requirements as well as relevant information about the projects. In addition, communication was improved by participating in small group discussion and by the subsequent presentation to the whole team.

Deliberating on the alternatives

Twenty-two options were proposed which included proposed new development, such as a theme park to attract tourists, an extension to Queen Elizabeth Hospital, an extension to the Hong Kong Polytechnic University Extension, an elderly home, a library, a car park; renovation works; and land sales to a private developer, etc. The scope and depth of the proposed options were considered acceptable by the researcher.

Satisfaction

Client's satisfaction

The client was satisfied with the process as well as the outcome of the strategic briefing workshop. The objective of the workshop was achieved.

Participants' satisfaction

The participants were satisfied with the team work of and cooperation by all the parties.

Facilitator's satisfaction

The facilitators were satisfied with the process and the outcome of the workshop. The performance of this first job was excellent. However, they felt that their skills in facilitating the workshop could be improved if they had more experience and qualifications.

The results of the measurement showed that a full picture of the performance of a VM study can be drawn by applying the performance measurement framework. The participants all indicated that the measurement result represented the performance of the VM study fairly. However, some of the performance indicators were overlapping, such as "experience of the facilitator" and "qualification of facilitator". This indicated that there is a need to identify the KPIs to make the measurement process more succinct. The scores of the indicators were given by the observer in this study, which ensured objectivity and consistency. In real life VM studies, it is not possible to assign performance observers during the studies. Therefore, how to ensure objectivity and consistency when scoring the indicators should be carefully considered in the detailed framework. Another disadvantage of the preliminary framework is that no weightings were assigned to the indicators. The importance of these indicators should be different according to the performance which they measure.

The results of the follow-up questionnaire survey about the real-time feedback are shown in Table 7.7. Most of the participants agreed that the feedback was useful in improving the performance of the study. They emphasised that the real-time feedback helped them perform better in the workshop. They also considered that three to five minutes of feedback was adequate and did not interrupt the workshop processes.

Table 7.7 Results of the questionnaire survey about the real time feedback

To what extent do you agree with the following statement?	Max	Min	Ave	StDev
The feedback was timely.	5	3	4.24	0.75
The time used to give feedback was adequate.	5	3	3.94	0.56
The feedback did not interrupt the process of the study.	5	3	4.24	0.66
The feedback was useful to improve the performance of study.	5	3	4.18	0.53
The feedback helped you participate better in the study.	5	3	4.35	0.61

7.4 Focus Group Meeting and Interviews

7.4.1 Focus group meeting

The objectives and design of this focus group meeting are introduced in Section 4.4. The developed performance measurement framework for VM studies in construction has been considered as a systematical framework to help the clients ensure their returns on the investment of VM. The attendants from government also admitted that they do not have system like this framework to prepare their workshops. They suggested that this framework could be used to measure the performance of future VM studies in their departments.

Two indicators, “knowledge of VM of the participants” and “knowledge of the project of the participants” have been raised as important but are missed in the group of predicting indicators. After discussions, the indicator “knowledge of the project of the participants” was linked to the existing KPI “clear objectives of workshop”. “Knowledge of VM of the participants” remained for investigation in further discussions during the interviews. “Relevant departments’ support” was revised to be “relevant stakeholders’ support” to better represent the meaning of this indicator. It is pointed out that relevant departments may refer to the departments in the client’s organization which may lead to misunderstanding. The term “relevant stakeholders” provides a better explanation of this indicator. The group of process-related performance indicators has been considered to be adequate. “Timely submission of the report” and “add value to the project” were raised as two important outcome performance indicators. After discussions, the indicator “add value to the project” was linked to the existing KPI “client’s satisfaction”. “Percentage of action plan carried out” was modified to be “percentage of action plan without uncertainty carried out” to make this indicator more accurate.

7.4.2 Questions in General

The results of the generic questions are shown as Figure 7.1. Basically, the answers to these questions are positive. Most interviewees agreed to these statements. No interviewee chose disagree or strongly disagree. The results demonstrate that the framework is regarded as useful in solving the problems encountered in the performance measurement of VM studies according to the interviewees’ opinions.

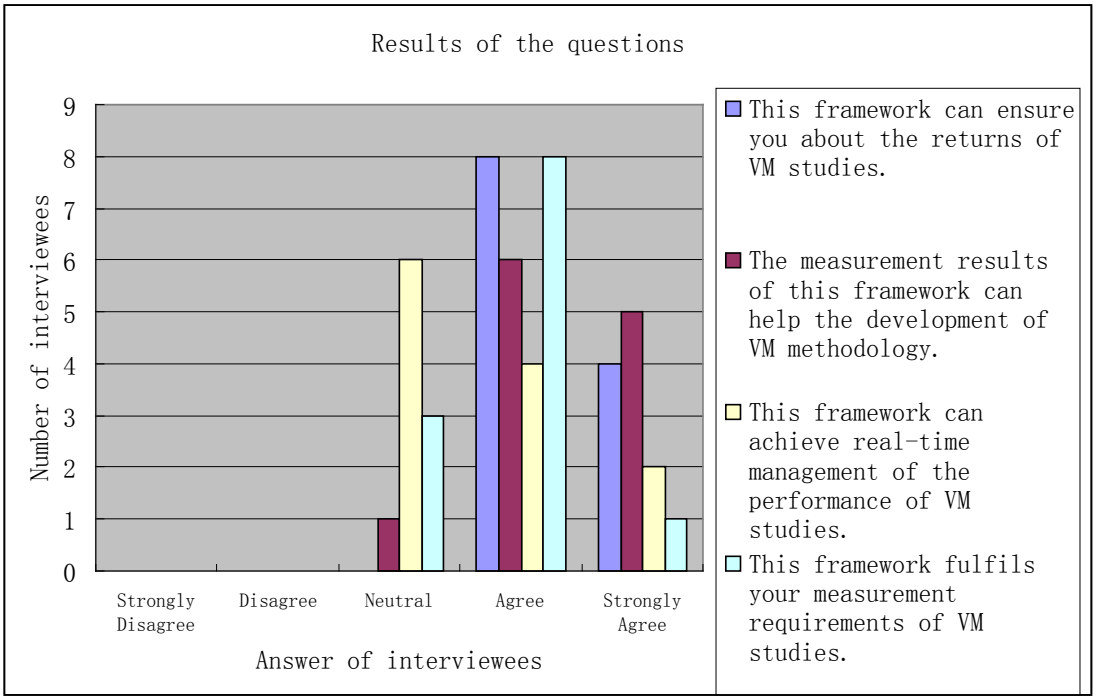

Figure 7.1 Results of the generic questions

All the interviewees agree or strongly agree that the framework can ensure them about the returns of VM studies. They pointed out that the KPIs used in this framework cover all the processes of a VM study which are important to ensure them about the return. All the interviewees commented positively on the three perspectives of the framework. The authors also noticed that the facilitators placed emphasis more on the predicting and process-related KPIs while the government representatives focused on the outcome. Most of the interviewees from the government departments raised a question about why cost savings and/or time savings, which seem to be important indicators about the return of a VM study, are not included. This is why they did not strongly agree to this statement. Generally speaking, VM studies are conducted in the early stage of a construction project to seek the maximum benefits. Cost saving and time saving are difficult to measure clearly because there are so many uncertainties throughout the project. After discussion, they all agreed that the return of the VM studies can be ensured without these two indicators. However, these two indicators

should be included while measuring a VM study conducted in the detailed design stage or construction stage of a project.

Only one interviewee chose neutral to the statement that the results of the framework can help the development of VM methodology. He pointed out that the results of the measurement can reveal the shortages of a specific VM study, however, how to improve VM at a macro-level has not been explained in the framework. The other interviewees agreed that though the framework itself does not give a way to improve the methodology, the improvement and evolution of VM can be achieved by benchmarking the measurement results of the framework. They considered that the predicting and process-related indicators can reveal the interrelationship of process and outcome of the VM studies, which is valuable to the improvement of the methodology.

Half of the interviewees were not so confident about the accomplishment of the real-time management of the performance of VM studies by using this framework. Most VM studies last only one day or even half a day in Hong Kong, therefore, they considered that it was difficult to make an alternative even if it was indicated as being necessary by the framework. The facilitators all agreed to this statement. They admitted that they control the processes of the workshops mostly based on their experience. The framework can help them monitor the performance of VM studies systematically. This will lead to a better real-time management of the performance of VM studies.

Regarding whether the framework fulfils the measurement requirements of VM studies, three interviewees chose neutral, all of whom are government representatives. They were not comfortable that all the objective indicators were excluded as KPIs. The other interviewees regarded the measurement as being adequate.

Only one interviewee said no when asked whether he would use the framework to measure the performance of VM studies in the future. He is a senior manager of a government department with a background in design. He said that he doubted the benefits of conducting VM studies and would not be willing to conduct VM in the future. Therefore, it is an objection to VM itself rather than the framework which made him answer negatively. All the other interviewees were willing to use the framework to measure the performance of VM studies in the future.

7.4.3 Inputs of the workshop

The previous questionnaire survey identified six KPIs as the predicting indicators (Shown in Table 7.8). All the interviewees agreed that these KPIs should be included in the framework. One interviewee pointed out that authorities should be delegated to the associated participants and stakeholders in the KPI "relevant stakeholders' support". Five interviewees from the government department claimed that "knowledge of VM of the participants" should be included in the list. They pointed out that many VM participants who did not have any knowledge of VM made little contribution to the VM studies in practice. However, the others, including two facilitators, did not consider this indicator as a KPI. They claimed that it is the facilitators' responsibility to organize the VM studies so that all participants can

contribute. It is enough that the participants use the knowledge of their own disciplines.

The interviewees' answers about who should score these predicting indicators are shown in Table 7.8. Four interviewees considered that the participants should also be the data providers to the KPI "qualification of the facilitator" because the participants directly observe the performance of the facilitators. However, most of the interviewees pointed out that the selection of facilitators is normally completed before the formation of VM team. Therefore, participants will not have the chance to evaluate the qualification of VM facilitators proactively. Another debate is on whether the participants should score the "client's support" on the VM studies. More than half of the interviewees considered that participants should be the key stakeholders who have a close relationship to the client in the specific project. Therefore, these participants should be able to judge the client's support of the VM study. One interviewee suggested that the facilitator should score the KPI "clear objectives of workshop" and four interviewees voted for client. However, most of the interviewees claimed that the objectives of the VM workshop should be initiated by the client and facilitator. Therefore, it is the participants' responsibility to judge whether the objectives of the workshop are clear.

Table 7.8 Data providers for the KPIs of inputs of the VM studies

Predicting indicators	**Numbers of answers**		
	Facilitator	**Client**	**Participant**
i3 Clear objectives of workshop	1	4	12√
i9 Client's participation	12√		12√

i10 Client's support	12√		7√
i11Disciplines of participants	12√	12√	
i12Qualification of facilitator		12√	4
i13 Relevant stakeholders' support	12√	12√	1

The results of the pair-wise comparison exercise are shown in Table 7.9. The weighting of each KPI is calculated. By analyzing the answers of each interviewee, the KPI "clear objectives of workshop" is recognized as the most important indicator by most of the interviewees. The interviewees who are facilitators gave more emphasis to "client's support" while government representatives did not give high weight to this KPI. The government representatives in the interviews are the clients of the VM studies in the reality. Therefore, they tend to underestimate the importance of their support to the VM studies. For the same reason, they give more emphasis on "relevant stakeholders' support".

Table 7.9 Weightings of the KPIs of inputs of the VM studies

KPIs	**Total Number**	**Weighting**
i3 Clear objectives of workshop	47	0.26
i9 Client's participation	24	0.13
i10 Client's support	30	0.17
i11 Disciplines of participants	21	0.12
i12 Qualification of facilitator	26	0.14
i13 Relevant stakeholders' support	32	0.18
Total	180	1.00

By summarizing the answers of the interviewees, the definitions of each scoring for the predicting indicators are listed in Table 7.10.

Table 7.10 Definitions of the scoring for the predicting indicators

KPIs	5	4	3	2	1
Clear objectives of workshop	All the objectives of the workshop are clearly addressed with interpretive documents from the inception of the study	The major objective of the workshop is clearly addressed with interpretive documents	The objectives are addressed before the start of VM workshop	The major objective is addressed before the start of VM workshop	Conducting the workshop without regard for objectives or outcomes
Client's participation	Decision maker of the client organization participates in the entire process of the VM study	Decision maker of the client organization participates in the VM workshop stage and a senior manager participates in the other stages	Senior manager participates in the entire process of the VM study	Senior manager participates in the VM workshop and client representatives participate in the other stages	No senior manager participates in the VM workshop
Client's support	Full support from the top management of the client organization	Support from most of the senior management of the client organization	Support from at least one of the senior management of the client organization	Support from the middle level management of the client organization	The VM study is conducted just to obey regulations
Disciplines of participants	All of the senior managers of the stakeholders are included in the VM team;	All of the senior managers of the key stakeholders and most of the representatives of the stakeholders are included in the VM team;	Most of the senior managers of the key stakeholders and the representatives of the other key stakeholders and stakeholders are included in the VM team;	All the representatives of the key stakeholders and some representatives of stakeholders are included in the VM team;	A representative from any of the key stakeholders is missing.
Qualification of facilitator	World-famous qualified VM facilitator	Qualified VM facilitator with more than 10 years experience and who has facilitated more than 10 VM studies in the	Qualified VM facilitator with more than five years experience and who has facilitated more than five VM studies in the	Qualified VM facilitator who has facilitated at least two VM studies	Qualified VM facilitator who has facilitated less than two VM studies or not qualified VM facilitator

		past two years	past two years		
Relevant stakeholders' support	Full support from all the relevant stakeholders	Full support from the key stakeholders	Support from the majority of the stakeholders	Support from some key stakeholders	No support from the stakeholders

7.4.4 Processes of the workshop

The previous questionnaire survey identified five KPIs as the process-related performance indicators. All the interviewees agreed that these KPIs covered the most important aspects of the processes of VM studies. Regarding the KPI "primary functions identified", an interviewee suggested that the primary processes should also be noted as many VM studies conducted at the beginning of a construction project focus on the identification of the primary processes of the projects. Therefore, this indicator is modified as "primary functions/processes identified".

The interviewees' answers about who should score these process-related indicators are shown in Table 7.11. Most of the interviewees considered that the background information of VM studies should be provided by the clients. The participants of VM studies can judge whether the information collected is complete or not. The interaction among the participants in each phase of the VM studies should be scored by both the facilitators and clients according to the answers of most interviewees. Several interviewees who are facilitators claimed that the facilitators should not score "client's objectives clarified" and "primary functions/processes identified" because it is the client's and stakeholders' task to judge these two KPIs. The other interviewees, on the other hand, claimed that facilitators should give scores to these two KPIs because facilitators will have an insight to the projects while organizing the VM studies. The facilitators are familiar with the VM methodology, especially the function analysis. This should make their opinions of these two KPIs more

meaningful. All the interviewees agreed that the clients and participants should judge whether the project givens/assumptions were clarified while four of them claimed that facilitator should also contribute to this KPI. However, most interviewees regarded the facilitators' opinions of this KPI as not being as important as the client's and participants' opinion.

Table 7.11 Data providers for the process-related KPIs

Process-related performance indicators	**Numbers of answers**		
	Facilitator	**Client**	**Participant**
i15 Background information collected	1	3	12√
i22 Client's objectives clarified	9√	10√	12√
i23 Interaction among participants in each phase	12√	11√	2
i24 Primary functions/processes identified	9√	5	12√
i25 Project givens/assumptions clarified	4	12√	12√

The results of the pair-wise comparison exercise of the process-related performance indicators are shown in Table 7.12. The weighting of each KPI is calculated according to the results. 'Client's objectives clarified' is ranked as the most important indicator by most of the interviewees. The interviewees who are facilitators focus more on the interaction among the participants during the VM studies while the interviewees from the governmental sector pay more attention to 'primary functions/processes identified'.

Table 7.12 Weightings of the process-related KPIs

KPIs	Total Number	Weighting
i15 Background information collected	9	0.08
i22 Client's objectives clarified	39	0.32
i23 Interaction among participants in each phase	28	0.23
i24 Primary functions/processes identified	31	0.26
i25 Project givens/assumptions clarified	13	0.11
Total	120	1.00

By summarizing the answers of the interviewees, the definitions of each scoring for the process-related indicators are listed in Table 7.13.

Table 7.13 Definitions of the scoring for the process-related KPIs

KPIs	5	4	3	2	1
Background information collected	Plenty of information containing the critical background information is collected and well-documented in various formats such as graphs, pictures and tables which can facilitate the VM team to understand the study	Plenty of information containing the critical background information is collected	The critical background information is collected with some other supplementary information	The critical background information is collected	Any critical background information is missing
Client's objectives clarified	Consensus of the client's objectives by all the VM team members is obtained after clarification	Most of the VM team members understand the client's objectives after clarification	Most of the VM team members understand the client's major objectives after clarification	Different understanding of some of the client's objectives still remains	Client's objectives are not clarified
Interaction among participants in	The interaction among participants is enthusiastic throughout the	The interaction among participants is positive in most of the	The interaction among participants is positive in most of the	The interaction among participants is positive in the information	The interaction among participants is limited

each phase	workshop	phases, no participants perform dominantly or silently	phases but some participants perform dominantly or silently during the workshop	phase, function analysis phase and creativity phase	
Primary functions/processes identified	All the functions/processes are identified and get the consensus of the VM members; a FAST diagram is drawn for reference during the workshop	All the functions/processes are identified and a FAST diagram is drawn, but a few team members have different views	All the primary functions/processes and some of the secondary functions/processes are identified	Primary and secondary functions/processes are listed but team members still have different views	Primary function/processes are not identified
Project givens/assumptions clarified	All the project givens/assumptions are clarified and well-documented for reference during the workshop	Most of the project givens/assumptions are clarified	The critical project givens/assumptions are clarified	Some of the project givens/assumptions are clarified but a lot are missing	Project givens/assumptions are not clarified

7.4.5 Outcomes of the workshop

The previous questionnaire survey identified seven KPIs as the outcome performance indicators. Several interviewees pointed out that the cost savings and time savings should be included in the list. The discussions about these two indicators are the same as the discussions in the generic questions. In the focus group meeting, most of the interviewees disagreed to the addition of the indicator "timely submission of the VM report" to the list because VM reports are submitted soon after the completion of the VM studies by the facilitators.

The answers about the data providers of the outcome performance indicators are shown in Table 7.14. All the interviewees agreed that the clients should score all the outcome performance indicators. More than half of the interviewees considered that participants should provide an evaluation of the quality of the VM report because they attended the VM studies and know what happened during the processes. Regarding

the identification and clarification of the client's requirements, most of the interviewees suggested all the facilitators, clients and participants should give a score to this KPI.

Table 7.14 Data providers for the outcome-related KPIs

Outcome performance indicators	Numbers of answers		
	Facilitator	Client	Participant
i31 Quality of the report		12√	7√
i32 Percentage of action plan without uncertainty carried out		12√	2
i39 Accelerating the decision-making	1	12√	1
i41Client's satisfaction		12√	
i42 Identifying and clarifying the client's requirements	10√	12√	12√
i43 Improving communication and understanding among stakeholders	2	12√	3
i45 Improving the project quality	1	12√	3

The results of the pair-wise comparison exercise of these outcome performance indicators are shown in Table 7.15. "Improving the project quality", "identifying and clarifying the client's requirements" and "improving communication and understanding among stakeholders" are considered to be the most important indicators by most of the interviewees. Many interviewees considered that client's satisfaction is the ultimate indicator to measure the performance of VM studies while the others claimed that this indicator is not so important in this list because the client's satisfaction is related to the other KPIs to some extent.

Table 7.15 Weightings of the outcome-related KPIs

KPIs	Total Number	Weighting
i31 Quality of the report	10	0.04
i32 Percentage of action plan without uncertainty carried out	16	0.06
i39 Accelerating the decision-making	23	0.09
i41 Client's satisfaction	43	0.17
i42 Identifying and clarifying the client's requirements	49	0.20
i43 Improving communication and understanding among stakeholders	52	0.21
i45 Improving the project quality	59	0.23
Total	252	1.00

By summarizing the answers of the interviewees, the definitions of each scoring for the outcome performance indicators are listed in Table 7.16.

Table 7.16 Definitions of the scoring for the outcome-related KPIs

KPIs	5	4	3	2	1
Quality of the report	The report is well-organized with the information about all the processes and outcomes of the study in it, and is submitted to the client soon after the workshop	The report contains all the important information of the study but is not organized so well	The report contains the outcomes of study and brief information about the processes	The report briefly summarizes the study but lots of useful information is missing	The report misses any important outcomes of the study or it is not submitted to the client after the workshop
Percentage of action plan without uncertainty carried out	All the actions listed in the action plan are one hundred percent completed and reported	All the actions are followed-up but some are not completed	Most of the actions are followed-up	Some of the actions are follow-up	The action plan is just a document on the shelf
Accelerating the	Decisions can	The outcomes	The	The outcomes	The outcomes

decision-making	be made immediately according to the outcomes of the VM study	of the study are important supports to the decision-making	outcomes of the study are useful to the decision-making	of the study slightly influence the decision-making	of the study have no influence on the decision-making
Client's satisfaction	Highly satisfied	Satisfied	Quite satisfied	Slightly satisfied	Not satisfied
Identifying and clarifying the client's requirements	All the client's requirements about the projects discussed in the study are identified and clarified, consensus of all the stakeholders of the project on the client's requirements is obtained	Most of the requirements are identified and clarified after the study	Most of the requirements are identified but some are not clarified	Some of the requirements are identified and clarified, but a lot are not	The misunderstanding on the client's requirements is still serious
Improving communication and understanding among stakeholders	All the key stakeholders of the project build up a positive relationship after the VM study	Most of the key stakeholders build up a positive relationship after the VM study	Most of the key stakeholders improve understanding between each other	Some of the key stakeholders improve understanding between each other	The communication and understanding does not improve at all
Improving the project quality	The project quality is highly improved in a lot aspects including primary functions by conducting the recommendations of the VM study	The project quality is improved in a lot aspects including primary functions	The project quality is improved in the primary functions	The project quality is slightly improved	The project quality is not improved or decreased

7.5 Refining of the Measurement Framework

According to the findings of the case studies, the focus group meeting and the interviews, the performance measurement framework is refined.

The measurement processes are mainly the same as introduced in Section 6.5.1. Some of the KPIs are revised. The revised KPIs for measuring the performance of VM studies are shown in Figure 7.2. The data providers for each KPI are refined according to the results of interviews. Table 7.17 shows the revised data providers for the KPIs belong to different groups. The weightings of the KPIs are standardized to a 1-10 scale according to their original weightings in each group to make the calculation easier. Table 7.18 to Table 7.20 lists the standardized weightings of the KPIs of the three groups.

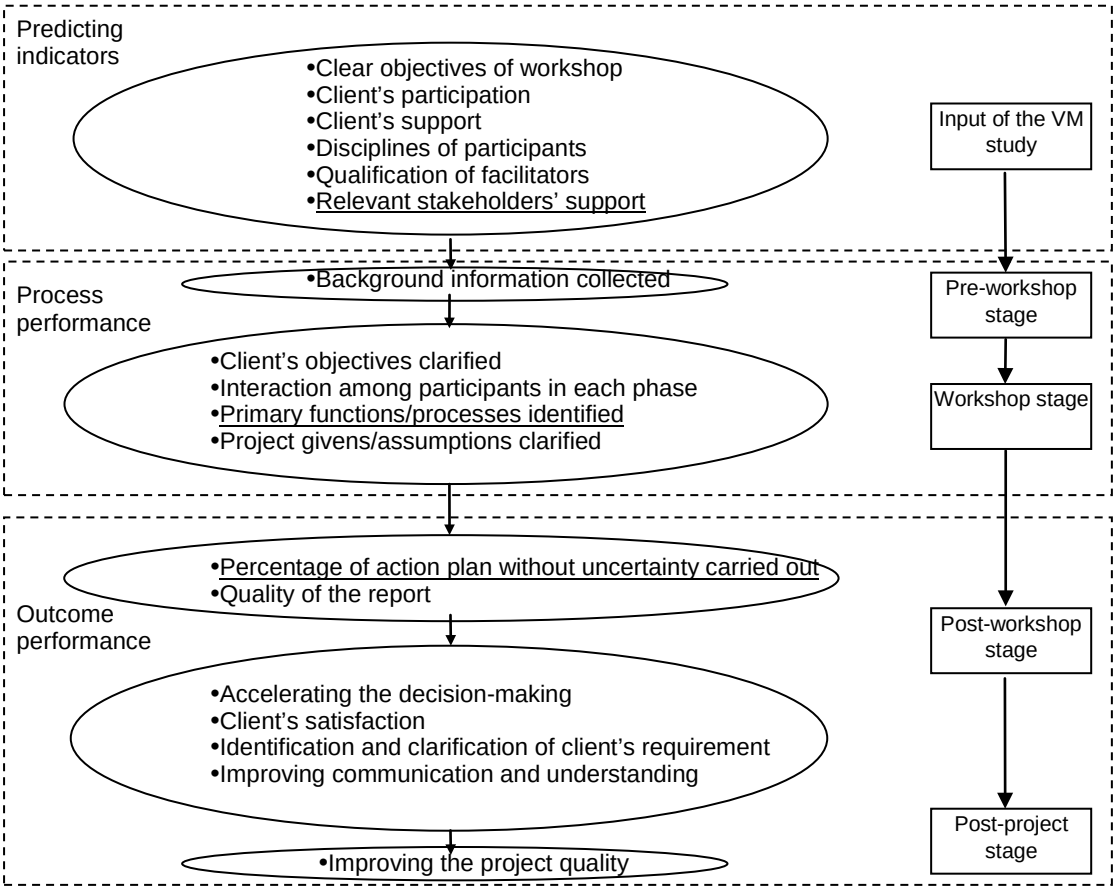

Figure 7.2 Revised KPIs for measuring the performance of VM studies

Table 7.17 Data providers for the KPIs of inputs of the VM studies

KPIs	Numbers of answers		
	Facilitator	Client	Participant
Predicting indicators			
Clear objectives of workshop			√
Client's participation	√		√
Client's support	√		√
Disciplines of participants	√	√	
Qualification of facilitator		√	
Relevant stakeholders' support	√	√	
Process-related performance indicators			
Background information collected			√
Client's objectives clarified	√	√	√
Interaction among participants in each phase	√	√	
Primary functions/processes identified	√		√
Project givens/assumptions clarified		√	√
Outcome-related performance indicators			
Quality of the report		√	√
Accelerating the decision-making		√	
Client's satisfaction		√	
Identifying and clarifying the client's requirements	√	√	√
Improving communication and understanding among stakeholders		√	
Improving the project quality		√	

Table 7.18 Weightings of the KPIs of inputs of the VM studies

KPIs	Original Weighting	Standardized Weighting
Clear objectives of workshop	0.26	10
Client's participation	0.13	5
Client's support	0.17	7
Disciplines of participants	0.12	5
Qualification of facilitator	0.14	5
Relevant stakeholders' support	0.18	7

Table 7.19 Weightings of the process-related KPIs

KPIs	Original Weighting	Standardized Weighting
Background information collected	0.08	3
Client's objectives clarified	0.32	10
Interaction among participants in each phase	0.23	7
Primary functions/processes identified	0.26	8
Project givens/assumptions clarified	0.11	3

Table 7.20 Weightings of the outcome-related KPIs

KPIs	Original Weighting	Standardized Weighting
Percentage of action plan without uncertainty carried out	0.06	3
Quality of the report	0.04	2
Accelerating the decision-making	0.09	4
Client's satisfaction	0.17	7
Identifying and clarifying the client's requirements	0.20	9
Improving communication and understanding among stakeholders	0.21	9
Improving the project quality	0.23	10

The performance indexes are built according to the scorings and weightings of the KPIs. The indexes are the overall indication to the performance of the VM studies.

$$INDEX_{Pre} = \frac{\sum S_i \times W_i}{39}$$

$INDEX_{Pre}$ is the index for the inputs of VM studies on a one to five scale. S_i is the scoring of the KPI that belongs to the predicting indicators, while W_i is the weighting related to the KPI. This index could be used to check whether the VM studies received adequate support and conducted necessary measures if it was needed.

$$INDEX_{Pro} = \frac{\sum S_j \times W_j}{31}$$

$INDEX_{Pro}$ is the index for the process performance of VM studies on a one to five scale. S_j is the scoring of the KPI that belongs to the process-related KPIs, while W_j is the weighting related to the KPI. This index represents the process performance of a VM study. It gives an overall impression on how well the VM workshop is being conducted.

$$INDEX_{Out} = \frac{\sum S_k \times W_k}{31}$$

$INDEX_{Out}$ is the index for the outcome performance of VM studies on a one to five scale. S_k is the scoring of the KPI that belongs to the process-related KPIs, while W_k is the weighting related to the KPI. This index shows the outcome performance of the VM study and indicates to what extent the investment is returned.

$$INDEX_{Per} = \frac{INDEX_{Pro} + INDEX_{Out}}{2}$$

$INDEX_{per}$ is the overall index which concludes the performance of the VM study.

7.6 Summary

This chapter presents the validation of the performance measurement framework by case studies, the focus group meeting and the interviews. Case Study 1 conducted a comparison study based on two VM studies using different methods. The findings show that VM studies which have clearer objectives lead to better outcome performance. The hypothesis "VM studies which have better scores in leading indicators will have better scores in lagging indicators" is partially proved.

The action research presents the use of the preliminary framework to the entire process of a VM study. The results of the measurement showed that a full picture of the performance of the VM study can be drawn by applying the performance measurement framework. There is a need to identify the KPIs to make the measurement process more succinct according to the duplicated measurement discovered in the case study. How to ensure objectivity and consistency when scoring, the indicators should be carefully considered in the detailed framework. Another disadvantage of the preliminary framework is that no weightings were assigned to the indicators. The importance of these indicators should be different according to the performance which they measure. The results of follow-up questionnaire survey show that most of the participants agreed that feedback is useful in improving the

performance of the study; they especially admitted that the real-time feedback helped them perform better in the study; they also considered that three to five minutes of feedback is adequate and does not interrupt the workshop processes.

A focus group meeting and in-depth interviews were conducted with the VM practitioners and government representatives to test the validity of the framework. The results of the focus group meeting and interviews show that the clients and VM facilitators are positively disposed toward the framework. Most of them agreed that the framework can ensure them about the returns of VM studies, can help the development of VM methodology, and fulfils their measurement requirements of VM studies. All of the interviewees were willing to use the framework to measure the performance of VM studies in the future, except one who was negatively disposed toward all VM studies. The focus group meeting and interviews also validate the KPIs identified by the previous questionnaire survey. Cost savings and time savings are two performance indictors paid attention to by several interviewees. They admitted that these two indicators are not suitable for the VM studies in the early stage of project though they may be important in some other cases. The data providers for each KPI are affirmed after the interviews. The weightings of the KPIs of each group are calculated with the results of pair-wise comparison exercises. The weightings take consideration of both the client's and facilitators' opinions. The definitions of the scorings for each KPI are deliberated according to the results of the interviews. These definitions can make sure that the measurement processes are prompt and consistent.

Based on the findings of the case studies, the focus group meeting and the interviews, the performance measurement framework is refined. This includes the revision of the

KPIs, the modification of the data providers, and the revision of the definition of scoring. The indexes which give the overall indications to the performance of VM studies are built. The next chapter will integrate this performance measurement framework into an existing VM computer system.

CHAPTER 8 INTEGRATION OF THE FRAMEWORK WITH IVMS

8.1 Introduction

The implementation of information technology (IT) brings significant productivity improvements to a wide range of industries, including construction. A proper implementation of IT could meet the challenges faced by VM, such as the time limitation, lack of communication and lack of promptness. This chapter first presents a collaboration system entitled IVMS which has been developed by colleagues of the researcher and the integration of the performance measurement framework into this system is then explained. A trial implementation of the system (Case Study 2) to measure the performance of VM studies is conducted to validate the effectiveness and efficiency.

8.2 Introduction to IVMS

IVMS was designed to support the whole process of a typical VM workshop on the Internet. It is a web-based system and can be easily accessed as long as one has a link to the internet or intranet. This software is installed and operated on a Web server; no installation is required in the clients' computers. Users can access the system using any machine, at any time, anywhere, and at any phase of the VM workshop (pre-workshop, workshop, and post-workshop).

In the pre-workshop phase, IVMS can be used to collect information relating to the project, either by inputting the information into the system or by uploading the

relevant documents. The system covers the six major phases in the VM workshop job plan, namely Information, Analysis, Creativity, Evaluation, Development, and Presentation. Participants can log in to the system using their own computers and enter their ideas on a keyboard, and each member can see on his or her own screen the ideas generated by others. These ideas will be categorized, scored and further developed in the system. A report will be generated automatically by the system after the workshop is finished.

During the whole process, the system automatically collects the ideas that have been generated and provides dynamic pages to categorize and score ideas according to the information inputted by the participants. In traditional VM workshops, participants generate ideas in a face-to-face approach and the ideas are recorded on paper. The sheets of paper are then collected and the ideas are inputted into an Excel or another computer file for categorization and scoring. The web-based and integrated features make it possible to increase the efficiency and effectiveness of VM workshops.

The system architecture is shown in Figure 8.1.

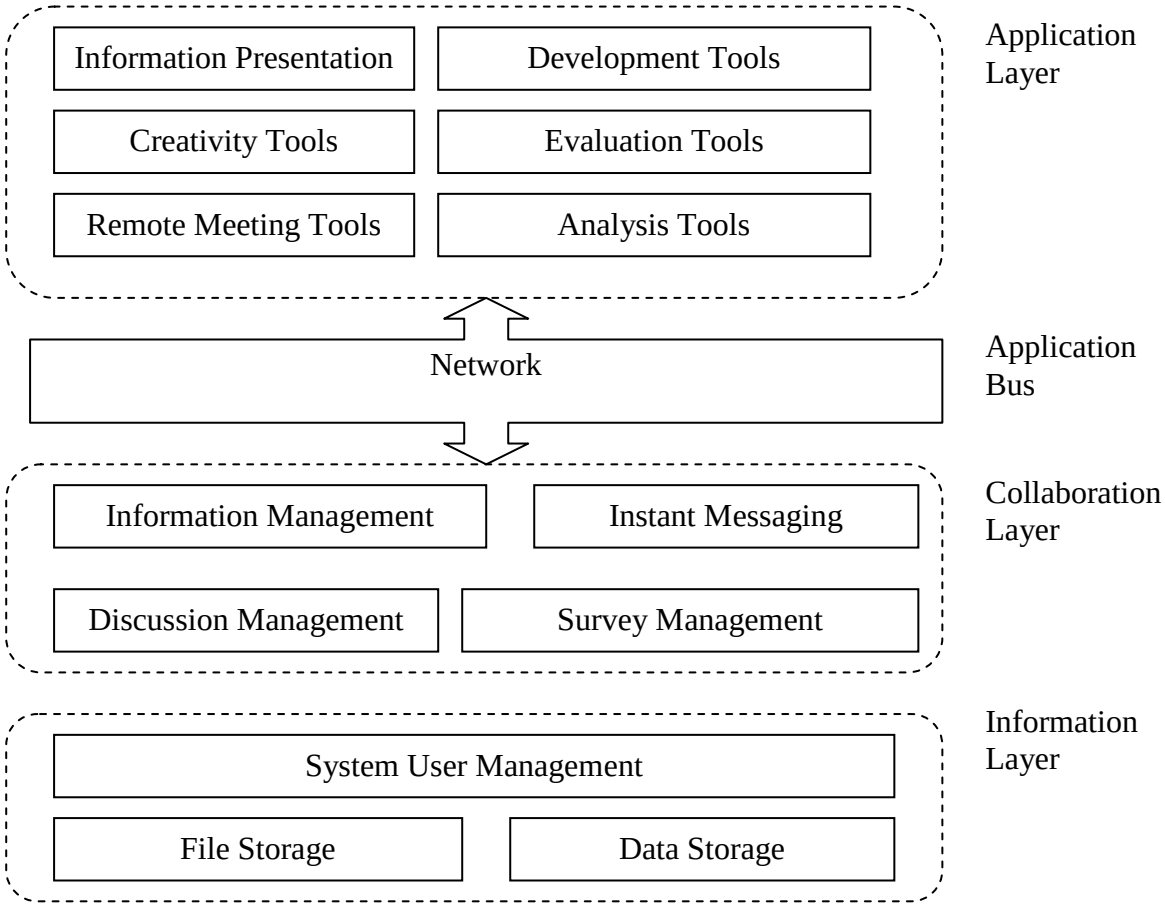

Figure 8.1 The system architecture of IVMS

In terms of logic, the system can be divided into three layers comprising the information layer, collaboration layer and application layer.

8.2.1 Information layer

The infrastructure of the IVMS structure is the information layer. This layer provides file storage function, data storage function and system user management. The database SQL Server is used to store all kinds of information. Windows SharePoint Services with SQL Server support is an expandable and manageable environment and offers full text search capabilities. As the IVMS is a web-based system, the user management is very important. Windows SharePoint Service provides a role-based

permissions mechanism and allows the management of user privileges, as shown in the following Figure 8.2.

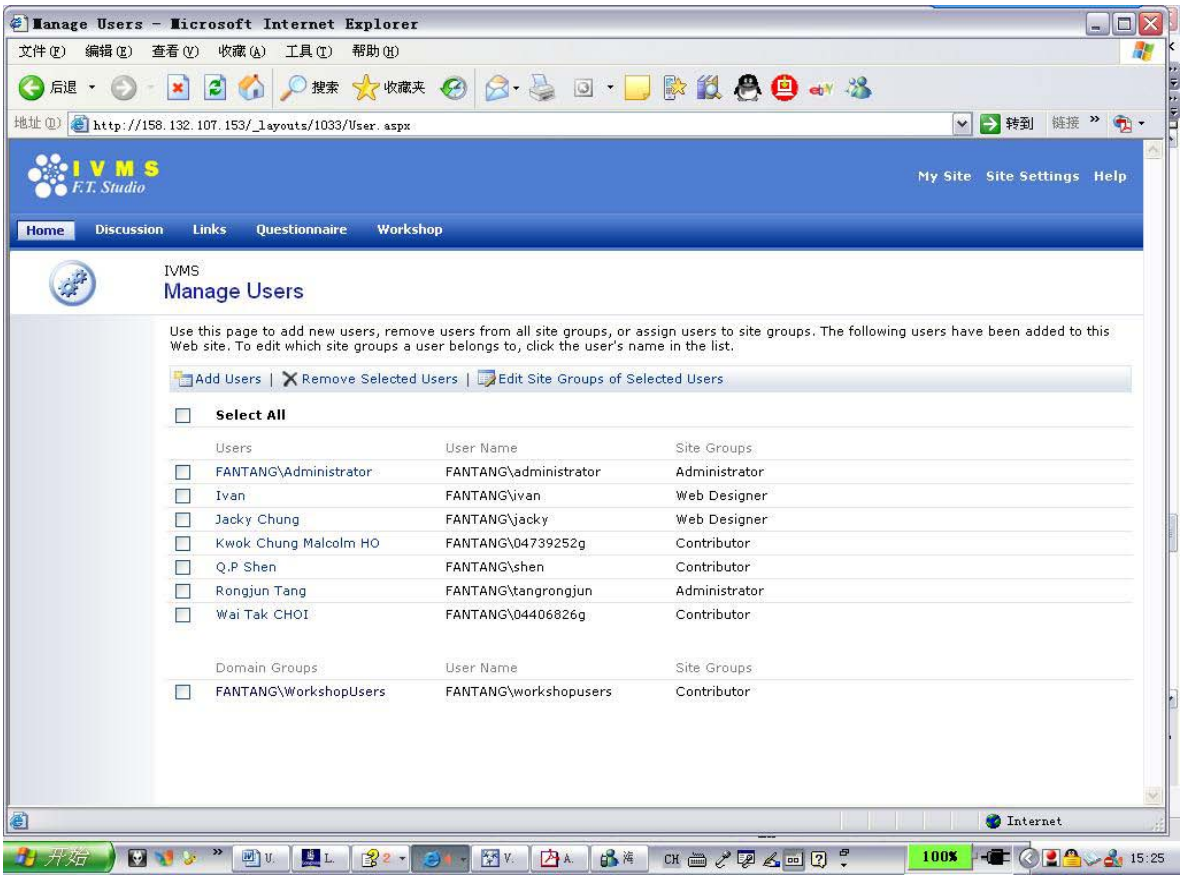

Figure 8.2 User management interface

Participants can enter the system by using their own user accounts and passwords in the VM workshop, and different participants will access different information correspondently. Certain users can be limited to read-only access to the documents in IVMS libraries or workspaces, which can ensure that they cannot revise the documents.

8.2.2 Collaboration layer

The collaboration layer provides four functions to improve collaboration between team members. They are information management, instant messaging, discussion management and survey management.

SharePoint technology offers a number of features, such as workspaces and discussion boards that provide a more conducive environment for sharing documents and information. Instead of emailing a document as an attachment to a group, a workspace that contains the documents can be quickly created, and members of the group can access the documents through the workspace. SharePoint technologies also offer a document check-out process that makes it clear who is now editing the document. Different versions of the document can be automatically saved, and comments can be added to different versions so that it is clear what changes have been made.

In IVMS, a discussion board can quickly be created to track threads of a discussion and offshoots of the original discussion. The VM participants can post a discussion easily and all the team members can communicate through the discussion board.

In addition, IVMS also provides another efficient communication tool, instant messaging. By using Windows Messenger, users can directly send messages to the people in the project contact list, which is created before the VM workshop. The participants may use Windows Messenger to launch a peer-to-peer conversation.

The survey management function provides the ability to create surveys and calculate the results automatically. Users can respond to surveys online. After they submit the response, IVMS can automatically generate results and can present the results in graphic mode or data table mode.

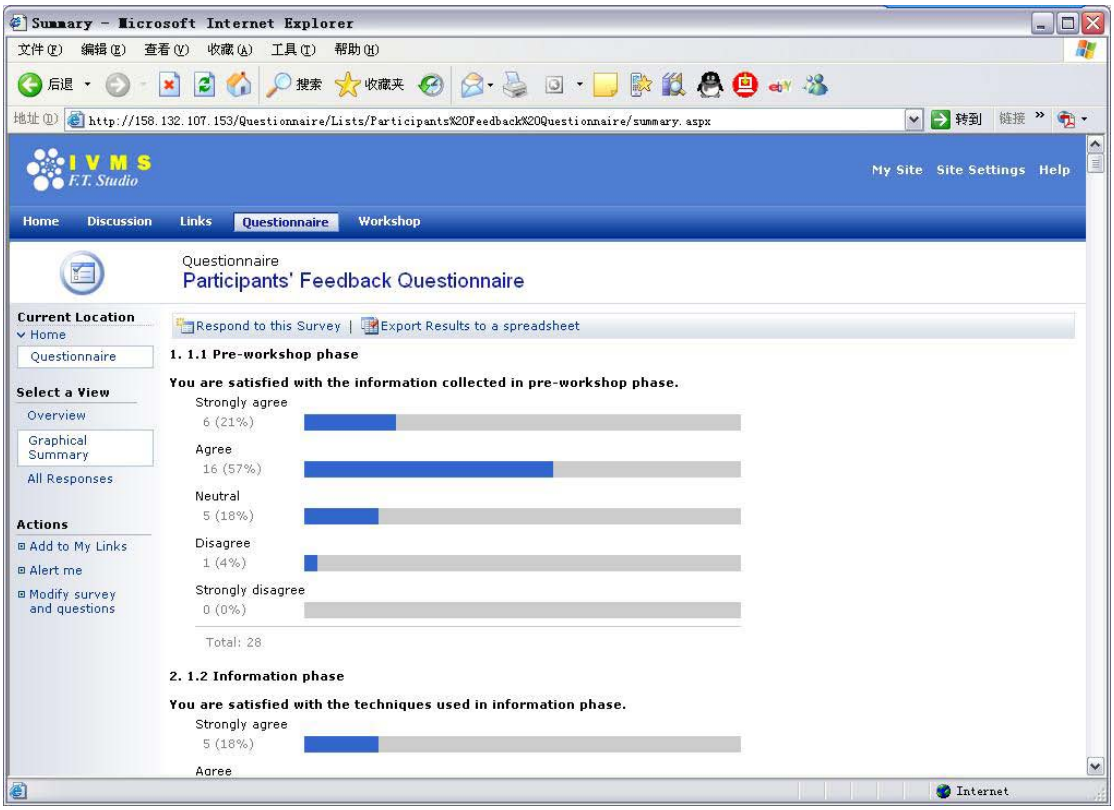

Figure 8.3 Online survey interface

8.2.3 Application layer

IVMS covers the six major phases in the VM workshop job plan, namely Information, Analysis, Creativity, Evaluation, Development, and Presentation. In each phase, previous researchers have developed some special tools to support the process. IVMS is designed to be an open system so that all these special tools can be easily integrated. By using the technology named Web Part, SharePoint Service can integrate other old programs into IVMS in a unique interface style. In this platform, the different tools can exchange data through the information layer. The system has the function to collect the workshop data such as ideas generated, scores of the selected ideas, and the major valuable data produced in the whole process of the workshop. Therefore, the system can be used to store historical data, which can be used to measure the performance of VM studies.

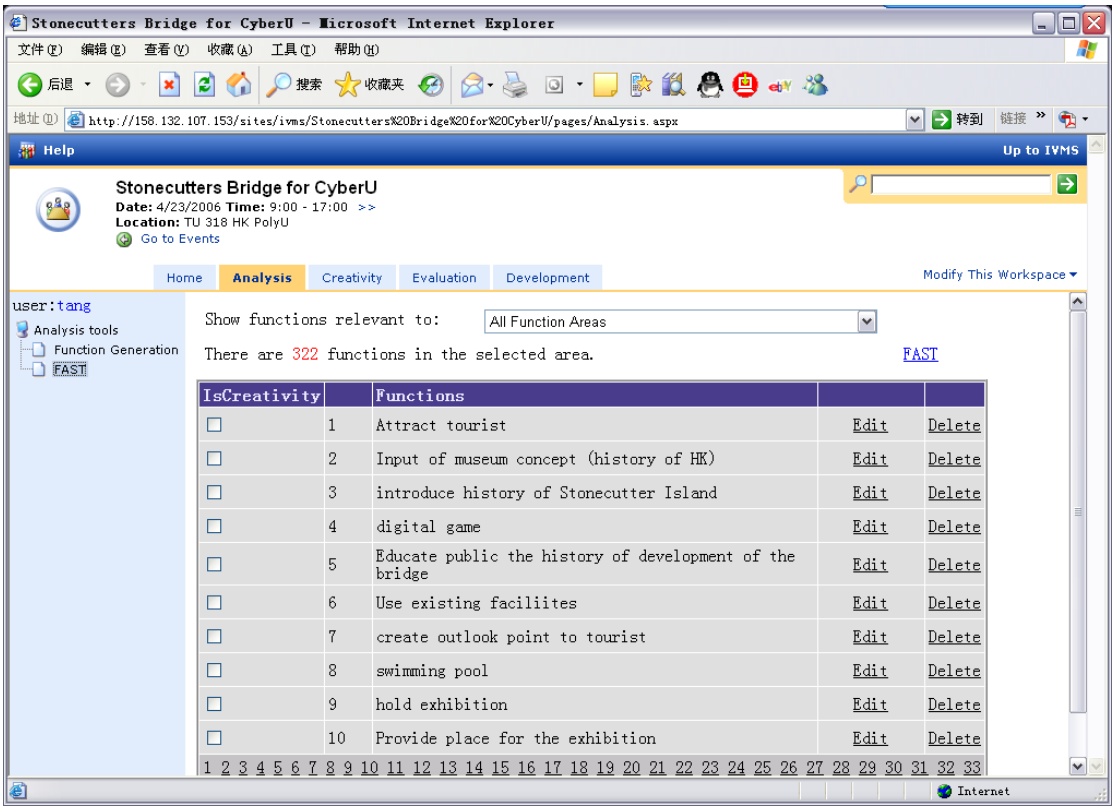

Figure 8.4 VM Tools integration interface

8.2.4 IVMS system network

Based on the logical system model, the IVMS system network architecture was designed, as shown in Figure 8.5. The main part of the system is in a local area network. The Microsoft SQL SERVER database is installed on a database server in which all of the data and files are stored. The SharePoint Service is installed on the collaboration server. The operating system of the collaboration server is Microsoft Windows Server 2003. Because SharePoint Service is tightly connected to Windows Server 2003 Active Directory (AD), a site administrator can simply use AD security groups or distribution lists when populating site groups, or new groups may need to be created in AD based on SharePoint 2003 access requirements. The application layer of IVMS is also in this server. All VM workshop participants in the local

network can easily access the collaboration server by using their personal computers or laptops. Wireless access points are used in the system to provide the capability of using wireless equipment. Participants can move around with their laptops in a venue without a network cable restricting their movement. Moreover, some new wireless equipment can also be used in the system, such as smart phones, wireless personal digital assistants (PDA) and tablet PCs. All of this equipment uses IEEE 802.11 protocol. 802.11 refers to a family of specifications developed by the IEEE for wireless LAN technology. It specifies an over-the-air interface between a wireless client and a base station or between two wireless clients. The IEEE accepted the specification in 1997. Within the embedded internet web browsers, this wireless equipment can use the system as well as things done on the personal computer. The IVMS system components are listed in Table 8.1.

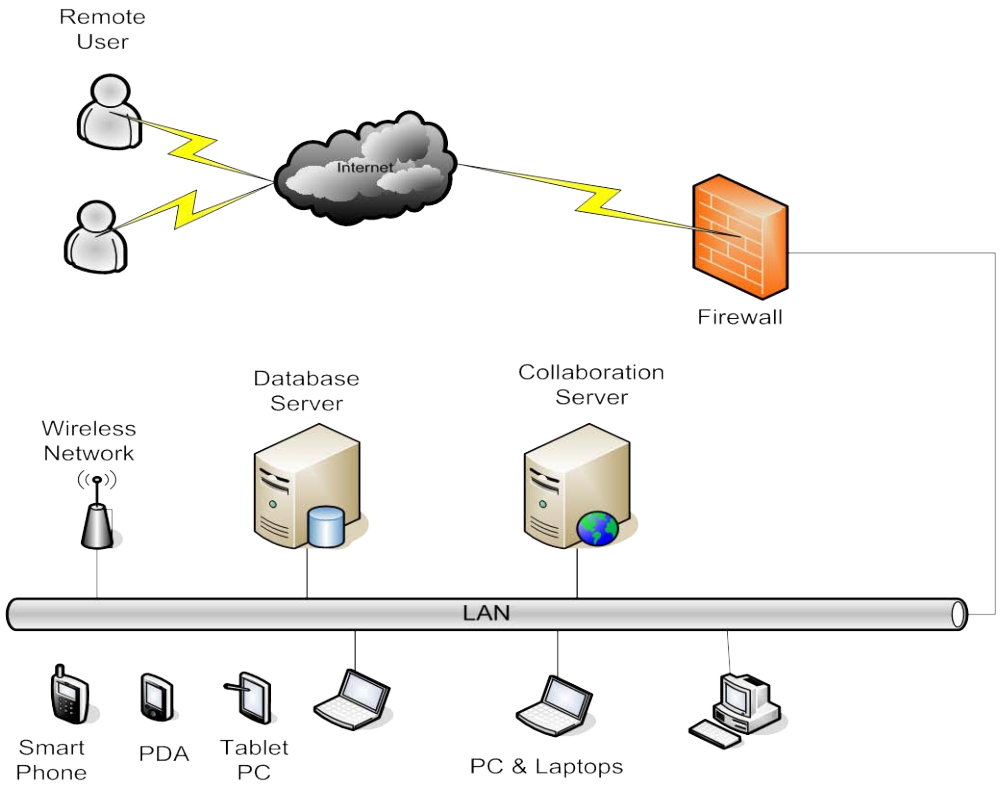

Figure 8.5 System network architecture

Table 8.1 IVMS System Components

	Component
Hardware	Dell server
	40 HP tablet PCs
	Wireless router
	LCD projector
Software	Windows Server 2003
	Windows SharePoint Server 2003
	SQL Server 2000
	Visual Studio 2003 .net
	Microsoft Office 2003 professional

8.3 Integrating the Performance Measurement with IVMS

The existing IVMS has the function to automatically generate reports of the workshop. Although it only presents the rough data such as numbers of ideas generated and the scores of the selected ideas, the major valuable data engendered in the whole process of the workshop is recorded by the system. Therefore, it is feasible to integrate the performance measurement with the system. Figure 8.6 illustrates the concept of the integration.

The indicators for measuring the performance of VM studies could be divided into two categories: objective indicators and subjective indicators. Most data of the objective indicators could be obtained and calculated by the existing system. An electronic questionnaire has been developed and integrated into the system to collect subjective data, such as the client's satisfaction, participants' satisfaction and interaction among participants etc.

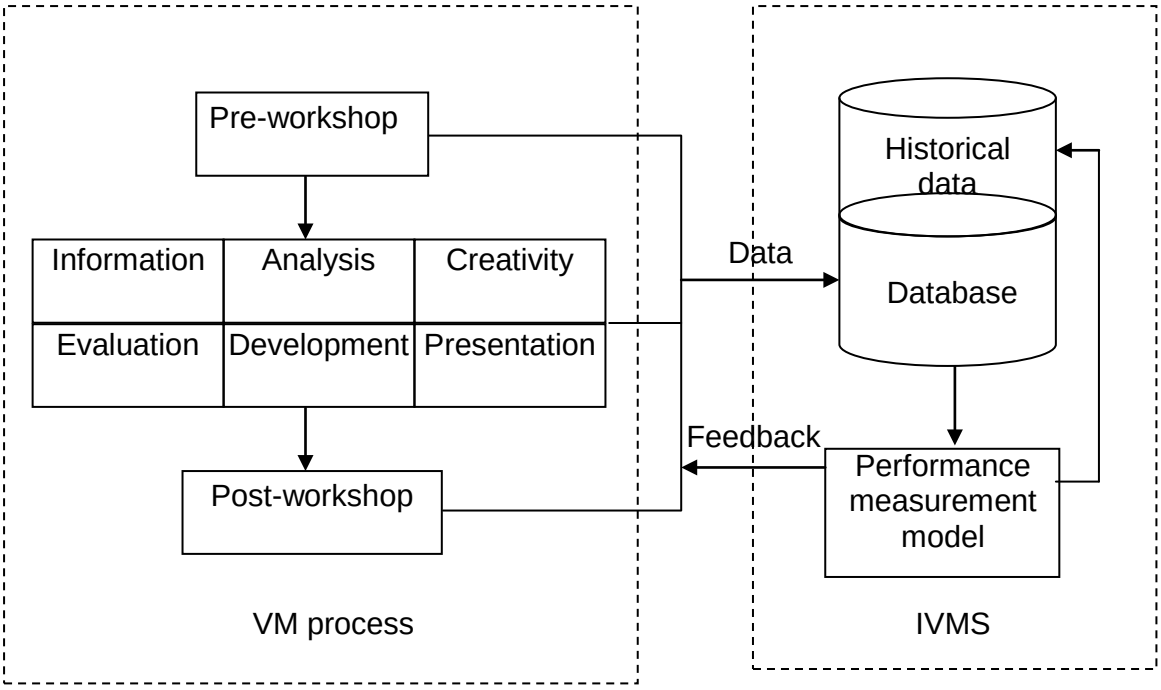

Figure 8.6 Integration of performance measurement into IVMS

Formulas are developed to convert the data of each indicator to a five-scale score, where five means best performance and one means worst performance. Weightings are assigned to the indicators according to the survey of the VM experts. By multiplying the five-scale score by the weighting, the standard score of each indicator is obtained. Finally, these standard scores are combined to generate a comprehensive performance index which indicates the performance of the workshop in general. All these phases are background processed and all the participants need to do is to fill in and submit the electronic questionnaire and get the performance scores and indexes. If it is needed, a detailed report on the performance of the specific criteria could also be generated automatically by the system. The result of the measurement could be sent to the decision makers immediately via email by the system.

The entire information flow of the measurement process is illustrated in Figure 8.7. The web-based interface serves as a single point of control and reference, giving the user the following options:

- Search project and workshop data and enter contract details
- Upload relevant documents and fill-in new data in the standard forms
- Use plenty of toolkits developed for VM workshops
- Check the outcomes and performance reports of VM studies.

The number of performance indicators to be used depends on the degree of sophistication of the project as well as the type of the study. The data of the VM studies in relation to each indicator are stored in the database for later use. This enables the benchmarking of different types of VM studies.

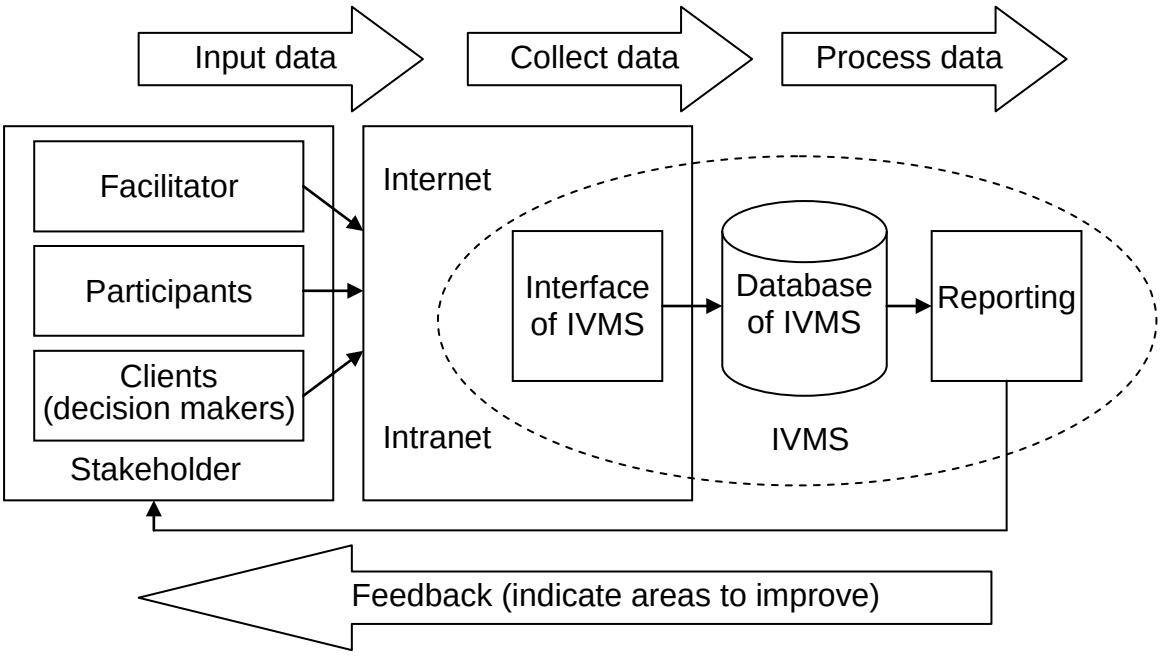

Figure 8.7 Framework of information flow

8.4 Trial Implementation of the System in VM Studies (Case Study 2)

In order to investigate the benefits of using IT in measuring the performance of VM studies, an experimental study which compared two VM studies was conducted. The traditional method of data collection and performance measurement was used in one of the VM studies, and IVMS integrated with performance measurement frameworks was used to assess the performance in the other one. The objectives and design of this case study are introduced in Section 4.5.2.

8.4.1 Performance measurement processes of the VM studies

Pre-workshop

VM Study A: The performance evaluator had to collect and sort the personal information of each participant. The analysis of historical documents and project-related documents was conducted by the participants individually. Therefore, the evaluator could not know the number of documents analyzed until the start of the workshop.

VM Study B: The personal information of the participants was automatically recorded by the computers when they first logged in to the system. The participants uploaded the related files to the system during the preparation period. Who uploaded the files and who downloaded the files were also recorded.

Workshop

VM Study A: The evaluator sat beside the groups to record the process of the workshop. He did not give any advice to the group during the discussion to avoid

disruption of the discussion. He recorded the participants who were not active during the discussion and gave some encourage in the tea break period. A number of ideas and issues were generated by the participants and written on sticky Post-it notes. The evaluator collected those notes after the completion of the discussion. Feedback was given by the evaluator when it was necessary. At the end of the workshop, the evaluator handed out the questionnaires to the participants and the facilitator to collect the subjective data.

VM Study B: The participants typed their ideas into the system using the computers assigned to them. All the ideas were automatically recorded in the database by the system (as shown in Figure 8.8). The facilitator modified the inappropriate expressions and deleted the duplicated ideas on the system at once. Some of the indicators such as the efficiency of idea generation (i.e. ideas generated per minute) were calculated by the computer simultaneously in the background. A pop-up window which encouraged the participants to perform more actively would appear if the system detected the participant did not type anything into the system for two minutes in creativity phase. The feedback by pop-up window could not be seen by other participants so that the whole discussion process was not disrupted. After completing the task, the system turned to the electronic questionnaire page (as shown in Figure 8.9) automatically. After the participants completed the questionnaires and submitted them, a brief performance report with a comprehensive performance score was generated by the system to give real-time feedback to the facilitator and participants.

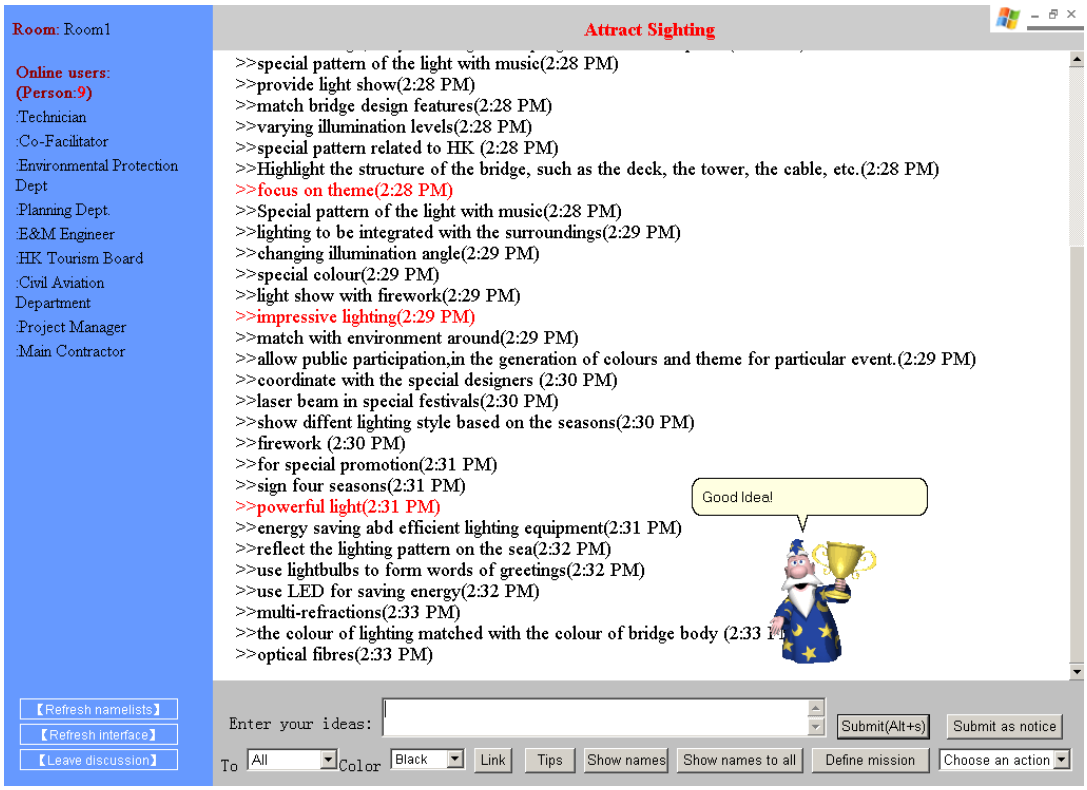

Figure 8.8 Interface of brainstorming in Creativity Session

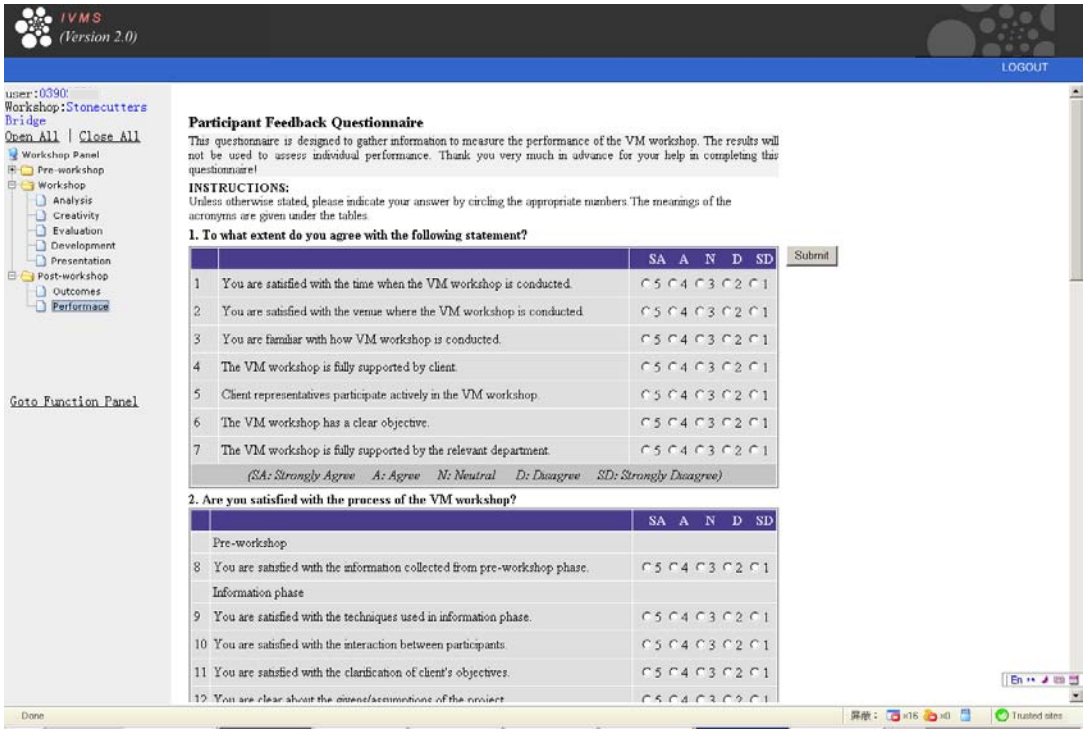

Figure 8.9 Interface of the electronic questionnaire

Post-workshop

VM Study A: The evaluator brought the materials from the workshop back to his office to collect, sort and analysis the data. Totally, there were 92 ideas generated by the participants and one third of them had expression problems. It took him a whole day to process all these materials and another day to produce the performance report of the VM study.

VM Study B: All the relevant data was stored in the database. The client, facilitator or participants could access the results whenever he/she wanted after the workshop. It was quite easy for the facilitator to complete the performance report.

8.4.2 Comparison of the results and discussion

According to the factors identified in Section 4.5.2, the values of each measure in these two VM studies were recorded (as shown in Table 8.2). The results show that a lot of time was saved by applying IT in the performance measurement of VM studies. The results could be even more evident when the VM studies have more participants and more complex tasks because of the increased amount of data. The accuracy of the data does not seem to be increased according to the mistakes in the report. Actually, the performance evaluator spent time to check the raw data collected from the workshop and corrected several mistakes before his writing of the performance report. Another reason is that the tasks of these two studies, which generated less data than complex ones, are quite simple. The control of the performance is enhanced with the support of IT. Meanwhile, the interruptions to the process of the workshop caused by real-time feedback were minimized. It is surprising to see that the satisfaction of participants to the performance measurement in the workshop with IT was less than

that in traditional workshop. Several participants pointed out that they were not unsatisfied with the performance results but the lack of interaction when the performance measurement was conducted by the computer. This is an area where the system could be improved.

Table 8.2 Results of the experimental study

Performance sub-indicators	Traditional workshop	Workshop with IVMS
Time taken for idea collection	6 minutes	2 minutes
Time taken for idea categorizing	30 minutes	5 minutes
Time taken for questionnaire survey (including data analysis)	2 hours	10 minutes
Times of feedback	4 times	18 times
Time taken for feedback	4 minutes	0 minute
Mistakes in the report	0	0
Satisfaction of decision maker to the performance report	4.5 (1: unsatisfied; 5: most satisfied)	4.7 (1: unsatisfied; 5: most satisfied)
Time taken to provide the performance report to the decision maker	1 day	0 minute
Satisfaction of participants to the performance measurement of the VM study	4.2 (1: unsatisfied; 5: most satisfied)	4.1 (1: unsatisfied; 5: most satisfied)

By comparing the performance measurement method in these two VM studies, it is quite obvious that the use of IVMS makes the measurement much easier. The manual method of data collection and performance measurement needs an extra evaluator to record the processes of the workshop and the relevant data. Even then, two days are required to process the data and complete the performance report. Generally, the VM teams will not include a special evaluator to record the information. As a result, more

valuable information may be lost during the measuring process and it takes the facilitators more time to process the fragmented data. If the workshop lasts for a longer time and is conducted by a larger team, the amount of data will be larger, and the efficiency improvement brought by IT will be more evident.

The traditional performance measurement of VM studies makes the management of performance difficult, which costs precious workshop time and interrupts the process of the workshop. Supported by the IVMS, the performance measurement could easily evolve to performance management or performance control. The system uses the pop-up windows to encourage inactive participants, to remind the facilitator of the time or give tips for better idea generation. All these activities are automatic and realized without disrupting the process of the workshop. It not only measures the performance, but also controls and improves the performance.

The benefits IT could bring to the benchmarking for VM studies are not well identified in this study because of the limited number of studies. The merit of using IT could be highlighted by comparing a large number of VM studies.

8.5 Summary

IVMS is designed to support the whole process of a typical VM workshop on the Internet, which could be divided into three layers. These three layers are the information layer, the collaboration layer and the application layer. The performance measurement framework is integrated into this system. All the calculation phases are background processed and all the participants need to do is to fill in and submit the

electronic questionnaire and receive the performance scores and indexes.

According to the results of the trial implementation, it is obvious that the use of IVMS makes the measurement easier. Time-saving and real-time control have been demonstrated by the comparison of two similar VM studies using different methods of measurement, one supported by IT and the other conducted with a traditional method. The improved accuracy and ease of benchmarking are not highlighted by this comparison due to the simplicity of the task and the limited number of workshops. If the workshop lasts for a longer time and is conducted by a larger team, the amount of data will be larger, and the efficiency improvement brought by IT will be more evident. The benefits IT could bring to the benchmarking of VM studies are not well identified in this study because of the limited number of studies. The merit of using IT could be highlighted by comparing a large number of VM studies.

Though the use of IT for performance measurement shows its benefits, the implementation of IT in this field is still in its infancy stage. The major use of IT is to collect, sort and analyze the data automatically, and the advanced usage of IT, such as artificial intelligence, has not been applied. Thus the benefits of using IT are limited to those basic functions. The future performance measurement system might be intelligent and could self-train using historical data to adjust its parameters. The best practice could therefore be realized by the facilitation and monitoring of IT supported performance measurement systems.

CHAPTER 9 CONCLUSIONS, CONTRIBUTION, LIMITATIONS AND FUTURE DIRECTIONS

9.1 Introduction

This chapter presents a summary of the entire research project. The main findings and contributions of the research are concluded. The limitations of the research and the future research directions are also provided.

9.2 Findings and Conclusions

This research identifies that the performance measurement of VM studies has not been widely used, which hinders the wider use and further development of VM methodology. Two major problems in this area have been identified:

1. Due to the lack of effective methods to measure performance, companies at present have no way of knowing whether adequate returns have been made on their investment in these studies;
2. It is also difficult to know what changes can be made to improve performance and to obtain maximum benefits from these studies.

As a result, some companies have had second thoughts on whether to continue to use VM, and many more companies are still reluctant to adopt it in the future. There is therefore a need to develop a comprehensive performance measurement framework for VM studies in construction.

9.2.1 Objective 1 – Investigation of the existing measurement frameworks

The review of the literature relating to VM concludes the development, the definition, the job plan, the benefits and critiques of VM. Three different views including the process view, the project view and the service view are described based on the different natures of VM studies. Essential factors including the clients, the facilitators, the participants, the team and team dynamics, the technique used in VM studies, the time and venue of VM studies, the processes of VM studies and the types of VM studies have been extracted from the models for implementation of VM studies.

The review of literature relating to performance measurement summarizes the development, the definition and the approaches of performance measurement. The strengths and weaknesses of existing performance measurement frameworks are critically reviewed to achieve the first objective of this research project. Performance measurement in the construction industry has caught more and more eyes in recent years. According to the review:

1. 61% of the papers related to performance measurement focused on the project level rather than the organization level;
2. 34% papers focused on overall performance rather than partial performance;
3. Environmental performance and human resource performance received most attention.

Factors influencing the performance of VM studies based on the project view are summarized, including the project, PPE and POE. CSFs and KPIs are two important issues which should be carefully considered when measuring. It is not suitable to adopt the existing popular measurement frameworks to measure VM studies due to their limitations in the context of VM. However, perspectives like multi-attitude

measurement could be adapted to a developed performance measurement framework for VM studies.

9.2.2 Objective 2 – Development of a performance measurement framework for VM studies in construction

Three views including the project view, the process view and the service view on VM studies and their implications for performance measurement have been further analyzed and linked to different measurement approaches. Each view is embraced by several approaches and each approach may have one or more views linked to it. The performance measurement based on a combined view will be more effective than that of one based on an isolated view. Thirteen factors are identified as having major impacts on the performance of VM studies according to the literature review. A theoretical foundation was established based on these thirteen factors. The interrelationships of these factors are introduced as the theoretical framework. This theoretical framework explains how the factors interact with each other and where the performance measurement framework will be in this theoretical foundation. Based on the theoretical foundation, further research is conducted to develop a comprehensive framework which can fulfil the measurement requirements of VM studies.

The desired features for measuring the performance of VM studies in construction have been identified:

1. A coherent but flexible framework should be established in order to meet the requirements of different VM studies;
2. It should be multi-criteria so as to provide a comprehensive measurement;
3. It should have prompt and succinct data collection and processing methods.

The dynamic feature desired for measuring is further introduced as two levels of interactions: study level and methodology level. A preliminary framework is developed based on the features desired which give a brief concept on how the measurement is conducted.

Eighteen KPIs out of forty-seven potential indicators, collected from previous research and interviews, are identified by a questionnaire survey. These KPIs are divided into three groups according to their characteristics, namely predicting indicators, process performance indicators and outcome performance indicators. By conducting the principle component factor analysis, the KPIs of process and outcome performance indicators are grouped into three components. Component 1 is a combination of five process related KPIs which indicates the process performance of the VM study. Component 2 represents the intangible outcome performance of the VM study. Component 3 consists of lagging indicators which indicate the tangible outcome performance of the VM study.

The detailed measurement framework which follows the processes of VM studies was developed according to the preliminary framework and the identified KPIs. The measurement starts from the objectives of the VM study and is in line with the processes of the study. The data providers for the KPIs are identified to avoid bias in measuring. A simplified calculation of the weightings of KPIs is introduced. In order to mitigate the subjectivity of scoring, the definition of each scoring is described precisely.

In order to validate the developed framework, case studies, a focus group meeting and interviews were conducted. Case Study 1 conducted a comparison study based on two VM studies using different methods. The findings show that VM studies which have clearer objectives will lead to better outcome performance. The hypothesis "VM studies which have better scores in leading indicators will have better scores in lagging indicators" is partially proved.

Action research presents the use of the preliminary framework to the entire process of a VM study. The results of the measurement show that:

1. A full picture of the performance of the VM study can be drawn by applying the performance measurement framework;
2. There is a need to identify the KPIs to make the measurement process more succinct according to the duplicated measurement discovered in the case study;
3. How to ensure objectivity and consistency when scoring the indicators should be carefully considered in the detailed framework. Another disadvantage of the preliminary framework is that no weightings were assigned to the indicators.

The importance of these indicators should be different according to the performance which they measure. The results of follow-up questionnaire survey show that most of the participants agreed that:

1. The feedback is useful in improving the performance of the study;
2. They emphasised that the real-time feedback helped them perform better in the study;

3. They also considered that three to five minute blocks of feedback are adequate and do not interrupt the workshop processes.

The results of the focus group meeting and interviews show that the clients and VM facilitators are positively disposed toward the framework. Most of them agreed that the framework can ensure them about the returns of VM studies, can help the development of VM methodology, and fulfils the measurement requirements of VM studies. All of the interviewees were willing to use the framework to measure the performance of VM studies in the future, except one who was negatively disposed to VM studies. The focus group meeting and interviews also validate the KPIs identified by the previous questionnaire survey. The data providers for each KPI are affirmed after the interviews. The weightings of the KPIs of each group are calculated with the results of the pair-wise comparison exercise. The definitions of the scorings for each KPI are refined according to the results of the interviews which makes sure that the measurement processes are prompt and consistent. A refined framework is developed according to the findings of these validating activities. The performance indexes for the VM studies in construction are then developed.

9.2.3 Objective 3 – Development of a computer-aided toolkit

A computer-aided toolkit which is integrated with IVMS has been developed to implement the measurement framework. IVMS is designed to support the whole process of a typical VM workshop on the Internet, which could be divided into three layers. These three layers are the information layer, the collaboration layer and the application layer. The performance measurement framework is integrated into this system. All the calculation phases are background processed and all the participants

need to do is to fill in and submit the electronic questionnaire and get the performance scores and indexes.

Trial implementation of the toolkit has been conducted to check its usefulness. According to the results, it is obvious that the use of IVMS makes the measurement easier. Time-saving and real-time control are demonstrated by the comparison of two similar VM studies using different methods of measurement, one supported by IT and the other conducted in traditional way. The improved accuracy and ease of benchmarking are not highlighted by this comparison due to the simplicity of the task and the limited number of workshops. If the workshop lasted for a longer time and was conducted by a larger team, the amount of data would be larger, and the efficiency improvement brought by IT would be more evident. The benefits IT could bring to the benchmarking of VM studies are not well identified in this study because of the limited number of studies. The merit of using IT could be highlighted by comparing a large number of VM studies.

9.3 Contributions of the Research

The contribution of this research includes the development of a performance measurement framework for VM studies in construction, the identification of the problems of VM studies without measurement in the current implementation, the development of a theoretical foundation for future research in this area and the integration of the measurement framework into web-based computer system.

The primary contribution of this research is the development of a performance measurement framework for VM studies in construction. A preliminary framework is first developed to explain the concept of the measurement according to the desired features of the measurement framework. The KPIs for the measurement are identified, highlighting the key performance aspects for the VM practitioners. The research also explores the interrelationship among the KPIs which helps the VM practitioners better understand why these KPIs are grouped as they are. A detailed framework is then developed based on the preliminary framework and the identified KPIs. The key components of the framework are the measurement process, data providers, weightings of KPIs, definition of the scoring. It is validated by Case Study 1, action research, a focus group meeting and Interview 2. The interviewees, included Hong Kong governmental officers, facilitators and construction consultant company representatives, all gave positive feedback to the framework and were willing to use this framework in their future VM studies. This performance measurement framework for VM studies in construction provides a prototype for VM practitioners to measure and manage the performance of their VM studies. Researchers in this field can also adapt this framework to build a suitable framework for VM studies in different stages of different projects.

This research reveals several problems of VM studies without measurement:

1. Clients have no way of knowing whether adequate returns have been made on their investment in the VM studies;
2. It is difficult to know what changes can be made to improve performance and to obtain maximum benefits from these studies;

3. It is also difficult to know how to improve the VM methodology without measurement.

Although there are researchers who have touched on this field (Male et al, 1998; Fong et al, 2001; Chang and Chan, 2004), this is the first time a comprehensive summary has been made of the disadvantages of VM studies in construction without performance measurement. No holistic research of this type has been undertaken to investigate the performance measurement of VM studies in construction and no such comprehensive measurement framework has been developed.

The research summarizes the current development of performance measurement in the construction industry and reveals the research trends in this area. The findings are not only useful to the measurement of VM studies in construction, but also helpful to the research about the performance measurement in construction. The research conducts a critical review of the existing measurement frameworks widely used to investigate their strengths and weaknesses, and adapts these frameworks in the context of VM studies in construction. It provides useful information and gives an example, for researchers interested in performance measurement, of how to investigate the different measurement methods in different areas.

This research identified thirteen factors which have major impacts on the performance of VM studies. The interrelationships of these factors are introduced as the theoretical framework. This theoretical framework explains how the factors interacted with each other and where the performance measurement framework will be in this theoretical foundation. Based on the theoretical foundation, researchers could build frameworks suitable for different types of VM studies.

The research manages to bring IT into the measurement process. The developed measurement framework is integrated into a web-based collaboration tool developed specifically for VM studies. This web-based computer toolkit is tested by a comparison study and shown to be useful in enhancing the effectiveness and efficiency of the measurement activities in VM studies.

9.4 Limitations of the Research

The research has several limitations. First, this research focuses on the performance from the inception to the end of the VM studies. The influence of VM studies to the success of the entire project is considered but not investigated in detail. Especially, the interactions between VM studies and other management tools used in the project management processes are not investigated. Second, although the case studies used to validate the framework are derived from real-life projects, they are not VM studies in real-life practice, due to the time limitation of the research project and the accessibility of real life VM studies. It is noted that this framework could be further improved and refined by using it in real-life projects in the construction industry. Third, the integration of the performance measurement framework into the web-based computer system is at the beginning stage, and the advanced usages of IT, such as data mining techniques, artificial intelligence and man-machine interaction, are not investigated in this research. Thus the benefits of using IT are limited to those basic functions in this research.

9.5 Future Research Directions

The framework developed in this research is applicable to all kinds of VM studies. However, regarding a specific type of VM studies, the measurement framework could be developed further to achieve more accurate measurement results. Future research could be conducted to look into the characteristics of various types of VM studies in construction and how to make adequate adjustments to the performance measurement framework. The concept of how to develop a performance measurement framework in this research could also be adapted to develop similar frameworks for VM studies in the other industries such as manufacturing.

This research presents the benefits of using VM studies in construction projects. However, the in-depth cause and effect relationship between the use of VM and the success of a project is not investigated. This research focuses on the internal processes of VM studies while future research could take into consideration the external factors which affect the performance of projects and their interactions with the VM studies.

Though the use of IT for performance measurement shows its benefits, the implementation of IT in this field is still in its infancy stage. The major use of IT is to collect, sort and analyze the data automatically, and advanced uses of IT, such as artificial intelligence, have not been applied. A future performance measurement system might be intelligent and could self-train using historical data to adjust its parameters. The best practice could therefore be realized by the facilitation and monitoring of IT supported performance measurement systems.

APPENDIX 1: Publications of Gongbo LIN

Refereed journal paper

Published

Lin, G.B. (2009). "Developing a Performance Measurement Framework for Value Management Studies in Construction." *Value World*, 32(1), 4-12.

Lin, G.B., and Shen, Q.P. (2007). "Measuring the performance of value management Studies in Construction: A Critical Review." *ASCE Journal of Management in Engineering*, 23(1), 2-9.

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Yu, A.T.W., Shen, Q.P., Kelly, J., and Lin G.B. (2006). "A Value Management Approach to Strategic Briefing." *Architectural Engineering and Design Management*, 2(4), 245-259.

Under review

Lin, G.B., Shen, Q.P., Sun, M. and Kelly, J. (2008). "Identification of the KPIs for measuring the performance of VM studies in construction." under review.

Lin, G.B., Shen, Q.P. and Sun, M. (2008). "Validation of Performance Measurement Framework for VM studies in Construction." under review.

Conference paper

Published

Lin, G.B., Shen, Q.P., and Sun, M. (2008). "Validating a Performance Measurement Framework for VM Studies in Construction." *Proceedings of 2008 Great China Value Conference*, Hong Kong.

Lin, G.B., Shen, Q.P., and Fan, S.C. (2007). "Comparing the Validating the Performance Measurement Framework for VM Studies in Construction." *Proceedings of 2007 International Conference on Construction & Real Estate Management*, Bristol, UK, 968-972.

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Tang, R.J., Shen, Q.P., Fan, S.C. and Lin, G.B. (2006). "Using Windows Sharepoint Service to Support Value Management Studies." *Proceedings of 2006 International Conference on Construction & Real Estate Management*, Orlando, Florida, U.S.A., 728-732.

Lin, G.B., Shen, Q.P., and Fan, S.C. (2005). "Utilizing Information Technology to Facilitate Performance Measurement in VM Studies." *Proceedings of 2005 International Conference on Construction & Real Estate Management*, Penang, Malaysia.

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Hu Y., Zhang, L., Lu, W.S., and Lin, G.B. (2004). "A Conceptual Framework for Implementing Value Management to Improve Contractor's Competitiveness." *Proceedings of the 2nd CIB Student Chapters International Symposium*, Tsinghua University, Beijing, China.

APPENDIX 2: VM Questionnaire survey for indentifying KPIs

This questionnaire is for a research project entitled "Measuring the Performance of Value Management Studies in Construction" funded by Research Grants Council of HKSAR. The results of the questionnaire will be used to develop a proper performance measurement framework for VM studies. Please be assured that the information obtained will be treated in the strictest confidence and it will be used for academic purposes only. For simplicity and standardization, we use VM to represent all relevant terms such as Value Engineering, Value Analysis, and Value Control. Thank you very much in advance for your help in completing this questionnaire!

INSTRUCTIONS:

Unless otherwise stated, please indicate your answer by inputting 'x' in '( )' or the cells under appropriate numbers.

Part I – Opinions on Performance Measurement in VM Studies

1. Have you ever conducted any performance measurement activities in VM studies?

Always ( ) Often ( ) Seldom ( ) Never ( )

2. What measures should be used to assess the performance of a VM study?

Reduction of time ( ) Reduction of cost ( ) Client's satisfaction ( )

A comprehensive performance score ( ) Others ( ) (please specify) _____

3. How should the criteria for measurement be determined?

Benchmarking ( ) Determined by client ( ) Determined by VM professionals ( )

Derived from historical data ( ) Others ( )(please specify) _____

4. Who should carry out the measurement?

Client ( ) VM Facilitator ( ) Independent performance evaluator ( )

Others ( )(please specify) _____

5. To what extent do you agree with the following views on performance measurement in VM studies?

(5: Strongly Agree 4: Agree 3: Neutral 2: Disagree 1: Strongly Disagree)

	5	4	3	2	1
Performance measurement was conducted in the VM studies which I participated in.					
I am clear about the performance/returns of the VM studies.					
I am satisfied with the existing measurement method for VM studies.					
Areas for improvement could be identified by measuring the processes.					
Merely focusing on cost reduction is not enough to measure the performance.					
Subjective indicators (e.g. client's satisfaction) are important in measurement.					
It will increase my confidence if the performance of VM studies is well measured.					

Part II – Selection of Key Performance Indicators from the Potential Lists

6. What weightings will you assign to the following potential indicators related to the inputs of the VM study?

(5 means the most important, 1 means the least important, 0 means useless)

Sub-categories	Potential indicators	5	4	3	2	1	0
Time	Satisfaction of the time when the VM workshop will be conducted						
Venue	Satisfaction of venue						
Participants	Disciplines of participants						
	Authority of key stakeholder participants						
	Years of professional experience of participants						

	VM knowledge of participants						
Facilitator	Years of experience of facilitator						
	Numbers of VM workshop facilitated						
	Qualification of facilitator						
Clients	Client's support						
	Client's participation						
	Clear objectives of workshop						
Relevant departments	Relevant departments' support						
Others	(Please specify)						

7. What weightings will you assign to the following potential indicators related to the pre-workshop stage?

Sub-categories	Potential indicators	**5**	**4**	**3**	**2**	**1**	**0**
Information collection	Time spent on preparation before workshop						
	Background information collected						
Pre-workshop activities	Number of pre-workshop meetings hold						
	Number of site visits						
	Number of related documents analyzed						
Others	(Please specify)						

8. What weightings will you assign to the following potential indicators related to the workshop stage?

Sub-categories	Potential indicators	**5**	**4**	**3**	**2**	**1**	**0**
All phases	Duration of each phase						
	Time keeping of each phase						
	Satisfaction of the techniques used in each phase						
	Interaction between participants in each phase						
Information phase	Client's objectives clarified						
	Project givens/assumptions clarified						
Analysis Phase	Primary functions identified						
Creativity Phase	Total number of ideas						
	Average numbers of ideas generated by each participants						
	Equal contribution of participants						
	Efficiency of idea generation						
Others	(Please specify)						

9. What weightings will you assign to the following potential indicators related to the post-workshop stage?

Sub-categories	Potential indicators	**5**	**4**	**3**	**2**	**1**	**0**
VM report	Duration to complete the report						
	Quality of the report						
Action plan	Percentage of action plan carried out						
Others	(Please specify)						

10. What weightings will you assign to the following potential indicators related to the outcomes of the VM study (Some of the indicators may not be available regarding different types of VM studies)?

Categories	Potential indicators	5	4	3	2	1	0
Finance	Proposed change on project investment						
	Proposed change on life-cycle cost						
	ROI of VM study, i.e. proposed savings /cost of VM						
Time	Proposed change on design schedule						
	Proposed change on construction schedule						
Function	Reducing the difficulty of construction, i.e. rework times						
	Improving the project quality						
	Improving the project appearance						
Communication	Identifying and clarifying the client's requirements						
	Accelerating the decision-making						
	Improving communication and understanding among stakeholders						
	Deliberating the alternatives						
Satisfaction	Client's satisfaction						
	Participants' satisfaction						
	Facilitator's satisfaction						
Others	(Please specify)						

11. Please specify any performance indicators which are important in your opinion but not listed above and assign weightings for them.

12. Comments/suggestions on performance measurement in VM studies:

Personal Information

All the personal information provided is only for aggregate analysis and will be kept strictly confidential.

1. How long do you know about VM?

<1 year ( ) 1-5 years ( ) 6-10 years ( ) >10 years ( )

2. Have you ever participated in any VM studies?

Never ( ) 1-5 times ( ) 6-10 times ( ) >10 times ( )

3. Have you ever facilitated any VM studies?

Never ( ) 1-5 times ( ) 6-10 times ( ) >10 times ( )

4. Are you a qualified VM facilitator?

Yes ( ) (Please specify what qualification you had) _____ No ( )

5. Have you or your organization ever called for a VM study as a client?

Yes ( ) No ( )

Thank you very much for completing this questionnaire!!!

- THE END -

APPENDIX 3: VM Questionnaire survey for case study 1

INSTRUCTIONS:
Unless otherwise stated, please indicate your answer by circling the appropriate numbers. The meanings of the acronyms are given under the tables.

1. Are you satisfied with the process of the VM workshop?

	SA	A	N	D	SD
Information phase					
You are satisfied with the techniques used in information phase.	5	4	3	2	1
You are satisfied with the interaction between participants.	5	4	3	2	1
You are satisfied with the clarification of client's objectives.	5	4	3	2	1
You are clear about the givens/assumptions of the project.	5	4	3	2	1
Function analysis phase					
You are satisfied with the techniques used in function analysis phase.	5	4	3	2	1
You are satisfied with the interaction between participants.....	5	4	3	2	1
You are functions clearly identified.	5	4	3	2	1
Creativity phase					
You are satisfied with the techniques used in creativity phase.	5	4	3	2	1
You are satisfied with the interaction between participants.	5	4	3	2	1
Evaluation phase					
You are satisfied with the techniques used in evaluation phase.	5	4	3	2	1
You are satisfied with the interaction between participants.	5	4	3	2	1
Development phase					
You are satisfied with the techniques used in development phase.	5	4	3	2	1
You are satisfied with the interaction between participants.	5	4	3	2	1

(SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree)

2. What is your assessment on the outcomes of the VM workshop?

	SA	A	N	D	SD
The workshop helped to identify and clarify the client's requirement.	5	4	3	2	1
The workshop helped to improve the project quality.	5	4	3	2	1
The workshop helped to improve the project shape.	5	4	3	2	1
You are satisfied with the outcomes of the VM workshop.	5	4	3	2	1

(SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree)

3. To what extent do you agree with the following statement on the support of IVMS?

	SA	A	N	D	SD
Support in Information phase					

IVMS can improve the availability ofinformation. …..……	5	4	3	2	1
IVMS can improve the information exchange process. …….	5	4	3	2	1
Support in Function analysis phase					
IVMS can simplify the function analysis processes.	5	4	3	2	1
IVMS can enhance the function analysis processes.	5	4	3	2	1
Support in Creativity phase					
IVMS can promote active participation in idea generation.	5	4	3	2	1
IVMS can avoid conformance pressure in idea generation. ……..	5	4	3	2	1
IVMS can prevent domination in discussion. ……...	5	4	3	2	1
The pop-up character in IVMS can enhance the atmosphere of creativity. ..	5	4	3	2	1
The function of "Tips" can help me in generating ideas. ……..	5	4	3	2	1
The function of "Color" can help me in reading others' ideas clearly……	5	4	3	2	1
Support in Evaluation phase					
IVMS can simplify the evaluation processes.	5	4	3	2	1
IVMS can enhance the evaluation processes.	5	4	3	2	1
Interface of IVMS					
I feel comfortable with the current interface of IVMS	5	4	3	2	1

(SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree)

Open-ended questions

4. What are the things that you like <u>MOST</u> about IVMS?

a) _____

b) _____

c) _____

5. What are the things that you like <u>LEAST</u> about IVMS?

a) _____

b) _____

c) _____

6. What are the functions that you think should be added to IVMS in the future?

a) _____

b) _____

c) _____

7. What are your comments or suggestions to improve IVMS?

a) _____

b) _____

c) _____

Thank you very much for completing this questionnaire!

- THE END -

APPENDIX 4: Questions for personal interviews

Questions in general

1. Do you agree that this framework can ensure you about the returns of VM studies? (If disagree, why)

5 Strongly agree
4 Agree
3 Neutral
2 Disagree
1 Strongly disagree

2. Do you agree that the measurement results of this framework can help the development of VM methodology? (If disagree, why)

5 Strongly agree
4 Agree
3 Neutral
2 Disagree
1 Strongly disagree

3. Do you agree that this framework can achieve real-time management of the performance of VM studies? (If disagree, why)

5 Strongly agree
4 Agree
3 Neutral
2 Disagree
1 Strongly disagree

4. Do you agree that this framework fulfils your measurement requirements of VM studies? (If disagree, why)

5 Strongly agree
4 Agree
3 Neutral
2 Disagree
1 Strongly disagree

5. Will you use this framework to measure the performance of VM studies in the future?

Yes
No

Group 1 Predicting Indicators

I3 *Disciplines of participants*
I9 *Qualification of facilitator*
I10 *Client's support*
I11 *Client's participation*
I12 *Clear objectives of workshop*
I13 *Relevant departments' support*
Knowledge of VM of the participants

Question 1: Is the list complete?

Question 2: Who should score the indicators?

Predicting indicators	Data provider		
	Facilitator	Client	Participant
I3 *Disciplines of participants*	√	√	
I9 *Qualification of facilitator*		√	
I10 *Client's support*	√		
I11 *Client's participation*	√		√
I12 *Clear objectives of workshop*			√
I13 *Relevant stakeholder' support*	√	√	
Knowledge of VM of the participants			√

Question 3: How should the indicators be ranked?

	I3	I9	I10	I11	I12	K
I3 *Disciplines of participants*						
I9 *Qualification of facilitator*						
I10 *Client's support*						
I11 *Client's participation*						
I12 *Clear objectives of workshop*						
I13 *Relevant departments' support*						
Knowledge of VM of the participants						

Question 4: How should the scores be defined?

Group 2 Process Performance Indicators

I15 *Background information collected*
I22 *Interaction between participants in each phase*
I23 *Client's objectives clarified*
I24 *Project givens/assumptions clarified*
I25 *Primary function identified*

Question 1: Is the list complete?

Question 2: Who should score the indicators?

Process performance indicators	Data provider		
	Facilitator	Client	Participant
I15 *Background information collected*			√
I22 *Interaction between participants in each phase*		√	
I23 *Client's objectives clarified*		√	√
I24 *Project givens/assumptions clarified*		√	√
I25 *Primary function identified*	√		√

Question 3: How should the indicators be ranked?

	I15	I22	I23	I24
I15 *Background information collected*				
I22 *Interaction between participants in each phase*				
I23 *Client's objectives clarified*				
I24 *Project givens/assumptions clarified*				
I25 *Primary function identified*				

Question 4: How should the scores be defined?

Group 3 Outcome Performance Indicators

I31 *Quality of the report*
I32 *Percentage of action plan without uncertainty carried out*
I39 *Improving the project quality*
I41 *Identifying and clarifying the client's requirements*
I42 *Accelerating the decision-making*
I43 *Improving communication and understanding among stakeholders*
I45 *Client's satisfaction*
Time submission of the report

Question 1: Is the list complete?

Question 2: Who should score the indicators?

Predicting indicators	Data provider		
	Facilitator	Client	Participant
I31 *Quality of the report*		√	
I32 *Percentage of action plan without uncertainty carried out*		√	
I39 *Improving the project quality*		√	
I41 *Identifying and clarifying the client's requirements*	√	√	√
I42 *Accelerating the decision-making*		√	
I43 *Improving communication and understanding among stakeholders*		√	
I45 *Client's satisfaction*		√	
Time submission of the report		√	

Question 3: How should the indicators be ranked?

	I31	I32	I39	I41	I42	I43	T
I31 *Quality of the report*							
I32 *Percentage of action plan carried out*							
I39 *Improving the project quality*							
I41 *Identifying and clarifying the client's requirements*							
I42 *Accelerating the decision-making*							
I43 *Improving communication and understanding among stakeholders*							
I45 *Client's satisfaction*							
Time submission of the report							

Question 4: How should the scores be defined?

APPENDIX 5: Relevant websites of VM resources

Names of organization	Addresses
SAVE International	www.value-eng.org
Institute of Value Management	www.ivm.org.uk
Canadian Society of Value Analysis	www.scav-csva.org
Society of Japanese Value Engineering	www.sjve.org
Australian Centre for Value Management	www.acvm.com.au
Indian Value Engineering Society	www.invest-in.org
Hong Kong Institute of Value Management	www.hkivm.com.hk
Value Engineering Society of Bejing	www.vesb.org
Value Management Institute of Taiwan	www.vmit.org
Lawrence Delos Miles Value Foundation	www.valuefoundation.org

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