DEVELOPING A PROJECT LEARNING MODEL CONSIDERING FRAGMENTATION IN CONSTRUCTION

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ABSTRACT

Learning in construction has received growing attention due to such benefits as enhancing performance, reducing the repetition of mistakes, and achieving competitive advantages. However, most studies in the field have focused on organizational level of learning, paying less attention to project level and ignoring the influence of project characteristics on learning process. Therefore, the purpose of the current study is to develop a project learning model that considers fragmentation as a distinguishing character of projects.

Fragmentation is defined in the current study as a multi-dimensional (hierarchical) concept indicated by level of integration, collaboration, coordination, barriers, decoupling of specializations, and spanning knowledge across boundaries. Project learning involves two dimensions, intra-project and inter-project learning, which are also identified as multi-dimensional latent constructs. The current study proposes a theoretical model that assumes a negative effect of fragmentation on project learning. However, to what extent fragmentation impacts learning and how learning can be achieved within a fragmented context remain unclear.

To fill these gaps, a mixed methodology of qualitative and quantitative studies was adopted. The purpose of the qualitative study was to explore factors that enable learning within fragmentation. It involved in-depth interviews with 11 professionals in construction projects. The purpose of the quantitative study was threefold: to test the theoretical model; to develop the measurement scales of fragmentation, project learning, and enablers; and to validate the results of the qualitative study. Using a questionnaire survey, the data were collected from 36 big building projects (Grade 7) in Kuala Lumpur and Selangor, Malaysia. The study targeted professionals working in these projects and collected 203 valid questionnaires.

Data analysis has involved parallel analysis, principal component analysis (PCA), and confirmatory factor analysis (CFA) to develop and validate second-order (hierarchical) measurement models of fragmentation and project learning. The relationships among fragmentation, project learning, and enablers were tested using partial least squares-path modeling (PLS-PM), a variance-based approach to structural equation modeling (SEM). The full model, comprises measurement and structural models, was analyzed using SmartPLS software. Model's quality, reliability, and validity were attained.

The results affirmed a negative significant influence of fragmentation on both intra- and inter-project learning. Further analysis indicated a partial mediating effect of the enablers of project learning. The results are expected to contribute to the body of knowledge in three main areas. Firstly, the hierarchical measurement scales of fragmentation and project learning can be used by future studies. Secondly, the enablers provide an explanation of how learning occurs within fragmentation. This implies greater focus on these factors to attain learning in construction projects. Lastly, the full model of project learning is sensible and appropriate for construction projects as it reflects their unique nature. However, further studies are recommended to generalize the model.

ABSTRAK

Pembelajaran projek atau pembelajaran berasaskan projek telah mendapat perhatian yang meluas disebabkan kelebihannya untuk meningkatkan prestasi, mengurangkan kesilapan secara berulang, dan mencapai kelebihan persaingan. Namun begitu, kebanyakan kajian dalam bidang ini lebih banyak tertumpu kepada pembelajaran di peringkat organisasi, tetapi kurang memberi perhatian di peringkat projek dan mengabaikan pengaruh ciri-ciri projek ke atas proses pembelajaran. Oleh itu, kajian yang dilaksanakan ini dibuat bagi membangunkan satu model pembelajaran projek yang mempertimbangkan faktor fragmentasi (*fragmentation*) sebagai ciri perbezaan projek.

Fragmentasi (*fragmentation*) ditakrifkan sebagai satu konsep pelbagai-dimensi (hierarki) yang diwakili oleh tahap integrasi, koloborasi, koordinasi, halangan, penyahgandingan pengkhususan (*decoupling of specializations*), dan pengetahuan merentasi sempadan. Manakala, pembelajaran projek melibatkan dua dimensi, iaitu, sesama (*intra*) projek dan antara (*inter*) projek, yang juga dikenalpasti sebagai konstruk tersembunyi (*latent constructs*) pelbagai-dimensi. Kajian ini mencadangkan satu model teori yang mengandaikan pengaruh negatif fragmentasi (*fragmentation*) ke atas pembelajaran projek. Walau bagaimanapun, sejauh mana pengaruh fragmentas (*fragmentation*) ini ke atas pembelajaran dan bagaimana pembelajaran boleh dicapai dalam konteks ini masih lagi kabur.

Bagi mengisi jurang (*gap*), kajian ini menggunakan pendekatan gabungan (*mixed methods*) iaitu kaedah kualitatif dan kuantitatif. Kaedah kualitatif dilaksanakan bagi meneroka faktor-faktor yang membolehkan pembelajaran di dalam lingkungan fragmentasi (*fragmentation*). Untuk itu, kajian ini melibatkan temubual secara mendalam dengan 11 orang profesional dalam projek pembinaan. Manakala, kajian kuantitatif dilaksanakan bagi menguji model teori; membangunkan skala pengukuran bagi fragmentasi (*fragmentation*), pembelajaran projek, dan pemungkin (*enablers*); dan untuk mengesahkan dapatan hasil kajian kualitatif. Data diperolehi dari 36 buah projek pembinaan berskala besar (Gred 7) di Kuala Lumpur dan Selangor. Kajian ini juga mensasarkan profesional yang terlibat dalam projek berskala besar dan sebanyak 203 soal-selidik yang sah telah dikumpulkan.

Analisis data yang dibuat melibatkan analisis sejajar (*parallel analysis*), analisis komponen utama (PCA), dan analisis faktor pengesahan (CFA) bagi membangun dan mengesahkan skala kedua (*hierarchical*) fragmentasi (*fragmentation*) dan pembelajaran projek. Hubungan di antara fragmentasi (*fragmentation*), pembelajaran projek, dan pemungkin (*enablers*) diuji dengan menggunakan *'partial least squares-path modelling'* (PLS PM), dan pendekatan varians berasaskan kepada pemodelan persamaan struktur (SEM). Manakala model penuh, yang mengandungi pengukuran dan model struktur telah dianalisis menggunakan perisian SmartPLS yang dapat menghasilkan model yang berkualiti, kebolehpercayaan dan mencapai kesahan.

Dapatan mengesahkan wujudnya pengaruh negatif yang signifikan bagi fragmentasi (*fragmentatio*n) dengan pembelajaran projek di kedua-dua peringkat iaitu sesama *(intra)* projek dan di antara *(inter)* projek. Analisis selanjutnya menunjukkan bahawa pengantara separa (*partial mediating*) mempengaruhi pemungkin (*enablers*) bagi pembelajaran projek. Oleh yang demikian,dapatan kajian dijangka dapat menyumbang kepada ilmu pengetahuan menerusi tiga bidang utama. Pertama, skala pengukuran hierarki fragmentasi (*fragmentation*) dan pembelajaran projek dapat digunakan untuk kajian masa depan. Kedua, pemungkin (*enablers*) dapat memberikan penjelasan bagaimana pembelajaran berlaku dalam linkungan fragmentasi (*fragmentation*). Dapatan ini membayangkan bahawa tumpuan yang lebih perlu diberikan kepada faktor-faktor ini untuk mencapai pembelajaran projek pembinaan. Akhir sekali, model penuh pembelajaran projek yang dihasilkan adalah munasabah dan sesuai untuk diterima pakai bagi projek pembinaan kerana ia menggambarkan ciri yang unik. Namun begitu, kajian lanjutan disarankan bagi mengeneralisasikan model ini.

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DEDICATION

This small effort is dedicated to my father for his great support and invaluable love…

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LIST OF ABBREVIATIONS

AVE	Average Variance Extracted
BARRIERS	A latent construct represents Barrier in projects, which causes fragmentation
CBSEM	Covariance-based Structural Equation Modeling (SEM)
CFA	Confirmatory Factor Analysis
CIDB	Construction Industry Development Board
CoP	Communities of Practice
cv-com	Cross-validated communality
cv-red	Cross-validated redundancy
DoD	A latent construct represents Decoupling of Diversity of professionals, which causes fragmentation
FRAG	A latent construct represents fragmentation of project team
INTEG	A latent construct represents level of project team Integration
INTER1	First dimension of learning across projects (represents two processes: experience accumulation and knowledge articulation)
INTER2	Second dimension of learning across projects (represents two processes: knowledge articulation and knowledge codification)
INTER-PL	Learning across projects (inter-project learning)
INTRA1	First dimension of learning within project (social or soft process of learning)
INTRA2	Second dimension of learning within project (technical or procedural process of learning)
INTRA-PL	Learning within project (intra-project learning)
KM	Knowledge Management
KS SUPP	A latent construct represents Knowledge Sharing Support
LO	Learning Organization
MANAG SUPP	A latent construct represents Managerial Support
OL	Organizational Learning
PA	Parallel Analysis
PCA	Principal Component Analysis
PLS	Partial Least Square
PLS-PM	Partial Least Squares, Path Modeling (variance-based SEM)
PRO CULT	A latent construct represents Project Culture
SEM	Structural Equation Modeling
SKB	A latent construct represents Spanning Knowledge across project's Boundaries
SMEs	Small and Medium Enterprises
SPSS	Statistical Package for the Social Sciences
VIF	Variance inflation factor

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CHAPTER 1: INTRODUCTION

1.0 Introduction

This chapter provides an overview of the current study and the research method used. It begins with a background that introduces the topics, followed by the motivation to conduct the study. Some related works are reviewed to highlight the gaps in literature. Then, problem statement, research questions, and objectives are presented. The last section of this chapter outlines research method used.

1.1 Background of the Study

The construction industry in Malaysia is currently confronted with complex challenges, including project performance, continuous improvement, and sustained competitiveness. Thus, it is compelled to transform itself into a world-class, innovative, and knowledgeable global solutions provider by 2015 (CIDB, 2007). The orientation toward a knowledge-based economy reflects the focus on knowledge sharing by enabling the integration of construction communities.

Construction is full with learning opportunities from and within projects (Anheim, 2003; Täube, 2007). Effectively obtaining insights from projects facilitates the realization of competitive advantage and project success (Sense & Antoni, 2003). Moreover, learning can reduce errors, thereby increasing the profitability of construction firms (Josephson, 1994), as cited in (Knauseder et al., 2007). Kotnour and Hjelm (2002) revealed that learning enables individuals to assimilate new ideas and transform these into action, improves member competencies and work atmosphere in organizations, increases productivity, and results in high morale.

Project learning practices can be defined as “the set of actions the project teams use to create and share knowledge within and across projects” (Kotnour, 2000, p. 396). In addition, project learning implies creating knowledge from experience, where improvement takes place in projects (Kotnour, 1999). There are two dimensions of project learning: intra-project and inter-project (Kotnour & Proctor, 1996). Intra-project learning is defined as the acquisition and use of knowledge and experience within the same project (Gieskes & Broeke, 2000). It focuses on tasks within a single project and supports the delivery of a successful initiative through problem identification and resolution during the project life cycle (Kotnour & Vergopia, 2005). Conversely, inter-project learning refers to the transfer of knowledge and experience from one project to another within the same time frame or to different projects over a period of time (Gieskes & Broeke, 2000).

Project learning is an important component for continuous improvement of the project-based organization (Garvin, 1993; Williams, 2008). In addition, learning from projects reduces the likelihood of repeating the same mistakes and “re-inventing the wheel.” Other benefits of learning include the following: guaranties competitive advantages, enhances project performance, improves innovation and professional expertise, and allows project management to respond to uncertainties and environment pressure (Abdul-Rahman et al., 2008; Ayas, 1997; Barlow & Jashapara, 1998; Drejer & Vinding, 2006).

However, project characteristics, discontinuity, and lack of mechanisms for knowledge transfer at project and firm levels may affect learning from and within projects (Bresnen et al., 2003; Maqsood et al., 2006). In addition, ad hoc working relationships among firms may influence the continuity of learning (Drejer & Vinding, 2004). Other challenges of learning in construction projects include the difficulty of establishing routine activities given the discontinuity of resources and information flow and project team fragmentation into different professional disciplines (Bresnen et al., 2003). Murdoch and Hughes (2008) stated that establishing a construction system creates a demand for detailed specialized knowledge and various skills. Increasing specialization and professionalization lead to fragmentation because professionals maintain temporary relationships and pursue different objectives (Murdoch & Hughes, 2008).

Fragmentation could be one of the primary problems that hinder learning (Knauseder et al., 2007), hence the loss of learning benefits. The current study focuses on the influence of project team fragmentation on project learning processes. Extant literature discusses two levels of fragmentation: construction industry and project. The former involves increasing the number of segregated small firms and reducing the number of large ones, while the latter entails the disintegration of construction processes and entities. Both levels are caused by team fragmentation (Gonz'alez et al., 1998). Fragmentation may stem from two reasons: the product necessitates more comprehensive production processes, and contractors and subcontractors are likely to specialize in specific areas in accordance with demand (Seymour, 1987). The current study intent to explore further aspects of team fragmentation. These include indicators that determine fragmentation such as lack of team integration, collaboration, and coordination; diversity and decoupling of specializations;

barriers among professionals; and lack of spanning knowledge across project boundaries. These will be elaborated in some next chapters.

1.2 Motivation for the Study

Given that construction is essentially organized around projects and not firms, examining the manner by which learning occurs at the project level is essential. Traditional organizational learning theories appear unable to reflect the nature of construction projects. Groák (1994) questioned the relevance of applying organizational learning at the construction project level. P. Chan et al. (2005, p. 747) stated that "it is felt that the research effort into organizational learning had hitherto focused on the study of companies, without paying attention to the project-based nature of the industry." Knauseder et al. (2007) affirmed that research on organizational learning in projects remains in its infancy, creating a need for more investigations on learning in temporary organizations. Huemer and Östergren (2000, p. 636) observed that literature mostly indicates what organizational learning should be rather than what it actually is, stating: "it is difficult to investigate how the connection between learning and the environment can be understood." Hence, more empirical investigations on project learning are necessary given the nature of the construction industry.

During construction, various people and organizations gather to accomplish the project. Thus, construction provides various opportunities for learning as a platform to document, assimilate, and share knowledge within and across projects (Anheim, 2003; Knauseder et al., 2003, 2007). Therefore, the present study focuses on project learning processes during the construction stage (i.e., production) and how these processes are influenced by the characteristics of construction.

1.3 Overview of Some Studies on Project Learning

One of the recently developed models on intra-project learning (learning within project) is that of Sense (Sense, 2004, 2007a, 2007b, 2008; Sense & Antoni, 2003). Using a case study in manufacturing industry, Sense's model was built based on the situated approach of learning (Lave & Wenger, 1991). The model included five elements affecting learning activities: learning relationships, cognitive style, knowledge management, learning mandate and learning environment support, and pyramid of authority.

Prencipe and Tell (2001) investigated three processes of inter-project learning (i.e., learning across projects), which are experience accumulation, knowledge articulation, and knowledge codification. Using case study in some industries, excluding construction, the scholars presented a matrix of the learning mechanisms according to three levels (i.e., individual, project/group, and organizational) of each of the learning processes. In addition, they presented the learning typology of these processes includes learning by doing, learning by using, learning by reflecting, learning by thinking, learning by discussing, learning by confronting, learning by writing and re-writing, learning by implementing, learning by replicating, and learning by adapting.

Gieskes and Broeke (2000) used a survey to investigate aspects of learning and continuous improvement in construction projects. They highlighted some problems related to learning in construction project including insufficient learning tools (such as benchmarking or problem solving mechanisms), inadequate knowledge exchange between team members and their leaders, lack of project reviews, and inability to capture lessons learned. They concluded that learning is difficult to achieve due to certain characteristics of the construction project. These include separation between design and actual realization of construction (i.e., production), one-off nature of projects and their organization, on-site character of projects that render communication difficult, culture of projects dominated by a focus on technical aspects, and an environment where project completion is the main orientation.

Other studies in construction include the review conducted by Knauseder et al. (2003), who investigated organizational learning according to three aspects: contract forms, construction process, and people. The first and second aspects indicate fragmentation, but not extensively. They highlighted that individuals learn more in total construction projects (such as design and build) due to enhanced feedback and greater time for reflection (cited in Carlsson & Josephson, 2001). Another study by the scholars, (Knauseder et al., 2007), indicated the issue of fragmentation in construction. They affirmed that boundaries between projects and the parent organization may reduce trust, limit contact between organizations, and reduce flow of experience. They proposed solutions for this problem, including cross-organizational and cross-functional project teams; team environments that encourage and support high performance collaboration; systematic documentation of experiences; and “live” capture and reuse of knowledge. However, this study and the previous one (Knauseder et al., 2003) were unable to address fragmentation extensively and were focusing on organizational learning and learning styles in construction.

1.4 Research Gaps

The overview in the previous section highlights the following: empirical studies on project learning in construction (not to be confused with organizational learning or project-based learning) are limited. In general, most studies on learning in the construction industry are qualitative-based and focus on the organizational level (refer to Chapter 2 for a comprehensive review). Studies that investigate the influence of project characteristics, specifically, fragmentation, on learning process are limited as well. Some studies claimed that fragmentation has a negative influence on the learning process (Barlow & Jashapara, 1998; Gieskes & Broeke, 2000; Knauseder et al., 2007; Tan & Elias, 2000). However, these studies did not demonstrate the extent of this impact.

More importantly, the concepts of project learning and fragmentation remain vague. Project learning is confused occasionally with similar concepts such as organizational learning and project-based learning. A precise definition of fragmentation remains lacking. Therefore, conceptualizing and determining these concepts is important to fill this gap.

1.5 Problem Statement

The construction industry is organized around the project and not the firm (Groák, 1994). In fact, there exist considerable differences between project and firm as milieus of learning. Insufficient understanding of the difference between the two settings may result in less practical and less realistic paradigms or models of learning (Ibert, 2004; Sense, 2007a). Learning in construction projects can be a difficult task due to their nature that is temporary, ad hoc-based working relationship, and fragmented.

Furthermore, determining the influence of project characteristics on learning (P. Chan et al., 2005; Gieskes & Broeke, 2000) is crucial to understand how learning occurs in construction projects. However, the vast number of studies on organizational learning and project-based learning failed to recognize the interaction between learning and the nature of construction projects. Fragmentation, as one of the unique characteristics of construction (Murdoch & Hughes, 2008; Winch, 2010), causes problems related to performance of projects and knowledge spanning and production (Anumba et al., 2002; Baiden et al., 2006; Egbu, 2006; Na et al., 2007). Inadequate awareness of fragmentation's influence may hinder learning processes and knowledge acquisition within and across construction projects.

1.6 Research Questions

Stating several pertinent questions is important to articulate the research gaps and problem and direct the study toward the appropriate methodology. The current study outlines three main inquiries. The first inquiry is related to understanding the meaning and features of project learning and fragmentation. Considering the fundamental differences between project and permanent organization (firm), one may ask: What are the aspects of learning in the project milieu? Is there any difference between project learning and similar concepts such as project-based learning? How does project learning influenced by prominent theories of learning such as organizational learning?

As stated previously, the notion of fragmentation is still vague. Therefore, it is important to identify the factors that determine this notion. In addition, it is assumed that fragmentation has a negative influence on project learning process. Thus, the second inquiry concerns about identifying the extent of fragmentation's impact on project learning.

The third inquiry concerns about exploring the factors that facilitate achieving learning within fragmentation. The research questions are depicted around the following three main inquires:

1) What are the features of project learning? Is there any difference between project learning and similar concepts such as organizational learning and project-based learning? What is fragmentation and how it can be determined?
2) To what extent does fragmentation influence project learning?
3) How to enable project learning within fragmentation?

1.7 Aim and Objectives

The present study aims to develop a model of project learning for construction projects. The model will attempt to explain how learning occurs within fragmentation. This model may contribute to the theory of project learning as well as the practice of construction management in construction. The objectives of the current study are as follows:

- To identify the aspects of project learning and fragmentation from the literature;
- To identify the factors that enable learning within fragmentation in construction projects; and
- To develop a model of project learning for construction projects considering fragmentation.

1.8 Research Scope

It is important to mention that the current study does not intend to offer any solutions to fragmentation, rather to understand its effect on learning and how learning occurs. This phenomenon can be examined within the scope of construction building projects in developing countries (i.e., the case of Malaysia). The current study is limited to big building projects that are under construction (i.e., in the production stage) during the course of this research. The influence of other stages (e.g., design stage) on learning activities could be indirect.

Project learning involves team members' action to learn. Therefore, the current study is focused on different individuals' involvement in learning processes. These include project managers, project engineers, project consultants, and other professionals in the construction site.

1.9 Research Methodology: An Overview

Aspects of project learning and fragmentation will be identified through review and synthesis of the literature. An initial theoretical model will be developed to demonstrate the relationship between fragmentation and project learning. A qualitative study comprising in-depth interviews will be used to explore new factors to enable project learning within fragmentation. Qualitative data analysis employs manual analysis of the interviews to explore codes and themes of the phenomenon (Creswell, 2008).

A quantitative study will be used then to validate the findings of the qualitative study and to develop the model further. Data will be analyzed using factor analysis to summarize the number of variables. Partial least squares-path modeling (PLS-PM) of structural equation modeling approach (SEM) will be employed to analyze the whole model. This approach suits exploratory-nature studies where prediction is the chief concern. In addition, PLS-PM enables testing of different levels of relationships (e.g., measurement and structural models) simultaneously. For example, it assesses the relationship between variables that indicate fragmentation; at the same time, it assesses the association between fragmentation and project learning. This grants a comprehensive testing and evaluation of the whole model of project learning.

1.9.1 Approaches and strategies

According to Yin (2009), research strategy depends on three elements: research question(s), control over behavioral events, and degree of focus on contemporary events. Three approaches are employed in research procedures: qualitative, quantitative, and mixed (Bryman, 2004; Creswell, 2009).

Mixed approach can involve three models: two-phase design, where the qualitative and quantitative phases are conducted separately; dominant-less dominant design, where one approach has a small portion of design compared with another approach; and mixed methodology design, where qualitative and qualitative approach are mixed in any part of the study (Creswell, 2008). The current research adopted the dominant-less dominant design model. The qualitative study is dominant-less, while the quantitative study is the dominant in this context.

A mixed-methods strategy has many sequential designs (see Creswell, 2009). The sequential exploratory design, which begins with qualitative approach and data analysis followed by quantitative approach and data analysis, appears to be appropriate for the present research. According to Creswell (2009), this sequence is used in exploration research and when developing a certain instrument is necessary. Table 1.1 illustrates research approaches and methods based on the research objectives.

Table 1.1: Research methods and approaches according to the research questions

Research Objectives	**Research Paradigm**	**Method of Data Collection (Analysis)**	**Purpose**
1. To identify the aspects of project learning and fragmentation	-	Literature review (Synthesizing)	- Conceptualize the notions of project learning and fragmentation
2. To identify the factors that enable learning within fragmentation	Qualitative (inductive)	In-depth interviews (Exploring Codes and Themes)	- Explore the factors that facilitate achieving project learning within fragmentation
3. To develop the project learning model considering fragmentation	Quantitative (deductive)	Questionnaire survey (PCA & CFA to refine the measurement scale / Hypotheses Testing using PLS-PM)	- Develop measurement models of fragmentation, project learning and enablers - Examine the association between fragmentation and project learning - Validate the results of the qualitative study

1.9.2 Justification of using mixed approaches

Identifying the association between fragmentation and project learning involves hypothesis testing and answering the question "What?," which requires a quantitative approach (Yin, 2009). Quantitative study has the ability to cover wide cases in numerical data. The last inquiry involves answering the question "How?" (i.e., how to enable learning within fragmentation), which implies a qualitative approach. The qualitative study is useful to explore the enablers that are limited in the literature. In fact, the current study will begin with the qualitative study to explore factors that enable learning. Subsequently, the quantitative study will be used to validate findings of the qualitative study and to answer the second inquiry. This sequence is useful for discovering new variables and obtaining rich context of a phenomenon (Creswell, 2009).

In sum, qualitative approach will be employed to discover enablers of project learning within a fragmented context. The quantitative approach will serve three purposes: to validate and generalize the findings of the qualitative study; to establish the relationship between fragmentation and project learning; and to develop the final model of project learning out of the theoretical model. The research procedure for developing the final model is shown in Figure 1.1.

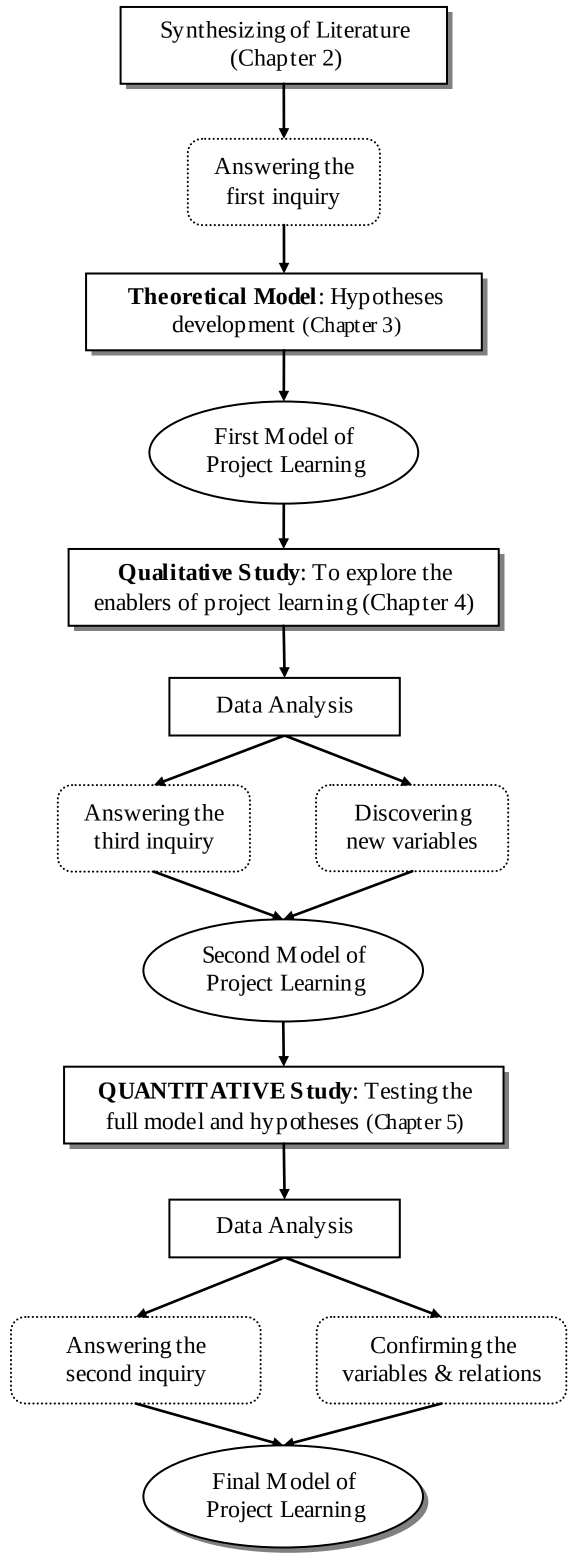


Figure 1.1: Research procedure

1.10 Outline of Thesis Structure

Including the current chapter, this thesis is divided into seven chapters.

Chapter 2: Literature Review

This chapter is divided into two sections, the first of which highlights the fragmentation phenomenon and identifies two levels of fragmentation: industry level and project level. It argues that both are related to team fragmentation. The second section reviews studies related to learning in construction to show the research gap. The section highlights several fundamental works on project learning and discusses the difference between this notion and other similar notions such as project-based learning. The outcome of this chapter is the point-form features of project learning.

Chapter 3: Theoretical Model and Research Design

This chapter proposes a theoretical framework of project learning. In this chapter, studies that indicate the relationship between project learning and fragmentation are reviewed. This chapter highlights specific indicators of project learning and fragmentation, which will be used to develop the measurement scales of these notions. The research design is proposed at the end of this chapter, which demonstrates the logical sequence of collecting data based on the research proposition.

Chapter 4: Qualitative Study

This chapter intends to identify the enablers of project learning within fragmentation. The chapter presents the findings of in-depth interviews with experts on construction projects. Method of analysis and discussions of the findings are presented as well.

Chapter 5: Quantitative Study

The purpose of this chapter is twofold: first to develop the final model of project learning out of the theoretical model proposed in Chapter 3. Second, to verify the findings of the qualitative study presented in Chapter 4. A questionnaire survey is used for this purpose. Steps for developing the questionnaire survey are presented, including conceptualization, operationalization, and measurement of variables. Pre-test of the questionnaire is conducted, including content validity, face validity, and pilot study. Steps for collecting data, data analysis, and results are outlined in this chapter.

Chapter 6: Discussions

This chapter highlights the main findings of the qualitative and quantitative studies. The chapter discusses the results of the final model of project learning. The role of enablers as mediating variables is discussed as well. Moreover, this chapter discusses in detail the structural and measurement models of fragmentation, project learning, and enablers of project learning.

Chapter 7: Conclusion and Recommendations

This chapter highlights the main findings and contributions of the current study. It shows the implications of the study to the academia and industry. Limitation of the current study and recommendations for future researches are presented as well.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter is divided into two sections. The first intends to review the characteristics of the construction industry and fragmentation. It begins with an argument that fragmentation is embedded in the nature of construction. This section elaborates fragmentation's levels, reasons, impact, and proposed solutions. Subsequently, the definition of team fragmentation as a multi-faceted notion is presented. The second section, meanwhile, highlights some gaps in the literature of learning in the construction field. It reviews fundamental works on project learning as well as related theories to learning such as organizational learning theory to provide a full picture of this notion. The connection between project learning with previous theories is discussed and features of project learning are identified.

SECTION I: FRAGMENTATION

2.1 Characteristics of Construction Industry and Projects

This section argues that fragmentation is rooted in the nature of the construction project and industry. Hartmann and Caerteling (2005) emphasized on the relationship between fragmentation (referred to as decoupling of construction services and process) and three criteria of construction: client dependency, location dependency, and weather-influenced activities. According to scholars, constructional task dependency on client and location results in three aspects: transaction uncertainty, transaction complexity, and post-contract asset specificity. The first aspect leads to fragmentation while the other two aspects lead to the need for coordination and integration (Hartmann & Caerteling, 2005).

Langford and Male (2001) emphasized that construction structure is derived from location and delivery requirements rather than volume-based consumer-oriented product delivery. Construction as a product can be regarded as the following: assembly is carried out at a particular site selected by the purchaser; high degree of product specificity (requires detailed plans and specifications); each facility is designed to order; and a unique price is determined for each project and a fixed price on a cost-incurred basis (Lange & Mills, 1979, p. 4). According to Hillebrandt (2000), the structure of construction industry can be determined by a large number of dispersed contracting firms and the usual separation of design from construction. Characteristics of construction products that determine the industry's structure include: final product is large, heavy, and expensive; it is situated over a wide geographical area; it is made mostly to the requirements of the individual customer; and most of the components are manufactured elsewhere (Hillebrandt, 2000, p. 5). The location-based production and order of construction present an extraordinary diversity and heterogeneity (Carassus, 2000).

In general, construction projects are regarded as a one-of-a-kind product, site-dependent production, and temporary organization (Koskela, 1992). Construction project as a temporary multidiscipline organization involves numerous stakeholders who collaborate with each other during the project life cycle (Dave & Koskela, 2009). The temporary relationship between these stakeholders and the statistic-based production escort fragmentation (Dainty et al., 2005). Other factors associated with the nature of projects that cause fragmentation include the following: separation of design and construction process, lack of coordination and integration between various functional disciplines, and poor communication (Love, Irani, et al., 2004b; Xue et al., 2005).

Vlies and Maas (2009) described the construction industry from the perspective of social capital theory. They argued that the industry contains little network closures and many structural holes caused by fragmentation and project-based contract. The relatively sizeable number of small construction firms makes the industry more segregated, while various players within a construction project contribute to the segregation of design and construction process (Vlies & Maas, 2009).

Studies on fragmentation are concentrated mainly on two levels. One appears at the industry's level, where a relatively large number of small firms cause structural segregation of the industry. The second appears at the project level due to disintegration of project activities and entities. Fragmentation can also be categorized into two dimensions: fragmentation of entities (e.g., firms, team, etc.) and fragmentation of processes (e.g., design and construction). The following section elaborates on these two levels.

2.2 Levels of Fragmentation

This study distinguishes three levels of fragmentation. The first is industry level or inter-organizational level, which occurs due to firms' segregation. The second is project level, which occurs due to the separation of construction process and entities. Although both have distinct features, it is believed that they are conflated. The third level of fragmentation may appear at the organizational level due to the hierarchical boundaries between different departments and section (Kofman & Senge, 1995).

The current study focuses on fragmentation at the project and industry levels, rather than at the organization. This is because fragmentation of construction process is considerably deeper than the fragmentation of functional departments (Fischer & Tatum, 1997; Yates & Battersby, 2003). Figure 2.1 illustrates the three levels of fragmentation. The sections to follow elaborate on both industry and project levels of fragmentation. The purpose is to clarify the difference between the two levels.

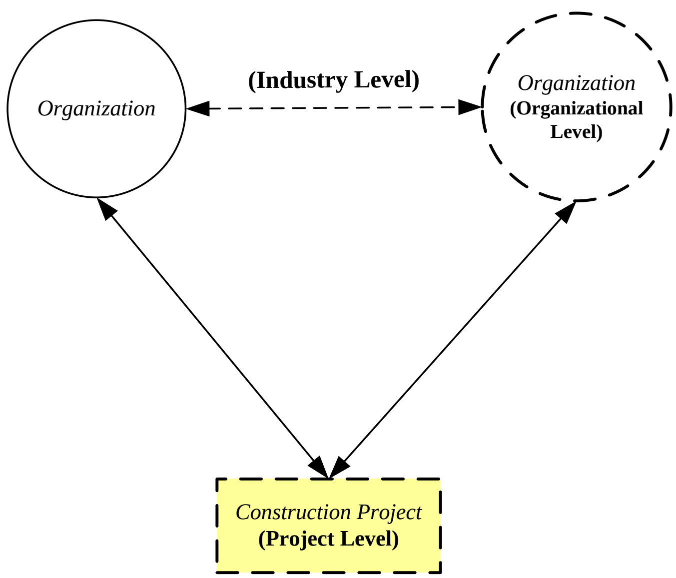


Figure 2.1: Levels of fragmentation
(source: author derived)

2.2.1 Fragmentation of the industry (firm fragmentation)

The construction industry is composed of a large number of small enterprises; it comprises multiple professions, occupations, and organizations to deliver the project (Garcia, 2005; Lange & Mills, 1979; Langford & Male, 2001). Ofori (1993, p. 12) stated that the construction industry is characterized by a multiplicity of small firms and a few large ones, which is largely due to the nature of construction activities involving discrete projects that are dispersed, location-specific, varied in scale, and predominantly small in size. Thus, fragmentation of the construction industry is related to the reduction of average size of big companies to small firms (Gonz'alez et al., 1998) and the scope of work packages.

The construction industry can be described as fragmented if no company has a significant market share and is able to influence considerable outcomes within the industry (Langford & Male, 2001). Graham Winch indicated that fragmentation occurs when "the bespoke-integrated intra-firm networks are difficult to establish because of the relatively small size of firms […]" (Winch, 2010, p. 391). Majority of these firms do not act together in such a way that can improve the performance of the construction industry as a whole.

In the United Kingdom, for example, small and medium enterprises (SMEs) account for over 95% of the construction industry (Oragne et al., 2005). The Malaysian construction industry is fragmented and shares similar characteristics compared to other developed and developing countries (Abdullah, 2004; CIDB, 2007). In 2011, more than 62,000 construction firms registered with the CIDB (construction industry development board) (CIDB, 2011). Approximately 50,000 firms are considered SMEs (under the categories G1, G2, and G3), representing approximately 80% of the total number of registered firms. A reason for this huge increase in small firms is related basically to construction characteristics that have been discussed previously. However, fragmentation at this level can be viewed as an enabler of competition among firms (Langford & Male, 2001).

According to Duffy et al. (2007, p. 462), SMEs own most of the skills and knowledge, but their performance can be hindered by setbacks such as lack of funds to invest individually in research and development. This is accompanied by the dynamic and temporary relationship between construction partners and the various disciplines in these firms (Duffy et al., 2007). The temporary coalitions of stakeholders result in complex and detailed contracts, low trust, and adversarial relationships (Winch, 2000). Garcia (2005) emphasized on the importance of a network of SMEs to enable integration and innovation, and to foster the creation, dissemination, and valuation of knowledge in a frame of cooperation and confidence.

2.2.2 Project level (production process level)

Fragmentation at this level implies lack of coordination, collaboration, integration, and poor communication between various functional disciplines and contractual partners in the project (Bresnen & Marshall, 2001; Xue et al., 2005). Another aspect of fragmentation at this level is the inability of specialists and professionals to work together efficiently. Specialization can cause certain concomitant problem to knowledge sharing. Moreover, knowledge created in construction is, to a certain extent, "situated" and a sizeable body of experiential knowledge created in practice remains tacit and thus difficult to transfer (Demaid & Quintas, 2006). "Of course, as there are obvious benefits to be gained from specialization, fragmentation itself is not necessarily a problem […] However, it is precisely the problems associated with lack of integration that have long been the focus of industry, government and academic attention (from Emmerson to Egan)" (Bresnen & Marshall, 2001, p. 343). Hence, collaboration and integration of professionals can attain the benefits of specialization and enable better communication and sharing of knowledge.

Another aspect of fragmentation at this level is the separation of design and construction stages. The function of the master builder was fragmented into designer and constructor specialties during the late part of the 19^{th} and early part of the 20^{th} century (Yates & Battersby, 2003). Thus, two different areas in this level can be distinguished: fragmentation caused by the separation of the master builder function into disintegrated design and construction function, and fragmentation caused by the specialization of design and builders into a specific field of operation (Yates & Battersby, 2003).

2.2.3 Other dimensions of fragmentation

Fragmentation can be viewed from a different angle and categorized into two dimensions: fragmentation of entities and fragmentation of process or function. The first implies segregation of expertise, specialist teams, and specialist firms (Hertog & Brouwer, 2001; Murdoch & Hughes, 2008). This dimension of fragmentation develops from lack of collaboration, integration, or common objectives of project teams and firms. The second dimension implies the disintegration of the construction process during the project life cycle. The project can be divided into several stages: initiation, design and planning, construction, and operation and demolishing. A vast divide exists between the design stage and construction stage (Baiden et al., 2006; Forgues et al., 2009; Oragne et al., 2005). People during the project life cycle work in silos (Anumba et al., 1997). Moreover, the construction stage consists of many disintegrated sub-stages. For example, construction work consists of site preparation, foundation works, structure works, and finishing and handling. All these stages involve a significant number of specialists and firms; at the same time, they involve separate and complex processes. Thus, the construction stage itself can be regarded as a case that contains both fragmentation of entities and fragmentation of function.

2.3 Definition of Fragmentation

The previously made distinction between the two levels of fragmentation (i.e., industry and project levels) indicates no specific agreed-upon definition for this phenomenon. Gonz'alez et al. (1998) affirmed that firm or industry fragmentation may be interpreted as **team fragmentation**. The scholars affirmed that fragmentation can be viewed as change in contractual patterns from employment relationship to market relationship, and "this qualitative change of contracts is a transfer of the entrepreneur's rights to other members of the team, who become entrepreneurs themselves. Thus, from this point of view, firm fragmentation is interpreted as team fragmentation" (Gonz'alez et al., 1998, p. 439).

The current study follows the view of Bresnen and Marshall (2001); Xue et al. (2005); Love, Irani, et al. (2004a); and Demaid and Quintas (2006) on fragmentation: it is defined as the lack of coordination, collaboration integration, poor communication, and diversity of specializations of contractual partners and various functional disciplines. Fragmentation here is a matter of degree rather than existence. Thus, fragmentation in the current study can be defined as follows:

Project team heterogeneity results from specific delivery process of the project and lack of collaboration, coordination, and integration. It is caused also by decoupling of diversities and the situated nature of knowledge in the project.

2.4 Causes of Fragmentation

As discussed previously, construction projects have two main characteristics: pre-demand nature of projects (the owner must buy the product before it is ready) and situated nature of projects in a certain location (Langford & Male, 2001). These characteristics cause "transaction uncertainty" and fragmentation (Hartmann & Caerteling, 2005). In addition, "variations in regulation" may cause fragmentation of firms, complexity of services, and market segmentation (Gonz'alez et al., 1998; Langford & Male, 2001; Oragne et al., 2005).

On the other hand, fragmentation at the project level can be traced back to various firms brought together to form the construction team. This team is selected based on professional capability rather than the team's ability to integrate and work together effectively (Baiden et al., 2006). Fragmentation at this level reflects fragmentation at the industry level, which sustains a contractual and confrontational culture (Sorrell, 2003). The technical complexity of the construction process and the problem of procuring system lead to a wide variety of skills and specialists (Murdoch & Hughes, 2008). In addition, further production and complexity of projects and proprietary of knowledge cause skills and diversity of specializations (Seymour, 1987). Anumba et al. (2002) described the traditional fragmented practice of construction project as "over the wall" approach, where several participants work independently while formulating decisions that affect others.

Fragmentation can be caused by poor coordination between various disciplines and division of labor during the project life cycle (Hertog & Brouwer, 2001; Vock', 2001). Other reasons for project fragmentation include the following: lack of trust (Hertog & Brouwer, 2001); temporary collaboration of several disciplines and participants (Anumba et al., 1997; Mohamed & Tucker, 1996); several stakeholders and several construction phases (Nitithamyong & Skibniewski, 2004); and sequential nature of the construction process (Dulaimi et al., 2002).

2.5 Impact of Fragmentation

Fragmentation has a negative effect on construction industry and projects. The impact of fragmentation can be categorized as follows: 1) performance of industry and projects; 2) communication and relationships; and 3) knowledge and learning.

First, fragmentation is one of the causes of less interest in strategic management implementation (Cheah & Chew, 2005). In addition, fragmentation of the industry may slow the uptake of information technology (IT) among small firms given a relatively small number of industry leaders who plan for strategic IT implementation (Stewart et al., 2004). Fragmentation may cause variability of performance and productivity of projects, as well as design clashes, omissions, and errors (Anumba et al., 2002; Baiden et al., 2006; Nitithamyong & Skibniewski, 2004). Forgues et al. (2009) cited the problems resulting from fragmentation mentioned in (Dupagne, 1991) into the following: lack of iterations in the design process, lack of consideration of constraints within subsequent phases, and lack of leadership and accountability. These problems, in turn, lead to suboptimal solutions, rework in design and construction, and lack of innovation (Forgues et al., 2009). Moreover, fragmentation limits the impact of human resource mechanisms (Cheng et al., 2007); impacts constructability (Fischer & Tatum, 1997); lowers investment and concern in the production process (Na et al., 2007); and hampers implementation of integrated technologies (Koskela, 1992).

Second, adversarial relationships and poor communication between parties can cause problems such as the lack of transparency and mistrust (Baiden et al., 2006); difficulties in communication, information processing and integration (L. Liu, Georgakis, et al., 2007; Nitithamyong & Skibniewski, 2004); misconceptions and misunderstanding among different participants (Anumba et al., 2002); and adversarial workplace attitude of the project team (Cheng et al., 2007). In addition, the limitation of communication among project teams leads to conflicts, dispute, time and cost overrun, and rework (Dave & Koskela, 2009; Tijhuis & Maas, 1996).

Lastly, fragmentation of projects can impact learning and innovation solutions (Hertog & Brouwer, 2001; Na et al., 2007) and knowledge capturing and sharing (Dave & Koskela, 2009). Fragmentation can inhibit knowledge production, thereby leading to a low level of productivity (Egbu, 2006; Oragne et al., 2005). In addition, fragmentation hinders the useful experience and know-how to be used sufficiently during the planning process (Vock', 2001). Moreover, fragmentation and the ad hoc-based working nature of small firms lower the rate of learning in these firms (Tan & Elias, 2000). Furthermore, it causes numerous contracts and points of information exchange (Tijhuis & Maas, 1996) that render information integration more complex and difficult to achieve. Finally, fragmentation of professional project team may impact the following: absorptive and innovative capacity of the organization, ability to recognize the value of new knowledge, assimilation of new knowledge with existing knowledge, and application of knowledge to commercial ends (Bresnen et al., 2003).

2.6 Overcoming Fragmentation

At the industry level, several approaches have been recommended to overcome fragmentation. These include the following: creating business-to-business network or internetworking (S.L. Chan & Leung, 2004; Winch, 2010); encouraging partnering, compromising, collaboration, and knowledge sharing in the supply chain (Egan, 1998; Egbu, 2006; Kagioglou et al., 2000; Oragne et al., 2005); encouraging cooperation and integration among firms and project parties via both the legal and social mechanisms (Hartmann & Caerteling, 2005); and developing the procurement using alliance-based management to overcome the IT literacy gap between large enterprises and SMEs (Stewart et al., 2004).

Oragne et al. (2005) indicated an approach called cross-organizational learning (COLA) to reduce the impact of fragmentation. This approach involves inter-organizational agreements and workshops to enhance communication and knowledge sharing. Maqsood et al. (2007) indicated this approach as well to develop a learning organization, and for knowledge sharing across the supply chain as well as development of trust and commitment of players.

On the other hand, the study of Forgues et al. (2009) underscored collaboration as the main solution for fragmentation. The study proposed three main approaches to encourage collaboration: integrated practices, integrated teams, and integrated design process. In addition, the study examined two factors that facilitate collaboration, namely, change practice and objects, to facilitate boundary crossing. In the first approach, the scholars underpinned the activity theory (Engeström, 1987) to explain how to break barriers at the pragmatic level. Meanwhile, the situated action theory (Lave & Wenger, 1991) was presented to identify ways that help to cross the boundary between communities of practice (CoP). A community of practice, according to Lave and Wenger (1991), is a term that describes a group of people who share an interest, craft, and/or profession. The group can evolve naturally because of the members' common interest in a particular domain or area, or it can be created specifically with the goal of gaining knowledge related to their field (Lave & Wenger, 1991). Through the process of sharing information and experiences with the group, members learn from each other and create an opportunity to develop themselves personally and professionally.

Forgues et al. (2009) proposed IT as a boundary crossing that facilitates collaborative work and transformational learning among member of a design team. On the other hand, Baiden et al. (2006) observed that team practices within the context of procurement approach affect the level of integration. Further recommendations and approaches of several scholars to overcome fragmentation can be categorized into the following:

1. Utilizing ICT and/or knowledge management: utilizing computer-integrated construction (CIC) methods (Koskela, 1992); providing a "knowledge centre" (Oragne et al., 2005); utilizing knowledge management and innovation (Vock', 2001); construction collaboration technologies (CCT) (Hore et al., 2009); and utilizing IT (Nitithamyong & Skibniewski, 2004).

2. Encouraging collaboration and team integration: promoting inter-sectoral collaboration (e.g., joint initiative of the associations of engineers, architects, and construction firms) to deliver a single and integrated product (Vock', 2001); addressing integration in the procurement techniques, as they are limited to addressing the production problem only (Naoum, 2003); motivating integration and closer cooperation between consultants and contractors (Dulaimi et al., 2002); providing a clearer definition of the role of other companies through specifications and contract (Sorrell, 2003); empowering the attitude of full integration, cooperation, and trust (Tijhuis & Maas, 1996); and developing a protocol of design and construction process (Kagioglou et al., 2000).

3. Utilizing design-and-build (D&B) and other approaches: promoting D&B and relatively new procurement methods (Anumba et al., 1997; Dulaimi et al., 2002); adopting concurrent engineering (CE) with appropriate organizational structure (Anumba et al., 2002); developing and empowering the multi-disciplinary team (Anumba et al., 2002); ensuring clarity and good procedures and responsibilities within the contracts (Tijhuis & Maas, 1996); developing procurement using alliance-based management (Stewart et al., 2004); and realizing the influence of design on project performance, clients' dissatisfaction with the currently dispersed responsibility, and prominence of specialist constructors, especially those whose contribution must be coordinated (Ofori, 2003).

In a discussion on the limitation of design-and-build approach, Ofori (2003) emphasized that D&B does not reduce fragmentation but transfers the problems from clients to contractors. Design-and-build, according to the scholar, is not a panacea for the industry's problems. In addition, Anumba et al. (1997) stated that D&B has suffered from poor design quality, lack of certainty on expected performance, high tendering costs, and lack of flexibility in accommodating client change. Tijhuis and Maas (1996) likewise criticized this method as it restricts the influence of the client and places higher risk on the contractor. Table 2.1 summarizes the literature on fragmentation's reasons, impact, and solutions according to the two levels of industry and project.

Table 2.1: A summary of fragmentation studies (industry and project levels)

(Author, year)	**Frag. of Industry**	**Frag. of Project**	**Reasons**	**Impact**	**Proposed solutions**
(Seymour, 1987)	√		-Further production of construction project needs highly diverse of skills -Proprietary of knowledge (knowledge may not transferable without some cost) cause specialization of firms -Complexity and size of supply of services.		
(Koskela, 1992)		√		-Hampers the implementation of integrated technologies	-Utilizing computer integrated construction (CIC) methods that facilitate communications of data, knowledge and design solutions.
(Tijhuis & Maas, 1996)		√		-Conflicts (errors in communication and information) -Several contracts and several points of information exchange	-Empower the attitude of fully integration, cooperation, and trust. -Clearness and the well done procedures and responsibilities within the contracts.
(Mohamed & Tucker, 1996)		√	-The nature of construction industry (large number of participants form a temporary group to accomplish the task)		

Table 2.1: A summary of fragmentation (industry and project levels) (Cont'd)

(Author, year)	**Frag. of Industry**	**Frag. of Project**	**Reasons**	**Impact**	**Proposed solutions**
(Anumba et al., 1997)		√	-Several disciplines work together for relatively short period. -Working independently while taking decisions that affect others 'over the wall' approach	-Poor integration, coordination and collaboration -Lack of communication -Unwarranted design change	-Automation of various aspects of the design and construction process -Using new procurement methods (e.g. D&B, although it has some limitations) -Computer-integrated framework for concurrent life-cycle design and construction (CLDC)
(Tan & Elias, 2000)	√			-Lowers the rate of learning of small firms (this besides the ad hoc nature of their work that leads to organizational forgetting)	
(Kagioglou et al., 2000)		√		-Poor communication between all parties	-Key elements: product development, project implementation, partnering the supply chain, and production of components -A protocol of design and construction process
(Hertog & Brouwer, 2001)		√	-Difficulty in co-ordination among various disciplines involved in the construction process -Various phases of this process -Lack of trust	-Limitation of learning -Innovative solutions to problems are not always well retained	
(Vock', 2001)		√	-Division of labor and poor co-ordination in the sequence of activities during the life cycle of construction projects.	-Useful experience and know-how is not used sufficiently in the planning process. -Difficulty of implementing innovative, efficient and beneficial solutions.	-The joint initiative of the associations of engineers, architects, and construction firms (inter-sectoral collaboration) -Utilization of knowledge management
(Langford & Male, 2001)	√		-Characteristics of construction industry (pre-demand, the localized project-based nature, project type, and the delivery requirements). -Large number of SMEs and small number of large companies (market segments)		-Organization should seek competitive advantage from knowledge and information based assets rather than through technologically based assets per se.
(Anumba et al., 2002)		√	-The traditional practice of construction project 'over the wall approach'.	-Misconceptions and misunderstanding of different participants -Fragmentation of design and construction data leads to design clashes, omissions and errors.	-Adopting concurrent engineering with appropriate organizational structure (e.g. the matrix structure) -Development and empowerment of multi-disciplinary team

Table 2.1: A summary of fragmentation (industry and project levels) (Cont'd)

(Author, year)	Frag. of Industry	Frag. of Project	Reasons	Impact	Proposed solutions
(Dulaimi et al., 2002)		√	-The sequential nature of the construction process	-Lack of integration across the value chain is the major cause of low productivity	-Motivation for greater integration and closer cooperation between consultant and contractors -Promoting D&B procurement method and adopting new organizational structure
(Fischer & Tatum, 1997) cited (Yates & Battersby, 2003)		√		-Hinders constructability	
(Naoum, 2003)		√			-Utilizing methods that address the problem of integration (e.g. partnering), whereas procurement techniques are limited to addressing the production problems only.
(Sorrell, 2003) cited (Egan, 1998)		√	-Fragmentation at project level reflects fragmentation at industry level, which sustain a contractual and confrontational culture.		-Define the role of other companies (through specifications and contracts)
(Ofori, 2003)		√			-Realizing the influence of design on project performance -Clients' dissatisfaction with the current dispersed responsibility -Prominence of specialist contractors especially those whose contributions must be co-ordinate. -(D&B is not appropriate as it transfer the problem from client to contractor)
(Stewart et al., 2004)	√			-Slow uptake of IT in the supply chain (small number of industry leaders in charge to plan for strategic IT implementation	-Developing the procurement using alliance-based management to overcome the IT literacy gap between the large and SMEs -Utilizing web-based information management system
(S.L. Chan & Leung, 2004)		√	-Fragmentation can occur geographically or functionally	-Coordination among various participants can be difficult task	Internetworking, specifically for AEC, to help overcoming the problem of communication and spreading information. It is cheap, widely available and not too difficult to use.
(Nitithamyong & Skibniewski, 2004)		√	-Many stakeholders and phases involved in a construction project	-Problems related to communication and information processing -Proliferation of adversarial relationships between the parties. -Low productivity	-Utilization of IT

Table 2.1: A summary of fragmentation (industry and project levels) (Cont'd)

(Author, year)	Frag. of Industry	Frag. of Project	Reasons	Impact	Proposed solutions
(Oragne et al., 2005)	√	√	-Huge number of small and medium construction enterprises. -Ownership and control of separate functions and processes resides in the hands of separate organizations.	-Critical barrier to change -Major factor of poor communications between parties working together on construction project	-Cross Organizational Learning Approach of knowledge sharing among partners -Restructure the industry by engendering a spirit of compromise and collaboration -Inter-organizational agreements and methods of communication, and clearer definition of roles and contract (recommended by Latham, 1994) -A 'knowledge Centre' to access to the required information (recommended by Egan, 1998)
(Hartmann & Caerteling, 2005)	√	√	-The dependency of constructional tasks on client and location that causes the 'transaction uncertainty' and fragmentation		-Cooperation and integration among firms and project parties via the legal mechanisms and the social mechanisms or networks
(Egbu, 2006)	√			- Inhibits knowledge production that lead to the low level of productivity	-Partnering (suggested by Egan) can also help in knowledge production
(Baiden et al., 2006)		√	-Various organizations brought together to form the team that is responsible of producing the product. -Team member are selected based on the professional capability rather than their ability to integrate and work together effectively.	-Reduce project delivery efficiency and poor performance -Adversarial relationships, lack of transparency and mistrust. This often results in a 'blame culture'. - Individual rather than team objectives -'The construction industry has not fully benefited from the increased productivity and product quality that can result from teamwork' -Increase design changes and unnecessary liability claims, which make true project life cycle analysis difficult to achieve	-Encourage collaboration and integration of process and team (from Egan: Accelerating Change) -'Integration Toolkit' -Team integration via improving project procurement (D&B) and product delivery process -Construction managers' roles
(Na et al., 2007)		√		-Low investment and concern in production process -Less motivation to invest in innovation -Hinders mutual sharing of information and knowledge	
(J. Liu, Li, et al., 2007)	√	√		-Adversarial relationships among project participants and lack of communication -Hinders information integration in construction logistic system	-Collaborative teamwork among construction players. -Building a favorable learning environment for contractors -Mutual cooperation

Table 2.1: A summary of fragmentation (industry and project levels) (Cont'd)

(Author, year)	**Frag. of Industry**	**Frag. of Project**	**Reasons**	**Impact**	**Proposed solutions**
(Cheng et al., 2007)		√		-Stymied performance improvement -Limited the impact of HRM mechanisms -Adversarial workplace attitude in the supposedly integrated project team environment	
(Maqsood et al., 2007)	√				-Development of learning organization and knowledge sharing across the supply chain and with clients/customers -Development of trust and commitment of players
(Murdoch & Hughes, 2008)		√	-Temporary relationship of different specialists and organizations. -Wide variety of skills resulted from the technical complexity of the problem associated with procuring buildings.		
(Forgues et al., 2009)		√		-Lack of iterations in design process; lack of consideration of constraints within subsequent phases; and lack of leadership and accountability -All those lead to suboptimal solutions, poor constructability, rework in design and construction and lack of innovation (cited Dupagne, 1991).	Role of IT and technology to increase the collaborative work
(Hore et al., 2009)		√			-Utilization of construction collaboration technologies (CCT) (e.g. computer-aided drafting, 3-D modeling, and a host of Internet and standard based design and project collaboration technologies).
(Dave & Koskela, 2009)		√		-Complexity of process -Hampers capturing and sharing knowledge -Limits communication which lead to dispute, time and cost overrun, and rework	
(Winch, 2010)	√				- Business to business Internet-based approach

Note: *Reference in bold font represents studies that indicated both knowledge or learning and fragmentation.*

SECTION II: PROJECT LEARNING

2.7 Levels of Learning

Learning occurs at certain levels, including individual, project (team/group), organization, and inter-organization (Ayas, 1997; Barlow & Jashapara, 1998; Sun & Scott, 2005; Wu, 2005). Literature involves numerous investigations on learning at the organization level. Individual learning is considered the underpinning of organizational learning (Argyris & Schön, 1978). Linkage between individual learning and organizational learning is discussed by studies such as Sun and Scott (2005) and Sense (2005). However, individual learning is saddled with shortcomings compared with collective learning. For example, individuals have limited capabilities to look at non-routine problems, to be involved in learning processes, and to deal with complex situations (Bourgeon, 2007). Both individual and group learning occur when an important issue arises (Anheim, 2003). As construction is a project-based industry, paying greater attention to the project level is more important. The current study focuses on the project learning level and entities that learn within this context. The following section reviews several studies on learning in construction at different levels, highlighting the need for more studies at the project level.

2.8 Learning in Construction: Highlighting Certain Gaps

This section summarizes several studies related to learning in the construction industry in different levels: individual, team, project, organization, and inter-organization. This review does not cover all studies on learning in the construction; rather, it provides an indicator of the direction of the investigations in the field. The purpose is to establish that there are limited empirical investigations addressing learning within and across construction projects. In addition, there are limited studies that intend to develop learning models in view of the construction project's characteristics. Table 2.2 shows studies on learning in construction according to level of learning, research method used, and location.

Table 2.2: A summary of different studies on learning in the construction industry

(Author(s), year)	Milieu or Level	Approach / method	Location	Study's contribution and some highlights
(Barlow & Jashapara, 1998)	Organization / Inter-organization	Quali. / Case study	UK	Explored the role of partnering in stimulating organizational learning (OL). Effective communication, codifiability, and trust within and between organizations all improve learning and knowledge transfer. Type of knowledge and organizational culture enable knowledge transfer between firms.
(Gherardi et al., 1998)	Individual / Organization	Quali. / Semi-structured interviews	Italy	Contributed to understanding social perspective of learning activity and developed a situated curriculum for construction project manager (based on situated learning theory).
(Barlow, 2000)	Inter-organization	Quali. / Case study	UK	Examined the role of partnering to stimulating learning and innovation. Forms of organizational learning in the case studies include vicarious learning, team learning and individual learning.
(Love, Li, Irani, & Faniran, 2000) / (Love, Li, Irani, & Holt, 2000)	Organization	Conceptual / Synthesizing of literature	-	Incorporated total quality management (TQM) philosophy, organizational learning and change in a conceptual framework for construction organization.
(Tan & Elias, 2000)	Industry	Quanti. / Archival data (production function approach)	Singapore	Found that learning by doing was not significant in construction industry. Reasons include **fragmentation** of the industry, the dependency on imported technology and unskilled foreign workers. Another reason is that learning is a social-embrace, which emphasizes on the need for comprehensive measure of learning at different levels.
(Vakola & Rezgui, 2000)	Organization	Quali. / Case study	Sweden, Norway, & France	Explored the role of re-engineering and innovation for organizational learning in construction companies. Also, investigated the influence of these aspects to enhance professionals in organizations.
(Gieskes & Broeke, 2000)	Organization / project	Quanti. / Survey	Netherlands	Identified three characteristics of construction projects: the one-off nature of projects and their organizations, the on-site character of projects, and culture. The results were organized around the following: organizations' dealing with projects; methods and techniques for learning; climate to support learning; tools for learning; and knowledge exchange.
(Huemer & Östergren, 2000)	Organization	Quali. / Interviews	Sweden	Investigated OL and strategic change in construction companies and found that learning takes place in cultural settings. Implications for learning are twofold. First, the identity of an organization makes possible a different set of actions. It alters the firm's strategic behavior. Second, learning cannot be understood solely as a process of adaptation to the environment. Triggers to learning arise from both internal and external factors.

Table 2.2: A summary of different studies on learning in the construction industry (Cont'd)

(Author(s), year)	Milieu or Level	Approach / method	Location	Study's contribution and some highlights
(Keegan & Turner, 2001)	Organization	Quali. / Interviews and observations	Different countries in Europe	Explored practice of OL across different industries, including construction. Challenges faced by organization to learn from project were analyzed based on: variations, selection, and retention. Characteristics of learning in project-based organizations include: time pressure; centralization of resources; and deferral. These also impede project-based member in learning from and through projects.
(Bresnen et al., 2002) / (Bresnen et al., 2003)	Project / organization	Mixed / Case study and survey	UK	Analyzed enablers and barriers of learning across different industries including construction. These are project and project process characteristics, networking, learning capture, and organizational context. The role of a regional engineering manager (REM) to organize engineering activities and support learning was introduced.
(Ren & Anumba, 2002)	Individual (agent system)	Quali. / Bayesian approach	UK	Reviewed some aspects of learning as method of learning (rote learning, learning from instructions, learning from examples, learning by analogy, and learning by discovery) and other aspects of negotiating agent learning in construction project.
(Davey et al., 2004)	Organization	Quali. / Case study	UK	Investigated the role of action learning in promoting innovation, continuous improvement and change culture as part of construction SMEs. Action learning can generate a motivated, committed and innovative management team, as well as better site management and leadership.
(Love et al., 2002)	Inter-organization	Quali. / Case study	UK	Developed a model that relates transaction cost with learning, alliance and contractual implication. Transaction cost can be affected by two concepts of learning within alliance environment: consider business decision that is influenced by learning climate (bounded rationality) and make best use of information (opportunism).
(Love et al., 2003)	Organization	Quanti. / Survey	Australia	Examined the influence of learning and quality on the level of the cost of re-work. There was no significant negative correlation between a firm's learning practices and rework costs. This suggests that firms have become accustomed to paying rework costs.
(Fong, 2003)	Team / project	Conceptual / Synthesizing of literature and case study	Hong Kong	Developed a model of knowledge creation process of multi-disciplinary team. Processes of knowledge creation are: boundary-crossing, knowledge sharing, knowledge generation, knowledge integration, and collective project learning.
(Knauseder et al., 2003)	Organization / intra-project	Conceptual / Synthesizing of literature	-	Introduced the concept of OL capability in order to understand existing and absent learning processes in construction projects. The study highlighted the characteristics of projects including construction process and fragmentation.
(Franco et al., 2004)	Inter-organization	Quali. / Workshops using Problem Structuring Method	UK	Developed Cross Organizational Learning (COLA) approach using strategic-based workshops to identify and review problems and success factors of project among partners. Obstacles of inter-organizational learning are: obstacles related to inter-organizational routines; less natural learning among partners; lack of trust; and the transient nature of project team.
(Love, Irani, et al., 2004a)	Organization / Inter-organization	Quanti. / Questionnaire survey	Australia	Investigated the role of benchmarking in obtaining the most from organizational IT investment in construction SMEs. Part of the process of benchmarking is the 'check phase', which, forms an integral part of the learning cycle of the organization. "Once organisations have evaluated themselves against 'best practice' firms within the industry, they need to be able to determine how they can learn from these firms as well—a process known as benchlearning".

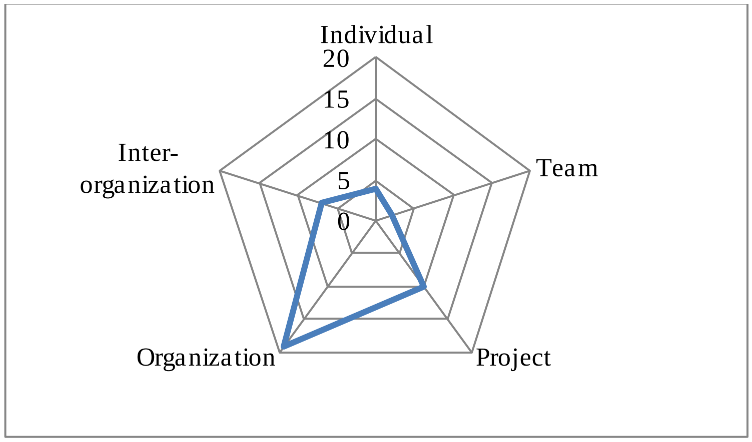
Table 2.2: A summary of different studies on learning in the construction industry (Cont'd)

(Author(s), year)	Milieu or Level	Approach / method	Location	Study's contribution and some highlights
(Love, Huang, et al., 2004)	Organization	Conceptual / Synthesizing of literature	-	Proposed a conceptual framework of learning organization (LO) of construction companies. Elements of LO include strategic shift, organization transformation, customer orientation and quality centered learning. Some other elements in this model were proposed in previous studies by the authors as for example (Love, Li, Irani, & Faniran, 2000).
(Hall, 2004)	Inter-project	Quali. / Case study and root cause analysis		Developed a learning framework based on quality costing includes three aspects: the manner in which the methodology is implemented, the use of root cause analysis as a diagnosis tool, and the strategic and operational use of the data measured.
(Fong, 2005)	Project (team)	Quali. / Case study	Hong Kong	Investigated the processes of knowledge creation using two case studies of project team (proposed in Fong, 2003). The study adapted the knowledge creation model of Nonaka and Takeuchi. The study found that knowledge creation is interwoven (non-linear) process. In addition, collaborative project team is important factor in creating knowledge.
(Wu, 2005)	Organization	Conceptual / Synthesizing of literature and pilot study	-	Themes of OL are: social constructivist (conversations and interactions between people); communities of practice (community building approach); communities of creation (participation of shared space); ecologies of knowledge (productive conversations; and activity systems (activity system within which people collaborate).
(P. Chan et al., 2005)	Project / Organization / inter-organization	Conceptual / Synthesizing of literature	-	Facets of OL are: contextual, policy, psychological, cultural and structural. The study highlighted the following enquiries extracted from gaps in literature: who takes the lead in laying down the policy for learning, partnering a *sine qua non* for organizational learning or vice versa, operational change rather than strategic change, and projects as 'learnt organization' or 'learning networks'? The study called for more emphasis on projects as the unit of organizational analysis.
(Hari et al., 2005)	Organization	Quali. / Interviews	UK	Investigated knowledge capture awareness in SMEs. There is a lack of awareness of knowledge capture processes, challenges and benefits in SMEs. Accordingly, a computer-based awareness tool on knowledge capture was developed, underpinned by Kolb's experiential learning theory. Knowledge capture implementation dependent on the vision and flair of the owner/partners of the firm. It is also determined by the culture, structure, people, finance and technology.
(Fu et al., 2006)	Individual within projects / networks	Quanti. / Survey	Hong Kong	Intended to understand the relationship between collective learning, learning networks, and collective knowledge of different professionals. Four learning networks: inter-firm networks; formal networks; theme-focused networks; and networks of individuals.
(Maqsood et al., 2007)	Organization	Quali. / Case study utilizing Soft System Methodology (SSM)	Australia	Soft system methodology (SSM) and interviews used to develop a rich picture of project histories, and this used to build a conceptual model of project histories. A framework was suggested for organizations to improve learning from projects.
(Knauseder et al., 2007)	Intra-project	Quanti. / Survey	Sweden	Identified components of learning in different types of construction projects: Organizing projects for learning, Experimenting, Networking, Leadership, and Openness and Influence. There are differences in the way learning is approached for different types of construction project.

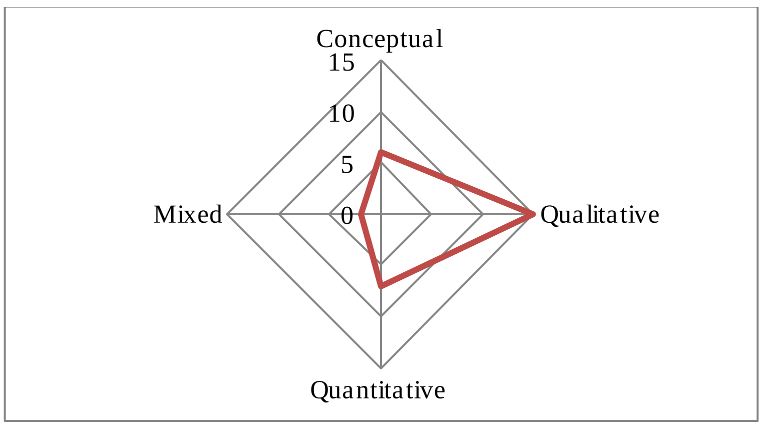
Table 2.2: A summary of different studies on learning in the construction industry (Cont'd)

(Author(s), year)	Milieu or Level	Approach / method	Location	Study's contribution and some highlights
(Hällgren & Wilson, 2007)	Intra-project	Quali. / Case study	Central America, Asia and Europe	Investigated how informal and incidental learning occurs when there is a deviation in the project. There are two levels of learning; learning occurs when handling the deviations and learning patterns emerge when handling remedies.
(Landaeta, 2008)	Organization / Inter-project	Quanti. / Survey	Europe, North, Central, & South America	Knowledge transfer across projects has a positive relationship with project body of knowledge and performance. However, variation explained of performance is not significantly influenced by knowledge transfer.
(Abdul-Rahman et al., 2008)	Intra-project	Mixed / Preliminary survey and case study	Malaysia	Developed a conceptual model that may assist in mitigating project delay. The model consists of four phases of project learning: knowledge identification; knowledge sharing, creation, and integration; knowledge exploitation; and knowledge storage.
(Hasle et al., 2009)	Individuals / Organization	Quali. / Case studies	Denmark	Explore how the owners of small construction and metal industry firms attribute accident causation and what they learn about accident prevention. The owners attribute the incident to two things: mostly to unforeseeable circumstances and secondarily to worker faults. Learning from accident seems to be negative as the owners need to withhold from accident prevention to maintain that accidents unforeseeable.

Figure 2.2 (a) indicates the distribution of the reviewed studies according to the level of learning. Clearly, most studies are at the organization level. Studies on individual and team levels are very limited. Number of studies at the project and inter-organizational levels are almost equal, but less than the organizational level. Figure 2.2 (b) shows the studies based on the methodology used. Most studies used the qualitative approach (including case study, interviews, etc.). Number of quantitative studies (using questionnaire survey, etc.) is approximately half of the qualitative studies. Similarly, the conceptual studies (used synthesizing of literature to develop models or frameworks) are likewise approximately half of the qualitative studies. Mixed approach is the less frequently used method.



(a)



(b)

Figure 2.2: Number of several studies on learning in the construction according to (a) level of learning and (b) methodology used

To summarize, learning at the project and team level has received less concern compared with the organization level. In addition, there are limited empirical studies of learning at project level. The influence of project characteristics on learning has obtained little attention. Lastly, most studies are qualitative-based, which call for more quantitative studies that examine project learning process.

2.9 Learning Approaches in Projects

Learning in project milieu can be distinguished according to type, model of learning, level of individual learning, and learning method. Storm and Savelsbergh (2005) identified three types of learning in projects: operational learning (e.g. lessons learned, learning curve, etc.); managerial learning (e.g. learning during execution of managerial tasks); and organizational learning through projects (e.g. project-based learning).

Models or styles that explain how learning occurs can be distinguished into the cognitive model and community model (Swan et al., 1999). According to Bresnen et al. (2002), the cognitive model deals mainly with codifying and circulating knowledge widely through the application of ICT, while the community model focuses on tacit dimension of knowledge whereby shared meaning of project team facilitates the understanding and application of knowledge. In cross-project learning, IT will be used predominantly in the cognitive model, while social networks will be utilized in the community model (Newell, 2004). The community model, in addition, emphasizes on the social and behavioral aspects of knowledge. Sense (2009) emphasized on the behavioral perspective of learning that focuses on the role of action in learning.

According to Mumford (1995), individual learning from experience can be distinguished into four levels or approaches: 1) intuitive (to learn from experience but without being conscious of it); 2) incidental (learning by chance resulting from jolt such as mishap, etc.); 3) retrospective (learning by reviewing and developing lessons to learn); and 4) prospective (to plan to learn before an experience takes place).

Learning methods can be divided into the following: rote learning (direct implementation of knowledge), learning from instruction and by advice taken, learning from example and by practice, learning by analogy, and learning by discovery (Ren & Anumba, 2002). Complexity and efforts in these methods increase from the first to the last.

Lastly, project reviews and learning methods can be classified into process-based methods and documentation-based methods (Schindler & Eppler, 2003). Process-based method involves gathering lessons learned from concluded projects and explaining the relevant steps and sequences of a project's timeline. It consists of two methods: post-project appraisal (PPA) and after action review (AAR). PPA represents a special type of project review that includes a strong learning element. AAR method can assist immediate team learning from errors and successes. Meanwhile, the documentation-based method is more about learning from project experience and storage of contents within the organization. This method consists of micro articles, learning histories, and recall.

2.10 Project Learning

Organizational learning may be applied differently to the project milieu (or locus) and organization milieu. As can be perceived from the previous section, an organization learns, similar to the individual and group. An important question to ask in this regard is, "Does a project learn?" To understand the notion of project learning, the researcher will attempt to distinguish between organization (routine organization) and project with regard to learning. The discussion will expand to identify similarities and differences between project learning and project-based learning. In addition, fundamental works of project learning will be reviewed. The review will include works of organizational learning cited by project learning studies. Lastly, features of project learning will be presented at the end of this chapter.

Projects differ from permanent organizations in many facets. Projects are described as one-shot, time-bound, goal-driven activities directed toward the delivery of new product or service (Arthur et al., 2001). Moreover, construction projects are situated on a site, unique, and fragmented (Winch, 2010). In the best situations, projects will be regarded as temporary multi-organizations (Disterer, 2002; Gieskes & Broeke, 2000; Koskela, 1992). Further discussion on the idea that projects are temporary organizations can be found in (Packendroff, 1995; Turner & Müller, 2003). The temporary nature of construction projects may affect the acquisition of learning and knowledge from previous experience (Ceci & D'Andrea, 2009). Moreover, existing knowledge in construction projects is described as dispersed (Garcia, 2005). Other characteristics of projects, which may also influence learning, include customization, discontinuity, complexity, interdependence, and uncertainty (Brady et al., 2002).

In organizations, learning activities are supported by organizational structure, routine, and resources to assimilate knowledge (Mian & Takala, 2008). Discontinuity of project practices, resources, and information flow render establishing routine tasks and learning (Bresnen et al., 2003; Scarbrough & Swan, 2008). Unlike organizations, projects lack a memory (e.g., experiential learning and work routines), rivaling cultures, or social background (Ibert, 2004). Thus, it can be inferred that projects per se cannot learn.

2.10.1 Toward a better understanding of project learning

Project learning may differ from **learning project** and **project-based learning**. Learning project, which appears less frequently in literature, can be defined as "an instrument for members of an organization to organize learning activities systematically around a central work-related theme or problem" (Poell, 2000, p. 179). Meanwhile, project-based learning has been studied and defined more clearly. For example, Storm and Savelsbergh (2005) defined project-based learning as the theory and practice of utilizing real-work assignments on time-limited projects to achieve mandated performance objectives and facilitate individual and collective learning. Project-based learning involves two main processes, namely, learning by absorption and learning by reflection (Scarbrough et al., 2004). In addition, Ayas and Zeniuk (2001, p. 64) pointed out the features of project-based learning as follows:

1) Learning is one of the project's objectives.
2) Environment offers psychological safety to tell the truth.
3) Projects are provided with the appropriate infrastructure to support learning.
4) There exist communities of practice (CoP) that cross project boundaries.
5) The leader of the project has commitment to learning.
6) There is a systematic and collective reflection, where problems are considered as a chance to learn and change.

According to Ayas (1997, p. 59), "Learning within a project does not happen naturally: it is a complex process that needs to be managed. Learning requires deliberate attention, commitment and continuous investment of resources." Thus, in project-based learning, there exist objectives, awareness, intention, and commitment of individuals and leaders toward learning activities. At the same time, the environment of the project is prepared to support these activities. In addition, project-based learning caters more to the community model or social process of learning. This is evident in a number of fundamental studies in construction projects and other projects, including for example (Arthur et al., 2001; Barlow, 2000; Bresnen et al., 2003; DeFillippi, 2001; Keegan & Turner, 2001; Midler & Beaume, 2010; Newell, 2005; Nicolini & Meznar, 1995; Scarbrough & Swan, 2008).

Moreover, project-based learning represents the fourth approach of learning that is prospective (i.e., planning to learn in advance) (Mumford, 1994). Project learning, on the other hand, may involve all four approaches, namely: intuitive, incidental, retrospective, and prospective. Both project-based learning and project learning are concerned about how to attain certain benefits of learning, such as enhancing performance, avoiding the same mistakes, and so on. On the other hand, project-based learning focuses more on the entity that learns and how learning occurs. Meanwhile, project learning focuses on knowledge as an outcome of the process of learning.

Sun (2006) distinguished between organizational learning and learning organization, where the first involves obtainable and natural facets of learning, while the second implies ideal and intentional learning practices. By analogy, we can regard project learning as organizational learning, and project-based learning as learning organization. The first involves single-loop learning, while the second involves both single- and double-loop learning (Argyris & Schön, 1978; Sun, 2006). Furthermore, project learning, as organizational learning, appears to be a description, while project-based learning (similar to learning organization) is a prescription.

In general, project learning involves tasks of detecting and correcting errors and activities of sharing, creating, and transferring knowledge (Ibert, 2004; Kotnour, 1999). The author believes that project learning encompasses natural or "unintentional" aspects of learning. In addition, project learning emphasizes the situated aspect of learning (Sense, 2004). Sense (2007b) agreed that learning is linked to people and their actions and the conditions in which it is generated: "…learning as a practical activity (in any setting), is always socially structured activity where the conditions and forms for learning are established unintentionally and tacitly by the community that shapes the practice…" (Sense, 2007b, p. 407). Thus, the general assumption is that learning occurs in any project.

At present, the definition of project learning remains broad. Some studies explicitly indicate project learning, while others regard it as organizational learning. A general definition was coined by Kotnour (2000, p. 396), who stated that project learning pertains to "the set of actions the project teams use to create and share knowledge within and across projects."

This definition implies three aspects of project learning, namely, actions (i.e., activities) of project team, outcome of this action (i.e., knowledge created and shared), and dimension or level of learning (i.e., intra- and/or inter-project). Intra-project learning can be defined as the acquisition and use of knowledge and experience within the same project (Gieskes & Broeke, 2000). It focuses on tasks within a single project and supports the delivery of a successful project by identifying problems and their solutions during the project life cycle (Kotnour & Vergopia, 2005). On the other hand, inter-project learning refers to the transfer of knowledge and experience from one project to other projects within the same time frame or to different projects over a period of time (Gieskes & Broeke, 2000).

Fong (2003) indicated that transfer of knowledge can happen concurrently while conducting the project or sequentially after finishing the project. In addition, Fong (2003, p. 484) stated the following:

> Central to inter-project learning is a certain degree of repetitiveness between projects, whether they are task similarities or the principles are the same. The most widely observed strategy in inter-project learning occurred in team members engaged in multiple projects rather than where knowledge was codified in any format.

Moreover, inter-project learning involves combining and sharing lessons learned across projects to develop new knowledge (Kotnour & Kurstedt, 2000). Hence, intra-project learning serves as a foundation for inter-project learning by providing the experiences to be assimilated from the project (Kotnour & Proctor, 1996).

The following section provides a chronological review of several prominent works on project learning in different fields, including construction. This review will attempt to provide more insight into project learning and how this concept is perceived by different studies.

2.10.2 Some studies on project learning

Until the mid-1990s, theories on learning within and between projects had been almost non-existent (Packendroff, 1995). However, the ensuing period witnessed some emerging works in this area. Poell (1998); Nobeoka (1995); and Schindler and Eppler (2003) respectively mentioned some of the earliest studies that indicated learning within project milieu, including Bouwen et al. (1992); Fujimoto et al. (1992); and (Nevison, 1994).

Nobeoka (1995) presented a model of inter-project learning in the new product development field. The model implies that technical knowledge can be transferred in two modes; the first occurs concurrently while developing the new product, where direct communication and interaction are applicable. The second is a sequential transfer after the completion of the base product. According to Nobeoka, documented knowledge (e.g., technical design) can be used in a subsequent product. However, direct transfer of knowledge is more efficient and effective compared with the subsequent mode. This is because the first mode can include specific activities such as direct interaction, task sharing, and mutual adjustment.

Kotnour and Proctor (1996) indicated project learning as part of the management system model. Learning within and across projects was indicated as part of organizational learning and knowledge management. The scholars viewed intra-project learning as a process of lessons learned to create, assimilate, and disseminate knowledge. Knowledge creation implies documenting an innovative way to achieve certain tasks or major problems encountered and approaches used for overcoming these problems. Continuous capturing of lessons learned attains knowledge assimilation. Meanwhile, knowledge dissemination implies a means of knowledge sharing among individuals within the project. On the other hand, inter-project learning occurs when the process of creation, assimilation, and dissemination of knowledge is implemented appropriately in a new project (Kotnour & Proctor, 1996).

A framework proposed by Kotnour (1999, 2000) attempted to integrate learning in the project management process. The framework was based on the idea of organizational learning that an organization (i.e., project-based) learns when individuals create, share, and apply knowledge. Kotnour discussed the role of lessons learned during these activities. Individuals learn when they engage in a learning experience, namely, the plan-do-study-act cycle (PDSA), which was developed from quality management (Juran, 1988). According to Kotnour, learning within a project occurs when the project team discusses about completing tasks or overcoming problems. On the other hand, learning across projects implies sharing lessons learned across projects to develop new knowledge. Tools to support this activity include IT and employee groups (peer groups) aimed at fulfilling this activity.

Kotnour and Hjelm (2002) identified five factors that help in understanding learning in the project team and to create a learning organization. These include organizational and leadership action, project manager action, project team action, project culture and learning culture, and organizational culture. The scholars focused on the role of leadership in supporting learning and emphasized on the relationship between project team's actions, the right culture, and the right leader's actions and support. Supporting aspects of learning within project include having a goal and program for learning, having managers' inner model (i.e., personal development), experimenting with new ideas, having a reward system, and forming a "community of learners" (Kotnour & Hjelm, 2002). Other works of Kotnour (Kotnour & Vergopia, 2005, 2007) focused on project reviews in aerospace industry. The works pointed out certain issues such as best practice in learning-based project review, effective lessons learned, and integration of organizational learning with project review.

Focusing on inter-project learning, Prencipe and Tell (2001) highlighted several criteria of projects and project-based organizations to understand the learning process. The scholars affirmed that projects embody technological as well as organizational traits, while project-based firm is organized around projects, embodying most business functions and working as a mechanism that integrates projects. Prencipe and Tell (2001) adopted three process activities to develop a framework for inter-project learning abilities, namely, experience accumulation, knowledge articulation, and knowledge codification. The scholars proposed learning typologies of each of the previous processes. For example, experience accumulation includes two typologies: learning by doing and learning by using. In addition, the scholars identified mechanisms of inter-project learning of the three processes according to different levels (i.e., individual, group/project, and organizational). For example, experience accumulation at the group or project level includes the following mechanisms: developed group thinking, person-to-person communication, informal encounters, and imitations. To understand the aspects of inter-project learning, the scholars developed a matrix called "learning landscape" that shows the learning mechanisms according to the different levels.

In the IT sector, Disterer (2002) underscored that valuable knowledge may be lost after the completion of projects due to their **temporary** nature. He affirmed that transferring knowledge from the **routine organization** to the project may be attained by means of team and users' participation and involvement, standard operating procedures (SOP), and other internal documentation. Meanwhile, transferring knowledge from projects to the permanent organization appears to be a task of **project management**. In addition, the scholar distinguished **two types of knowledge** that should be documented: knowledge with regard to working results and knowledge about methods, tools, and innovative outcomes.

Examples of the first type of documented knowledge include technical drawings, user's manual and operating instructions, and training courses and materials. The second type of knowledge is more difficult to document as it encompasses several aspects of tacit knowledge and day-to-day working activities. It requires "professional" project management techniques. These include project reviews, project profiles, and lessons learned meant for other members to use in future projects. Defining new responsibilities in the organization, as project experience manager or knowledge harvester, may foster these activities (Disterer, 2002).

Ibert (2004), among a few scholars, attempted to distinguish between learning within firm (routine or permanent organization) and learning within project according to three aspects of organizational learning, namely: memory, experience, and reflection. Ibert stated that learning in the firm setting has three approaches: strategic management approach (i.e., leaders' role to strategize the aim of learning and provide a climate of openness); evolutionary approach (members' talent to learn, i.e., focusing on inner factors rather than external factors); and CoP approach (i.e., formation and creation of knowledge localized in these communities). He affirmed that learning in a project is a task of problem solving and is featured with four aspects: **knowledge in action** (i.e., action or practice to form the knowledge and this contradicts the cognitive style and emphasize the situated approach); **integration of diversity** (i.e., participation of different skills, identities and learning trajectories, and relationships and reputation; however, diversity may cause tensions that may stimulate learning process); **de-coupling from organizational routine** (i.e., low inertia that allows change to build up momentum; this implies reflection as a way of learning); and **task-commitment** (i.e., "challenging task" and collective aim provide learning efforts; task commitment also provides integration of firms and professionals) (Ibert, 2004).

Newell (2004) considered that effective lessons learned can be achieved if the lessons focused on capturing successful processes and procedures in projects. Project members can share lessons learned through social or personal networks, which are more effective than ICT tools. The scholar identified two features of learning; the first implies that learning is about perceived need (called timeliness of knowledge). People will seek knowledge when they need it and when there is knowledge in a similar context. Second, knowledge is about content and sharing knowledge is easier when there is a common ground or overlapping between two contexts (i.e., knowledge redundancy or absorptive capacity). In this context, Newell (2004) distinguished between two contents of knowledge: product (what was actually accomplished in a project) and procedural (how the task was performed). This is similar to the previous distinction of knowledge (Disterer, 2002). The second type is more appropriate for developing shared knowledge across projects.

In another study, Newell (2005) investigated knowledge transfer via short-circuiting the learning cycle of Kolb (Kolb, 1984). This can be performed by codifying the abstract conceptualization and transferring it to others for use. The scholar identified knowledge characteristics that render knowledge transfer problematic. She described knowledge as distributed, ambiguous, and disruptive. These characteristics highlight three issues: availability of usefulness of knowledge, acceptance and trust of knowledge, and resistance to change practice. Based on these characteristics, the scholar suggested the following steps: facilitate awareness of potentially useful knowledge, support the interpretation of knowledge, and encourage acceptance of knowledge and change in practice.

Williams discussed several important issues in project learning, including how an organization can learn from projects, why post-project reviews do not occur frequently in practice, and what are the current practice of developing efficient lessons learned (Williams, 2003, 2004, 2007, 2008). Some problems of learning from projects include the temporary nature of projects, complexity of projects, and difficulties in identifying the non-intuitive lessons learned. The scholar suggested practical approaches that can be used in post-project review to develop easily understood lessons learned. Systems dynamic and mapping techniques are two examples used for this purpose. On the other hand, learning in projects includes two approaches: the first implies that knowledge creation is a socially constructed activity and the second implies that knowledge is actively built by the cognizing subject (constructivism approach of knowledge).

One of the recently developed models of intra-project learning is that of Sense (Sense, 2004, 2005, 2007a, 2007b, 2008; Sense & Antoni, 2003). The model was developed based on a case study method in manufacturing industry. The main theories used to construct the model are the Situated Learning Theory and Cognitive Learning Theory. The significance of this model stems from its ability to integrate cognitive, behavioral, and sociological perspectives of learning (i.e., information, action, and community dimensions). In two of his works (Sense, 2004, 2007b), he proposed five elements that form the architecture of project learning, namely: learning relationships, cognitive style, knowledge management, learning mandate and learning environment support, and pyramid of authority. In some of the previous studies, Sense elaborated on each of these elements extensively.

2.10.3 Studies on project learning in construction

Gieskes and Broeke (2000) investigated how infrastructure firms learn from their projects. The scholars discussed the finding based on three characteristics of construction projects: one-off nature of projects and their organizations, the on-site character of projects, and culture. Their results were organized around the following: organizations' learning from projects, methods and techniques for learning, climate to support learning, tools for learning, and knowledge exchange. Lastly, the scholars discussed difficulties in learning, which can be related to the characteristics of construction projects.

Fong (2003) investigated project learning as part of the knowledge creation model of project team. According to Fong, knowledge creation includes five processes: crossing boundaries among multi-disciplinary team and boundaries between consultants, client, and contractor; enabling knowledge sharing; enabling knowledge generation via interaction and communication; enabling knowledge integration of various disciplines during design and decision-making process; and collective project learning. The scholar emphasized that project learning involves absorbing new technologies and techniques, creating the appropriate environment that encourages enquiries and learning, using problem-solving mechanisms, viewing failure as a way of learning, and undergoing the inter-project learning process.

Bresnen et al. (2003) discussed the challenges involved in learning in construction projects, including fragmentation of the team into different professional disciplines and the difficulty to establish routine activities within projects due to discontinuity of resources and information flow. According to Bresnen and colleagues, there are two approaches to learning in projects: cognitive and community. The first implies codifying and circulating knowledge via information-based tools and ICT, while the second focuses on the tacit dimension of knowledge and its embeddedness within the social group. The study introduced the role of a middle-level manager (called regional engineering manager or REM) to spread engineering-based knowledge among different professionals. Another contribution of this study is identifying enablers and barriers of cross-project learning, including organizational structure; cultural context and climate for change; skills and capabilities; communications, networks, and information flows; technological mechanisms; and objectives and outputs. In addition, the study indicated two aspects of learning: product innovation and process innovation. Product innovation includes different sources of knowledge that can be integrated into a single product. Learning in this case can be captured and transferred to explicit form easily. In process innovation, what is learned is often in tacit or intangible form, which makes it difficult to measure, evaluate, and capture in an explicit form. Construction projects involve these two aspects, but more of the process innovation; this can explain the need for more social patterns and practices in construction projects (Bresnen et al., 2003).

P. Chan et al. (2005) highlighted the question of whether organizational learning is sustainable in the project context and whether projects are "learnt" organizations rather than "learning" organizations. The scholars argued the need to consider the nature of the construction industry, which is project-based, when developing the organizational learning model. The scholars identified facets of organizational learning, namely, contextual, policy, psychological, cultural, and structural facets. They highlighted the following enquiries extracted from gaps in literature: Who takes the lead in laying down the policy for learning, partnering a sine qua non for organizational learning or vice versa, operational change rather than strategic change, projects as "learnt organization" or "learning networks"? Lastly, the scholars called for greater emphasis on projects as the unit of organizational analysis, and consequently, a requirement for greater research focus on the inter-organizational dynamics involved.

Using multiple case studies of construction power plant projects, Hällgren and Wilson (2007) investigated how informal and incidental learning occurs in case of a deviation in the project. The scholars stated that when a deviation is discovered, the project team will face what the authors called "mini-muddling," where they have to make an initial decision or choice until progress is made. When the deviation is sensitive, people will make choices based on previous knowledge or experience, rather than create new solutions. In this regard, the scholars affirmed two aspects of learning: learning occurs when handling the deviations and learning patterns emerge when handling remedies. When proposing new solutions, new knowledge can be developed. However, the team on site may not be able to handle certain deviations and, in this case, the team at the corporate level may interfere to propose appropriate remedies (Hällgren & Wilson, 2007).

2.10.4 Organizational learning and project learning

The current section does not intend to review the entire body of organizational learning (OL) literature; rather, to highlight the main studies that have contributed to this field, which cited by several studies on project learning.

According to Easterby-Smith and Lyles (2005), the idea of organizational learning was indicated first by March and Simon (1958) and articulated by Cyert and March (1963) as part of a decision-making model. Ideas in Cyert and March's theory include the firm's adaption to its environment, firm's ability to learn from its experience, and an early distinction between single- and double-loop learning (Easterby-Smith & Lyles, 2005). Cangelosi and Dill (1965) were perhaps the first to mention the term “organizational learning” in the title of their article, and observed that this notion is suitable for established organizations in stable environments. The work of Argyris and Schön (1978) considered one of the main works that contribute to articulation of the field of organizational learning. Argyris (1977) defined organizational learning as a process of detecting and correcting errors. Behaviors of detecting and correcting errors can be attained on two levels: single-loop and double-loop learning (Argyris & Schön, 1978). Single-loop learning involves detecting and correcting errors while permitting the organization to retain its current policies and objectives. Double-loop learning, on the other hand, occurs when detecting and correcting errors in a way that involves changing the basic policies and objectives of the organization.

Easterby-Smith and Lyles (2005) distinguished the field of organizational learning into two traditions: the first considers the efficiency of knowledge utilization, where humans are regarded as obstacles (called the neo-rationalist tradition). This tradition appears in the fundamental works of March (1991); Huber (1991); Epple et al. (1991); and Simon (1991). The second tradition examines organizational learning from the social perspective. This appears in the works of Brown and Duguid (1991); Lave and Wenger (1991); Cook and Yanow (1993); Nicolini and Meznar (1995); and von Krogh (2005).

Learning organization (LO) emerged later during late 1980s from organizational learning (Easterby-Smith & Lyles, 2005). Some early works in this new field include those of Garratt (1987); De Geus (1988); and Pedler et al. (1989). The major contribution to this field was the work of Senge (1990), who provided practical steps for organizations to achieve learning. Organizational learning has contributed to the learning organization concept. For example, Örtenblad (2004) and Love, Li, Irani, and Faniran (2000) proposed models of the learning organization based on organizational learning.

However, there are crucial differences between organizational learning and the learning organization. Organizational learning is regarded as a descriptive term to explain and quantify learning activities, while the learning organization is an organization designed to enable learning (Love, Li, Irani, & Faniran, 2000). Sun (2006), among others, investigated this issue and summarized several differences between the two streams, as follows:

1) Descriptive vs. perspective (i.e., OL is descriptive and concerned about how learning occurs, while LO is perspective and implies how an organization should learn);
2) Naturally occurring vs. not naturally occurring (e.g., single-loop can happen naturally in OL, while LO requires a more complex process, including double-loop learning);
3) Obtainable vs. ideal (i.e., obtainable implies that all organizations should learn to survive, while ideal implies that organization shall follow certain archetypes);
4) Domain of academics vs. domain of practitioners (theory vs. practice); and
5) A distinction according to learning entities and knowledge location. In OL, knowledge exists outside individuals and organizational memory is the primary focus. Entities of learning are the individual and organization as a super-person. In LO, the case is opposite, where focus on organizational memory is less and that on individual learning on behalf of the organization is more emphasized.

Other fields that may have a relationship with project learning are organizational knowledge and knowledge management. According to Easterby-Smith and Lyles (2005), organizational knowledge has been around for a long time and some fundamental works include those of Polanyi on knowledge. Other works include for example Nelson and Winter (1982); Alvesson (1993); Starbuck (1992); Starbuck (1993); Blackler (1995); Nonaka and Takeuchi (1995); and von Krogh (2005). On the other hand, knowledge management emerged recently in the late 1990s. According to Easterby-Smith and Lyles (2005), some few fundamental works in this area include those of Nonaka and Takeuchi (1995) and Davenport and Prusak (2000).

Project learning is related to the four areas: organizational learning, learning organization, organizational knowledge, and knowledge management. This is evident from several fundamental studies on project learning that cited works from these four areas, as shown in Figure 2.3. This indicates that project learning is quite new compared with the previous four areas.

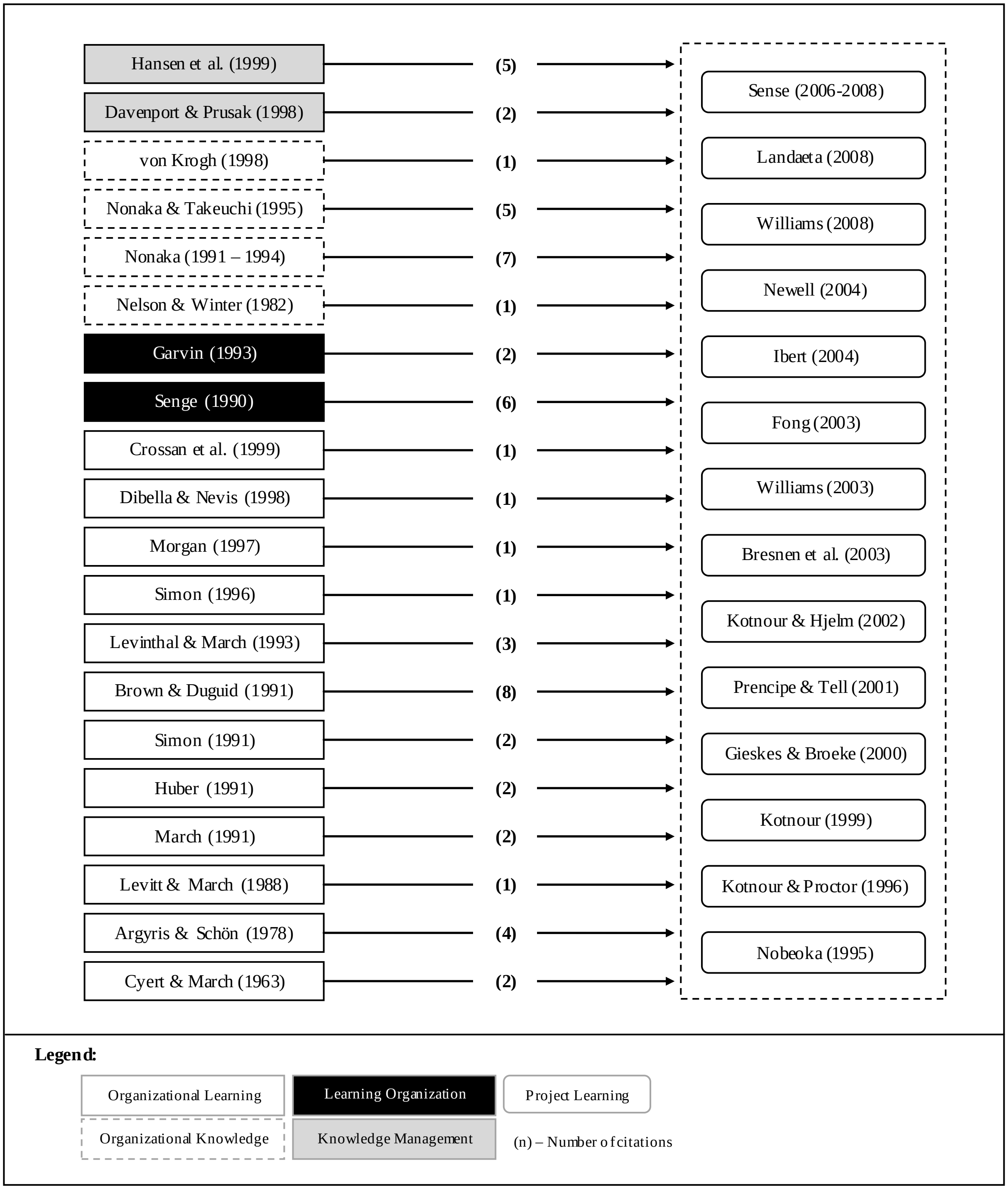


Figure 2.3: Connection of some fundamental works on project learning to other fields

2.11 Features of Project Learning

The previous section provided a chronological review of some works on project learning in different fields, including construction. In general, project learning implies three aspects: action to learn (i.e., mainly involves the team as entity), dimension of this learning (i.e., within and across project), and outcome of learning process (i.e., knowledge being created and shared). Unlike an organization, projects cannot learn.

Based on the previous review of fundamental works in project learning and several works in other related fields such as organizational learning, the current study identifies features of project learning. These are summarized as follows. Some of these features will be investigated further in the current study.

- Project learning is essentially a task of the project team to detect errors and identify solutions for problems.
- Project learning involves two dimensions: learning within project (intra-project learning) and learning across projects (inter-project learning). The two dimensions are associated but have different criteria. In addition, both focus on knowledge as an outcome of learning process.
- Project learning may involve intentional and unintentional (natural) aspects of learning, thus, it can involve the four modes of experiential learning including intuitive, incidental, retrospective, and prospective.
- Project learning, especially when the intention is to transfer knowledge to organizations or other projects, is a task of project management, but other entities have significant roles to play.

- Projects *per se* cannot learn (at least from the perspective of the current literature) because they are discontinuous, have insufficient recourses, and do not have a memory. However, project repositories and documentation could be the temporary memory of projects.
- Project's milieu and the non-routine nature enable learning via practice or action of knowledge (situated approach), participation of different identities and skills (integration), challenging task and collective learning efforts (commitment), and reflective and decoupling from routine activities.
- Project's characteristics (such as fragmentation, the sequential and temporary nature, diversity, difficulty to establish routine tasks, and so on) may influence learning activities.

2.12 Summary

This chapter reviewed studies on a distinct criterion of the construction industry and project, namely, fragmentation. Studies on fragmentation are concentrated around two levels: the industry and project levels. Both are related to team fragmentation, which was defined accordingly. In addition, this chapter elaborated the reasons, influence, and solutions of fragmentation.

This chapter also reviewed some significant works on project learning. The review commenced with an overview of general studies on learning in construction. The purpose was to point out the gap arising from limited empirical investigations on learning at the project level. Subsequently, the chapter argued the difference between project learning and other concepts such as organizational learning (i.e., learning within a permanent organization) and project-based learning. Learning in project differs from learning in the organization in some aspects, including lack of memory, decoupling of routine, challenging task, and influence of project characteristics on the learning process. Project learning is akin to organizational learning, while project-based learning is akin to learning organization. Unlike project-based learning, however, project learning involves unintentional aspects of learning. Other features of project learning were identified to clarify what project learning is.

CHAPTER 3: THEORETICAL MODEL AND RESEARCH DESIGN

3.0 Introduction

This chapter attempts to conceptualize the notions of fragmentation, and intra- and inter-project learning. Conceptualization includes identifying the indicators that determine these notions. In addition, this chapter reviews studies that highlight the association between fragmentation and learning. The purpose is to understand how fragmentation influences project learning.

The current study presumes that fragmentation has a negative influence on both intra- and inter-project learning. Thus, the assumption is that enabling project learning within fragmentation is vital. A theoretical model will be coined and hypotheses will be developed to determine the relationships among fragmentation, intra-project learning, inter-project learning, and enablers of learning.

3.1 Framework of Fragmentation

The purpose of this section is to identify the factors that determine (measure) the level of fragmentation. As the current study is concerned about identifying latent variables that influence the level of fragmentation, factors such as project delivery process or procurement method will not be considered. As proposed in the previous chapter, fragmentation is a multi-faceted construct consisting of the following latent variables: level of integration, coordination, collaboration, boundaries, decoupling of diversity, and spanning knowledge across boundaries.

Integration of the construction project team is defined as the point “where different disciplines or organizations with different goals, needs and cultures merge into a single cohesive and mutually supporting unit with collaborative alignment of processes and cultures” (Baiden & Price, 2010, p. 129). Characteristics of integrated construction project team include single focus and objectives, diminished boundaries between individuals, and teamwork based on beneficial outcomes (Baiden & Price, 2010). Indicators of level of integration are identified in the study of (Baiden et al., 2006). Tools to support team integration include toolkit for integration, project delivery process, computer-integrated construction (CIC), construction collaboration technology (CCT), computer-integrated framework for concurrent life-cycle design and construction (CLDC), and so on (Anumba et al., 1997; Koskela, 1992; Nitithamyong & Skibniewski, 2004; Vock', 2001).

On the other hand, low levels of coordination and collaboration imply a high level of fragmentation, as discussed previously in Chapter 2. Ali et al. (2009) identified the factors that determine coordination during refurbishment of the design process, including lateral relationship, IT, interpersonal relationships, and the architect’s role. The role of architect can be replaced by that of the coordinator to suit the current study’s setting, which is the construction site. On the other hand, collaboration of the project team can be determined by the following factors: common goal among firms, trust, self-governing teams, focus on end-user needs, and free exchange of information (Baiden et al., 2006).

Fragmentation can be affected by boundaries within the project. Ratcheva (2009) identified boundaries that hinder knowledge integration of multi-disciplinary teams. These are action boundary, knowledge boundary, and social boundary. Fong (2003) identified boundaries that influence teams' ability to exchange and integrate knowledge, which include expertise and hierarchical boundaries. Boundaries between team members of different disciplines are regarded as expertise boundaries. Other boundaries exist among the client, consultant, and contractor as hierarchical boundaries. These and other boundaries, such as cultural or language boundaries, may contribute to fragmentation.

Construction project encompasses multi-disciplinary or multi-professional teams. Disciplines of the project team differ in terms of number of specialized individuals, territories, and epistemology (i.e., world of thoughts and functional departments) (Ratcheva, 2009). Diversity of project team members in terms of varying professions and specializations is not a problem per se (Bresnen & Marshall, 2001). However, diversity of knowledge may influence effective sharing process (Ratcheva, 2009). In addition, the inability of the team members to collaborate with each other may influence learning and knowledge creation. This can be referred as decoupling of team members' specializations or diversity. Decoupling of diversity can be determined by the following: participation of different disciplines in projects, adversarial relationship among team members, misconception and misunderstanding, design clashes, and omissions and errors, typically due to data fragmentation (Anumba et al., 2002).

Ratcheva (2009) proposed knowledge integration processes of a multi-disciplinary team across different boundaries. This process, termed boundary spanning, integrates knowledge across three boundaries: 1) project social boundary (i.e., boundary within the team); 2) project knowledge boundary (i.e., boundary around the team); and 3) project action boundary (i.e., boundary across the project). Each type of boundary entails different types of knowledge, which are occupational knowledge, contextual knowledge, and project relevant knowledge (Ratcheva, 2009). The current study can consider contextual type of knowledge as it appears to reflect fragmentation of project team. The process of boundary spanning of the second type entails integrating two types of knowledge: occupational and contextual. During this process, the project team will face certain difficulties such as different meanings of members' knowledge and the manner by which they acquire such knowledge (Ratcheva, 2009). This will affect the level of understanding among team members with different disciplines. Table 3.1 summarizes the six components of fragmentation and their indicators.

Table 3.1: Indicators of fragmentation of projects

Components of Fragmentation	Factors/Indicators	Reference
Level of Integration	Single team focus and objectives, seamless operation, mutually beneficial outcomes, increased time and cost predictability, unrestricted cross-sharing of information, team flexibility and responsiveness to change, creation of single and co-located team, equal opportunity for project inputs, equitable team relationships and respect for all, and ''No blame'' culture	(Baiden et al., 2006)
	• Project delivery process and procurement (like D&B) • 'Integration Toolkit'	(Baiden & Price, 2010); (Dulaimi et al., 2002)
	Construction collaboration technologies (CCT) (e.g. computer-aided drafting, 3-D modeling, and standard based design and project collaboration technologies), computer-integrated framework for concurrent life-cycle design and construction (CLDC), and computer integrated construction (CIC) methods that facilitate communications of data, knowledge and design solutions.	(Vock', 2001); (Anumba et al., 1997);(Koskela, 1992); (Nitithamyong & Skibniewski, 2004)
	Teamwork as **collaborative** activity (united effort to solve project shared task) and teamwork as **cooperative** activity (efforts to solve the shared project task by initiating individual activities.)	(Leinonen & Bluemink, 2008); (J. Liu, Li, et al., 2007)
Level of coordination	Lateral Relationship, IT, interpersonal relationships, & coordinator role.	(Ali et al., 2009)
Level of collaboration	Common goal among firms, trust, self-governing teams, focus on the end-user needs, and free exchange of information.	(Baiden et al., 2006)

Table 3.1: Indicators of fragmentation of projects (Cont'd)

Components of Fragmentation	Factors/Indicators	Reference
Boundaries	Expertise boundaries, hierarchical boundaries, and cultural-related boundaries between professions	(Fong, 2003)
	Project action boundary, project knowledge boundary and project social boundary	(Ratcheva, 2009)
Decoupling of Diversity	Participating of different professionals in projects, adversarial relationship, misconception and misunderstanding, and design clashes, omissions and errors (due to data fragmentation).	(Anumba et al., 2002)
Level of boundary-spanning of knowledge	• Level of integrating two types of knowledge: occupational and contextual knowledge during the construction stage (sufficiency of information from previous stage). • Understanding information from other occupational or disciplinary team members	(Ratcheva, 2009)

3.2 Framework of Project Learning

A framework of project learning may help to articulate learning in construction projects and develop a conceptual model of this notion. Indicators or aspects of project learning process can be identified from literature. According to the definition of project learning postulated by (Kotnour, 2000), project learning consists of four components: project team action to learn, knowledge creation, knowledge sharing, and dimension of learning either within or across projects. The following sections discuss each of the four components in detail.

3.2.1 Project team and action to learn

The current study focuses on the team action to learn as a basic component of project learning. Typically, there are six types of construction project team: self-directed team, traditional work-based team, problem-solving team, virtual-based team, management-based team, and research-based team (Kululanga, 2009). Project team learning is the process that integrates individual and organizational learning (Horvath et al., 1996).

Knowledge integration can be attained by the team only (Ratcheva, 2009) and teams' features contribute to positive influence with respect to learning (Anheim, 2003). It is important to highlight that composition or type of team and their influence on learning is out of the scope of the current study. Bourgeon (2007) examined the influence of project team composition, called staffing approach, on collective learning conditions. He emphasized on certain points in collective learning, including diversity, homogeneity, project duration, and management and leader's role. In addition, he identified dimensions of collective learning, including the following: empathy of team with its project; team commitment in the error correction process; participative management mode implementation; knowledge sharing; and problem resolution agendas.

Moreover, Ayas (1997) proposed an alternative structural arrangement for the project team to facilitate learning, particularly the project network structure (PNS). This structure contains a core team that can be formed at the beginning of a project and contains a desired mixture of skills and specialties. Each member of this core team becomes responsible for another team at another level of hierarchy to perform a certain task. Coordination within this network is simple and error identification is easier. The holistic approach of learning in this network is via information and knowledge crossing of the organizational and functional boundaries. Lastly, formal and informal communication between the team is cultivated faster (Ayas, 1997).

Anheim (2003) identified the factors that influence project team learning, namely, arena for learning, tacit to tacit, combination, high tolerance, scope for decision, team composition, and dialogue. He emphasized on a climate that supports mistake admission to foster project team learning. Lastly, Anheim identified the following conditions to enable team learning within and across construction projects:

- A dynamic team (mixed people with different skills) is required in the interaction process between tacit and explicit knowledge.
- Dialogue is a significant element of team learning (adopted from the fourth discipline in Senge's theory).
- Workplace is an important arena for exchanging experience, especially if supported by a good working environment. However, the team can give rise to negative consequences as such as conflict of interest and territorial thinking.
- A good environment for project team requires six factors: shared goals, shared values, ability to accept new members, not permitting subgroups with their own delineations, freedom, and ability to resolve conflicts.
- Individual members need to feel affinity, security, and respect for their fellow members.

According to Kotnour and Hjelm (2002), project team action is associated with the right culture and right leader's actions and support. Aspects of project team learning include the following: ability to absorb new technology and techniques; self-directed learning (i.e., creating an environment to maximize opportunities for individual inquiry and learning); problem-solving; and learning from failure (Fong, 2003, 2005). Abdul-Rahman et al. (2008) identified the following aspects of learning from construction projects: formal face-to-face interaction, periodic meetings, documentation learning, and problem-solving methods. On the other hand, tools and methods of learning can support project team activities for learning. For example, Williams (2008) highlighted some learning approaches that the project team can use, including formal procedures, meetings, project audits, lessons at all stages, learning diaries, narratives, interview, specific departments, external facilitator, and external team. Moreover, a number of tools can improve team communication and consequently facilitate learning, namely, dialogue, learning histories, leadership styles and management techniques, and role of organizational goals and strategies (Law & Chuah, 2004). Table 3.2 summarizes the indicators of project team action to learn discussed previously.

Table 3.2: Indicators of project team action to learn and learning methods

Factors / indicators of project team action to learn	**Reference**
Project team action associates the right culture and the right leader's actions and support. Learning-by-doing is useful here and the plan-do-study-act cycle is used to represent the learning process in a project environment.	(Kotnour & Hjelm, 2002)
Absorb new technology and techniques, Self-direct learning (creating an environment to maximize the opportunities for individual inquiry and learning), Problem solving, and Learning from failure	(Fong, 2003)
Formal face-to-face interaction, Periodic meetings, Documentation, and Problem solving methods	(Abdul-Rahman et al., 2008)
Formal procedures, Meetings, Project audits , Lessons at all stages, Learning diaries, Narratives, Interview, Specific departments, External facilitator, and External team	(Williams, 2008)
Tools improve team communication and consequently facilitate learning: Dialogue; Learning histories; Leadership styles and management techniques; and Role of organizational goals and strategies.	(Law & Chuah, 2004); (Anheim, 2003)

3.2.2 Knowledge creation

Knowledge creation significantly benefits a project team's long-term effectiveness, innovation, and productivity (Senge, 1990). Project team action to create knowledge is considered one of the most prominent aspects of learning (Kotnour, 1999). Roth et al. (2000) affirmed that no learning can occur without knowledge creation and vice versa.

Fong (2005) identified collective learning of project team as the core process of knowledge creation. In this regard, Stahl (2002) indicated that learning can be viewed as a knowledge creation process instead of knowledge-transmission process, which occurs during conversations with others.

Nonaka and Takeuchi (1995) proposed a model of knowledge creation, which is considered one of the fundamental works in the field of organizational knowledge. Basically, knowledge creation involves a complex process of conversion between tacit and explicit knowledge within a context (Nonaka & Takeuchi, 1995). This model consists of four modes: socialization, externalization, combination, and internalization (SECI).

Socialization implies sharing tacit knowledge through face-to-face communication, informal social interaction, or teaching by practical examples. Externalization means attempting to convert tacit knowledge to explicit knowledge by developing concepts and models. In this process, tacit knowledge is converted to an understandable and interpretable form, so others can utilize this knowledge as well. Externalized and theoretical knowledge, as the scholars affirmed, is a base for creating new knowledge. Combination, meanwhile, indicates compiling and organizing of externalized explicit knowledge to broader entities and concept systems. Lastly, internalization means understanding explicit knowledge. It occurs when explicit knowledge is transformed into tacit knowledge and becomes part of the individual's basic information. When individuals share their tacit knowledge again, the cycle continues in the spiral of knowledge back to socialization (Nonaka & Takeuchi, 1995). The SECI model was further developed by Nonaka (1999) and Nonaka et al. (2000), who added the effect of moderator and emphasized more on the context or "ba."

Fong (2003) modified the previous model of Nonaka and Takeuchi (1995) by identifying five elements of knowledge creation within the construction project team. The first element encompasses crossing boundaries within the team members and the project. Objects used for this process include for example drawings, personal conversations, team members valuing others' experience, and examples set by project managers. The second element is knowledge sharing, which can be influenced by openness, motivation, trust, and time pressure. The third element is knowledge generation, which involves social networks, print sources, and interaction between customers and competitors. The fourth element is knowledge integration, which implies that multiple stakeholders' perspective, project documentation, and design object are integrative tools. The last element is collective project learning, which involves individual, team, and inter-project learning. In addition, the knowledge creation process may be influenced by the following factors: IT support, incentives, individual competency, and collaborative vision of leadership (Teerajetgul & Charoenngam, 2006). Other factors include shared values and a unified vision for knowledge creation in projects (Ajmal & Koskinen, 2008).

Egbu (2006) identified three streams of knowledge creation or "production" from literature. First is the mainstream systems thinking, which represents a complex process of transforming knowledge from one form to another within a context (Nonaka & Takeuchi, 1995; Stacey, 2001). The second stream is the social constructionist, which focuses on learning (also in a context) to produce knowledge. According to Egbu, this stream emphasizes the relationship among action, understanding, and communication. The last stream is complex responsive process (Stacey, 2001), where knowledge is produced in the communicative interaction between people. Knowledge production in construction involves several approaches, including reflective practice, transformation, and combination of existing knowledge (Egbu, 2006). Table 3.3 summarizes the factors that indicate the knowledge creation process.

Table 3.3: Indicators of knowledge creation

Factors / indicators of Knowledge Creation	**Reference**
Socialization, Externalization, Combination, Internalization, and 'Ba'	(Nonaka & Takeuchi, 1995); (Nonaka et al., 2000)
• Reflective practice, transformation, and combination of existing knowledge • Triggers to knowledge creation are: need to solve problems, need to innovate and the management of change	(Egbu, 2006)
Factors affecting the modes of Nonaka and Tackeuchi in construction include: Individuals competency, IT, Incentives (rewards), Collaboration, and Vision of leadership.	(Teerajetgul & Charoenngam, 2006)
Collaboration among multidisciplinary project team	(Fong, 2005)
• **Boundary crossing** (Expertise boundaries and Hierarchical boundaries) • **Knowledge sharing:** competition; communication thickness; and sharing from different knowledge domain. Contributing factors include: (openness, motivation, trust, and time pressure). • **Knowledge generation:** social networks, print sources; and customers and competitors. Contributing factors include: (time, and motivation) • **Knowledge integration:** multiple stakeholder's perspectives; and project documentation and design object as integrative tool). • **Collective project learning:** (individual, team and intra-project learning)	(Fong, 2003); (Fong, 2005)
• Seven enablers of learning acceleration that enable also knowledge creation: **scanning imperative**; **experimental mind-set**; **climate of openness**; **continuous education**; **multiple advocates**; involved **leadership**; and **systems perspective**. • Enablers of knowledge creation within project during the execution phase: **Physical closeness** (Informal Dialogues between colleagues ('coffee break discussions'); **clear goals and purposes** (Contacts with External consultants); **mentor relationships** (Discussion take place when time and context allows).	(Roth et al., 2000)

3.2.3 Knowledge sharing

Factors affecting knowledge sharing are sufficiently documented in literature. For example, Issa and Haddad (2008) highlighted three main factors of knowledge sharing: organizational culture, IT (i.e., computer-supported collaborative work), and mutual trust.

Learning and solving problems can be facilitated in an environment of trust (Alderman & Ivory, 2007). Mechanisms of knowledge sharing include IT infrastructure, organizational structure, organizational culture, and communication level (Knauseder et al., 2003; Malone, 2002; Williams, 2008). In addition, Newell et al. (2002) emphasized that social models have a role in knowledge sharing within projects, while information and communications technology (ICT) would facilitate the transfer of knowledge across projects. Other facilitating factors of knowledge sharing include formal and informal networks (Landaeta, 2008) and social interpersonal process (e.g., communities of practice - CoP) (Ardichvili et al., 2003; Williams, 2008). However, Scarbrough and Swan (2008) questioned the applicability of CoP within a project environment. Table 3.4 indicates several factors affecting knowledge sharing within projects.

Table 3.4: Indicators of knowledge sharing

Factors / indicators of Knowledge Sharing	**Reference**
Formal and informal networks (from project to another)	(Landaeta, 2008)
Communities of Practice (working on a specific problem)	(Ardichvili et al., 2003); (Williams, 2008)
Communication	(Knauseder et al., 2003); (Malone, 2002)
Employee groups aimed at sharing knowledge across the organization, IT (computer-supported collaborative work), and mutual trust	(Kotnour, 2000); (Issa & Haddad, 2008)
Documentation of process knowledge of projects, ICT (for knowledge transfer and cross project learning), and lessons learned in database	(Newell et al., 2002)
Infrastructure (hardware/software), Infostructure (rules), and Infoculture (stock of background knowledge).	(Pan & Scarbrough, 1998)
Practice of transferring and sharing knowledge are: Organizational learning and knowledge management in projects, practice for distribution lessons (database of lesson learned), and facilitating factors and hinders (lack of IT, organizational structure, and organizational culture).	(Williams, 2008); (Malone, 2002)

3.2.4 Inter-project learning and knowledge transfer

There are two modes of inter-project learning; the first is transfer of knowledge to other projects directly via individuals and the second is transfer of knowledge to the organization and subsequently to other projects (Disterer, 2002). Prencipe and Tell (2001) adopted the processes of inter-project learning, which are experience accumulation, knowledge articulation, and knowledge codification. Each of these processes is presented according to three levels of entities: individual, group/project, and organization. The current study is concerned about the group/project level. Experience accumulation at the group level, for example, includes the following mechanisms: group thinking, person-to-person communication, informal encounters, and imitation (Prencipe & Tell, 2001).

Knowledge transfer requires developing a certain level of shared meaning that allows one group to understand and apply another's insights and knowledge within their own context (Bresnen et al., 2002). In addition, Knauseder et al. (2003) emphasized on having a common understanding and interpretation of concepts that would help in reducing uncertainty and miscommunication. There are several tools and methods that enable knowledge transfer. These include, but are not limited to, project audit, project reviews, communications, experience diffusion, and knowledge anchoring in the organization (Ayas, 1997; Drejer & Vinding, 2006; Wheelwright & Clark, 1992).

However, knowledge transfer is associated with certain barriers. For example, Sun and Scott (2005) investigated this issue at the individual, group, organizational, and inter-organizational levels. Barriers to the transfer of knowledge from team level to organizational level include the following: organizational system and structure; team climate; organizational climate; and individual imperative (Sun & Scott, 2005). Obstacles to the transfer of knowledge from team to organizational level are considered one of the hindrances to inter-project learning (Disterer, 2002; Hall, 2004). Other obstacles to knowledge transfer include the following: difficulties in attaining a clear analysis of failures and reasons for mistakes; barriers related to open and productive atmosphere; lack of motivation to undertake appropriate review of projects; and lack of supportive leadership (Ajmal & Koskinen, 2008).

Table 3.5: Indicators of knowledge transfer and inter-project learning

Factors / indicators of Knowledge Transfer and Inter-project Learning	Reference
Inter-project learning modes: Project team to transfer knowledge directly to other projects and project team to transfer knowledge to organization and then to other projects	(Disterer, 2002)
• **Experience Accumulation:** group thinking, person-to-person communication, informal encounters, and imitation • **Knowledge Articulation**: brainstorming, formal reviews, de-briefing meetings, ad hoc meetings, lessons learned meetings, intra-project correspondents • **Knowledge Codification**: project plan/audit, milestones, meeting minutes, case writing, project history, intra-project lessons learnt database	(Prencipe & Tell, 2001)
Shared meaning of project team	(Bresnen et al., 2002)
Project audit / post-project review, experience diffusion and knowledge anchoring, and communication	(Wheelwright & Clark, 1992); (Ayas, 1997); (Drejer & Vinding, 2004); (Knauseder et al., 2003)

3.3 Fragmentation and Project Learning

Studies that investigate the relationship between fragmentation and project learning are limited. The current section highlights the studies that indicated both. Oragne et al. (2005) addressed the problem of fragmentation through the processes of knowledge management and organizational learning. They emphasized on a cross-organizational learning approach to promote organizational learning among construction partners.

Egbu (2006) stated that the characteristics of construction and fragmentation inhibit knowledge production, which is the reason for low levels of productivity. To enable knowledge production, Egbu recommended moving toward change and collaboration. At the project level, Egbu recommended effective team composition, high level of expertise, and trust among project team members.

Fong (2003) identified two types of boundaries, namely, expertise boundaries and hierarchical boundaries, which can be considered as another aspect of fragmentation. Crossing these boundaries is important to attain learning and to create knowledge. Knauseder et al. (2007) also viewed fragmentation as boundaries between projects and permanent organization. These boundaries may affect trust, contact among organizations, and the flow of experience. Solutions to overcome these boundaries include cross-organizational and cross-functional project team, an environment that encourages and supports high performance collaboration, systematic documentation of experiences, and "live" capture and reuse of knowledge (Knauseder et al., 2007). In addition, project team approach and learning networks may overcome organizational boundaries (Ayas, 1997; Fu et al., 2006). Individual learning networks are divided into two types: social networks and coordination networks (Fu et al., 2006).

J. Liu, Li, et al. (2007) emphasized on collaboration and a favorable learning environment for contractors to improve performance and overcome fragmentation. Forgues et al. (2009) pointed organizational learning approach to overcome boundaries among specialists, which causes fragmentation of knowledge. They emphasized several approaches to tackle fragmentation, including collaboration, integrated practices, integrated team, and integrated design process.

Delivery process of project (e.g., procurement method) may influence both fragmentation and learning. For example, people learn more in total construction contract (Carlsson and Josephson, 2001 cited Knauseder et al., 2003). In this regard, partnership increases learning, possibly due to improved communication over organizational boundaries (Barlow & Jashapara, 1998; Knauseder et al., 2003). However, fragmentation escorts certain boundaries, which may hinder communication among team members. These include difficulty in understanding each other, lack of shared language (e.g., vocabulary), and lack of knowledge brokers (Knauseder et al., 2003; Newell et al., 2002).

To summarize, fragmentation can influence knowledge creation, collective learning, trust, contact, and flow of experience. Boundaries to communication can have different facets such as insufficient understanding among individuals, lack of shared language, and lack of knowledge brokers. Solutions to fragmentation with regard to learning include the following: collaboration among project team, partnering, learning networks, appropriate project delivery methods, cross-organizational and cross-functional project teams, and systematic documentation of experiences.

3.4 Enablers of Project Learning within Fragmentation

As indicated previously, fragmentation may have a negative influence on project learning. Therefore, one may ask about the factors that facilitate learning within fragmentation. These factors can be referred to as "enablers" of learning as they work as stimuli to achieve learning. Related literature provides very limited materials about these enablers. The qualitative study in Chapter 4 will provide more insights into these enablers. However, a number of factors from literature appear to suit this purpose. These include boundary object, boundary-crossing, and several elements of Sense's model of project learning.

3.4.1 Boundary objects and boundary-crossing

The concept of boundary object was developed by Star and Griesemer (1989) based on a model coined to explain how a group of workers in a museum can manage discrepancy between divergent of viewpoints. Boundary object is "an analytic concept of those scientific objects which both inhabit several intersecting social worlds and satisfy the informational requirements of each of them. Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Star & Griesemer, 1989, p. 393). A simpler definition was proposed by Star (1989, p. 47) as object that works to establish a shared that sits in the middle. In addition, boundary object serves as an interface between different communities of practice (Koskinen & Mäkinen, 2009).

Phelps and Reddy (2009) identified the characteristics of boundary objects that enhance collaboration among construction team members: boundary objects shall be familiar and trusted by the project team, must be important, and must have power or control so the project team can create the need for information or make it available. Furthermore, Carlile (2002, p. 451) identified the following characteristics of good boundary object in new product development: 1) boundary object shall establish a shared syntax or language for individuals to represent their knowledge; 2) shall provide a concrete means for individuals to specify and learn about their differences and dependencies across a given boundary; and 3) shall facilitate a process where individuals can jointly transform their knowledge. However, the characteristics of boundary objects are difficult to sustain "as problems and people change" (Carlile, 2002, p. 452).

Phelps and Reddy (2009) highlighted the importance of boundary objects as they can guide information search activities and guide the type and timing of collaborative activities by establishing the process for capturing, modifying, or using information. The importance of the concept of boundary objects in this study stems from its ability to overcome boundaries between specialized knowledge that may result from fragmentation.

According to Koskinen and Mäkinen (2009), there are two types of boundary objects: institutionalized (e.g., memos, drawings, manifestations of shared understanding, and so on) and non-institutionalized (e.g., factors that foster openness, trust, togetherness, and so on). Examples of boundary objects in a construction project include drawing, specifications, and reports (Phelps & Reddy, 2009). Other examples include artifacts, documents, and even vocabulary that can help people from different organizations to build a shared understanding (Koskinen & Mäkinen, 2009). Lastly, Fong (2003) highlighted two types of objects: drawings and personal conversations (to overcome expertise boundaries); and team members consciously breaking down any barriers by valuing the expertise of others and examples set by project managers (to overcome hierarchical boundaries).

Breakers or boundary crossing serves as the media that hold boundary objects and may help in achieving collaborative teamwork. Forgues et al. (2009) identify IT as a boundary crossing object for knowledge sharing and generation during the design process of construction and aerospace industries. They employed IT to break up two barriers of power structure and asymmetry of knowledge. Another example of boundary crossing is construction contract identified by (Koskinen & Mäkinen, 2009).

3.4.2 Situated learning theory and Sense's model

Situated learning theory was coined by Lave and Wenger (1991). The theory implies that situation is what drives people's learning, and not the goal. This theory emphasizes the role of practice and feedback in learning process (Newell et al., 2002). Thus, the theory can help to explain how learning occurs with the fragmentation context. There are two notable schools of thought in the discipline of learning: cognitive school and behavioral school (Huber, 1991). Situated learning theory can be categorized under the second type. In this school, people learn from actual experiences, experiment, and practice to determine what works best (Newell, 2005). On the other hand, practical and social aspects of learning can be situated within an arena or a community (e.g., CoP) within an organization (Forgues et al., 2009). An important criterion of this theory is the context, which embodies practical and social aspects of learning (Sense, 2004, 2007a).

Sense (2004; 2007a; 2007b) utilized this theory, in addition to the cognitive learning theory to create a model of project learning. The model can be used to create a supportive situated environment, contains five elements: learning relationships, cognitive style, KM, pyramid of authority, and learning environment support. Last element consists of two domains: workplace of a project team and organizational workplace (Sense, 2007b).

Project environment can support learning activities via establishing strategic thrusts of learning; establishing infrastructures for learning (e.g., time and space for conversation and reflection); and nurturing an ongoing stimulus environment supportive of learning through the project life cycle (Sense, 2007b). Table 3.6 summarizes the enablers of project learning discussed in this section as well as other enablers.

Table 3.6: Indicators of enablers of project learning within fragmentation

Factors/indicators of Boundary objects / boundary crossing / Sense's Model	References
Boundary Objects: Drawings, specifications, and reports	(Phelps & Reddy, 2009)
Boundary Objects: Artefacts, documents and even vocabulary that can help people from different organizations to build a shared understanding. Memos, drawings, manifestations of shared understanding, etc. (**institutionalized**) Factors that foster openness, trust, and togetherness, etc. (**non-institutionalized**)	(Koskinen & Mäkinen, 2009)
Boundary Objects: Drawings and personal conversations (expertise boundaries). Team members consciously breaking down any barriers by valuing the expertise of others and secondly, examples set by project managers (hierarchical boundaries).	(Fong, 2003)
Boundary Objects: Collaboration among project team, partnering, learning networks, appropriate project delivery methods, cross-organizational and cross-functional project teams, and systematic documentation of experiences.	(Ayas, 1996); (Liu et al., 2007); (Carlsson & Josephson, 2001); (Fu et al., 2006)
Boundary-crossing objects: IT and construction contract	(Forgues et al., 2009); (Koskinen & Mäkinen, 2009)
• Favorable workplace of learning • Five elements of project learning (learning relationships; cognitive style; KM; pyramid of authority; and learning mandate and learning environment support)	(Sense, 2004, 2007a, 2007b, 2008)

3.5 Theoretical Model and Hypotheses Development

Based on the reviews in this chapter and the previous one, a theoretical model can be proposed to highlight the relationship between fragmentation and both intra- and inter-project learning via enablers. Direct relationship between fragmentation and both intra- and inter-project learning is assumed to be negative. Meanwhile, the role of enablers will be to stimulate learning within fragmentation (i.e., intervening effect). As discussed previously, fragmentation can be affected by six factors: level of project team integration, coordination, collaboration among team members, decoupling of diversity, boundaries among professionals, and spanning-boundary of knowledge. Intra-project learning consists of the following processes: knowledge creation, knowledge sharing, team action to learn, and learning support. Inter-project learning consists of experience accumulation, knowledge articulation, knowledge codification, knowledge transfer, and networking. Lastly, enablers of project learning include boundary object, boundary crossing, and Sense's model. Other enablers will be identified in a qualitative study in the next chapter. Figure 3.1 shows the initial model of project learning.

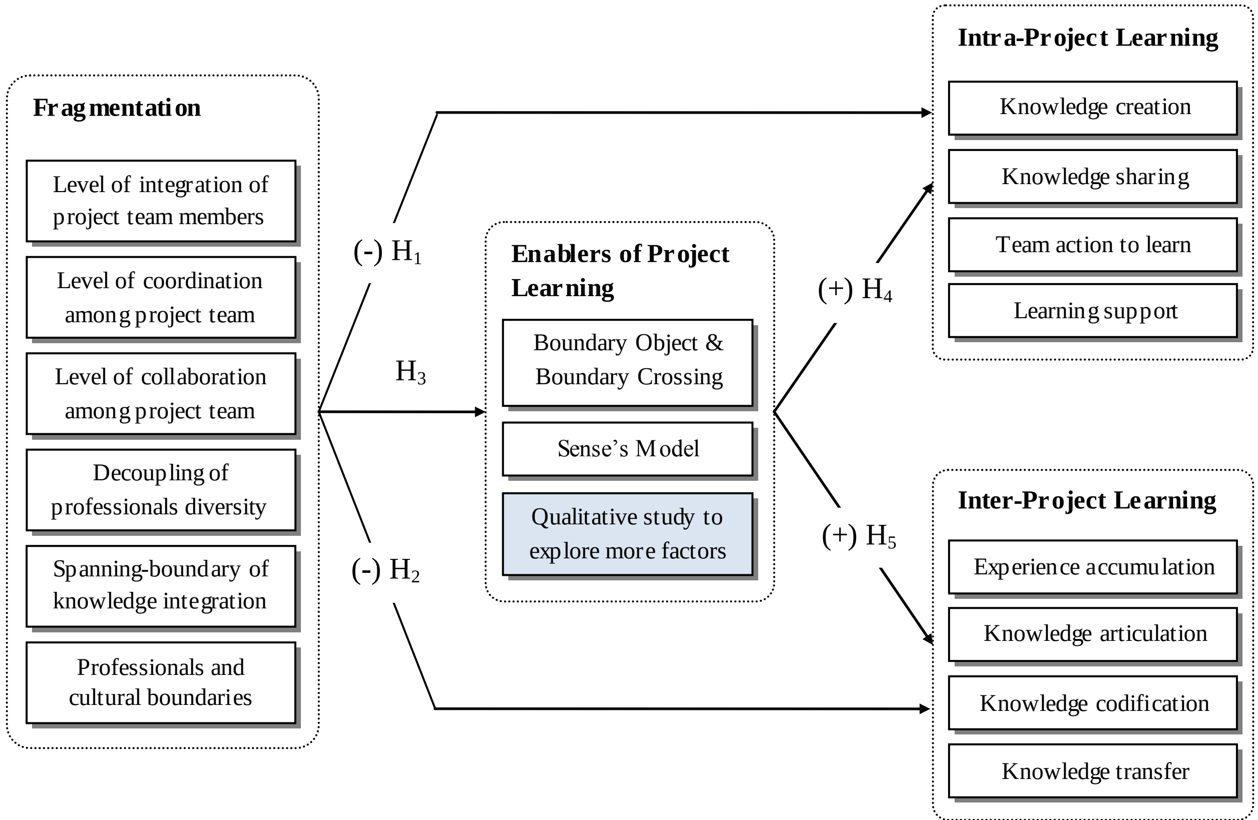


Figure 3.1: Theoretical model of project learning considering the influence of fragmentation

To articulate the relationship among fragmentation, project learning, and enablers, several propositions can be highlighted. It is assumed that there is a negative influence of fragmentation on intra- and inter-project learning processes. Enablers would have an intervening influence of this relationship. In addition, it is assumed that there is an association between each concept and its components. For example, there is a relationship between fragmentation and the six components that indicate it. These relationships will be tested in a quantitative study (Chapter 5) using PLS-PM approach. Research propositions are articulated around the following hypotheses:

Hypothesis 1: There is a negative and significant relationship between fragmentation and intra-project learning process.

Hypothesis 2: There is a negative and significant relationship between fragmentation and inter-project learning process.

Hypothesis 3: There is a significant relationship between fragmentation and enablers.

Hypothesis 4: There is a positive and significant relationship between enablers and intra-project learning.

Hypothesis 5: There is a positive and significant relationship between enablers and inter-project learning.

3.6 Research Design

Research design is an important procedure to guide the research prior to data collection. In addition, research design provides a logical sequence that connects research questions and conclusion through data compilation, analysis, and interpretation (Yin, 2009). Research design consists of five main components, namely, research questions, propositions or purpose of study, unit of analysis, logical linking of the data to propositions or purpose, and criteria for interpreting the findings (Yin, 2009).

Cavana et al. (2001) proposed a comprehensive model of research design, and the current study adapted some items from this model. Figure 3.2 shows several items involved in the research design that are suitable for the current study. Further explanation of the main components is explained as follows.

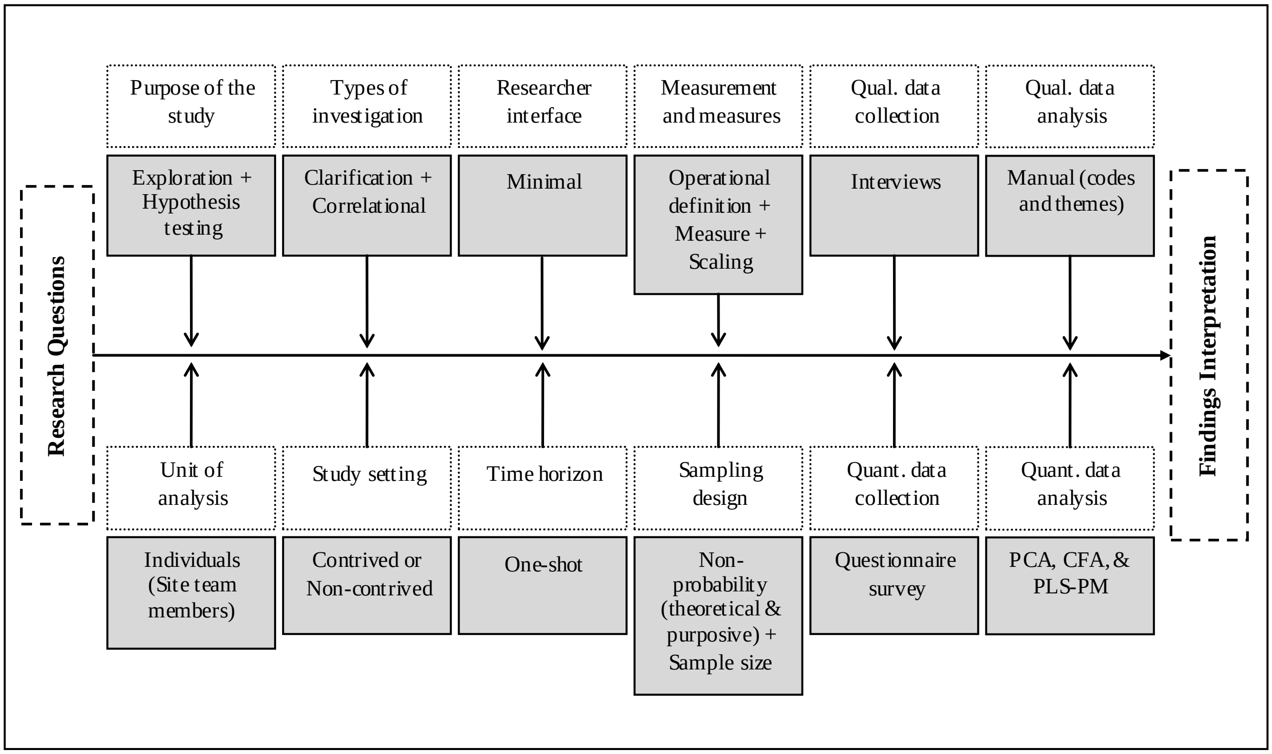


Figure 3.2: Detailed research design and decisions followed in the current study (adapted from Cavana et al., 2001)

1. Research questions: As indicated previously, the research questions of the current study involve the questions "What?" and "How?" The first research question investigates the association between fragmentation and project learning. This implies the use of hypothesis testing for this purpose. The second question is related to exploring the enablers of project learning. This implies qualitative investigation to explore the conditions for achieving project learning within fragmentation.

2. Proposition: The main hypothesis of the current study is that fragmentation has a negative influence on project learning; in particular, it reduces the efficiency of learning. Thus, one may inquire about the condition to achieve an efficient project learning process. These conditions or enablers are believed to work as stimuli for project learning.

3. Unit of analysis: This indicates the levels of information source, including individuals, groups, and organizations (Cavana et al., 2001). According to Creswell (2008), data can be gathered from one or multiple levels, depending on the research questions/hypotheses or research variables. Project managers and professionals working in the construction project site (production phase) are the main source of information. Project team members are regarded as entities that create and transfer knowledge and experience from the project level to the organization level and to other projects.

4. Sampling design: This requires a decision on the following: target population, parameters of interest, sampling frame, appropriate sampling method, and required size of the sample (Cooper & Schindler, 2006). Sampling design will defer according to the research approach. For example, the current study will use a theoretical purposive sample for the qualitative approach and non-probability purposive sampling for the quantitative approach. Creswell (2008) indicated that purposeful qualitative sampling is used to develop a detailed understanding of the phenomenon. Purposive (or judgment) sampling of the quantitative study can be used when the target groups have criteria set by the researcher and they “are in the best position to provide the information required” (Cavana et al., 2001, p. 263). The findings of this kind of sampling cannot be confidently generalized to the population (Cavana et al., 2001). However, this is not the main concern here as the current study is exploratory in nature.

5. Data collection methods: In-depth interviews with experts in construction (i.e., open-ended questions) can help to obtain better understanding of the enablers of learning in a fragmented context. On the other hand, questionnaire survey is appropriate to determine the extent of fragmentation's effect on project learning. Thus, data collection procedure followed by the current study is the cross-sectional method, consisting of qualitative interview and survey method (Bryman, 2004).

6. Logical linking of data to propositions: This involves testing the previous proposition of the association among fragmentation, enablers, and project learning. Relationship among these factors can be affirmed by hypotheses testing. More comprehensive methods of testing shall be used. These include structural equation modeling (SEM), which is capable of testing multiple factors at the same time. Partial least squares (PLS) approach of SEM is adopted for data analysis. Chapter 5 will discuss this method in detail.

7. Criteria for interpreting findings: This involves developing an appropriate interpretation of the obtained data. Data interpretation in this study will consist of interpretation of qualitative data and quantitative data. This will be elaborated in Chapter 6.

3.7 Summary

This chapter was divided into two sections: theoretical model and research design. Developing the theoretical model involves identifying the indicators of fragmentation, project learning, and enablers of project learning. As a latent concept, fragmentation can be determined via level of integration, coordination, and collaboration among team members. Other indicators of this concept are decoupling of specialists and diversities, spanning knowledge across project boundaries, and barriers. Indicators of project learning include project team action to learn, knowledge creation, knowledge sharing, inter-project learning processes, and knowledge transfer. Lastly, indicators of enablers include boundary crossing and boundary objects, and some elements of Sense's model in the situated learning theory. The theoretical model proposed a need to conduct further investigation to identify more enablers of project learning.

Research design summarizes the procedure of collecting, analyzing, and interpreting data through a logical connection between research questions and conclusions. Research design of both qualitative and quantitative studies was presented. The next chapter presents the procedures and results of the qualitative study, which will be used to explore the factors that enable project learning within fragmentation. The findings are expected to contribute to the development of the theoretical model presented in this chapter.

CHAPTER 4: QUALITATIVE STUDY

4.0 Introduction

The purpose of this chapter is to explore factors that enable project learning within fragmentation. These factors will help in explaining how learning occurs within this context. This chapter attempts to develop the theoretical model proposed in Chapter 3. In general, qualitative study is useful in identifying the underlying themes and phenomena that were unexplained due to limitation in literature (Creswell, 2009).

Data collection was performed using in-depth interviews with individuals who were involved and possessed experience in construction projects. Prior to this, a pilot study was conducted to ensure clarity, sufficiency, and accuracy of the interview questions. The findings indicated new enablers and confirmed some factors proposed previously in the theoretical model.

4.1 Sampling Design

The purpose of qualitative sampling is not to generalize findings to the population, but to develop an understanding of the phenomenon (Creswell, 2008). In a qualitative study, choosing participants depends on whether they are “information rich” and relevant to the research questions (Bryman, 2004; Creswell, 2008). The current study employs purposive sampling method. According to Bryman (2004), purposive samples can be divided into snowball sampling and theoretical sampling. Meanwhile, Creswell (2008) divided this sampling method into several sampling methods, depending on the time they were conducted, either before or after data collection. The current study adopted theoretical sampling, as it is more appropriate to achieve the research objectives.

Theoretical or concept sampling is undertaken before data collection to generate or discover a theory or specific concepts within a theory (Creswell, 2008). This method entails conducting qualitative interviews and the number of interviews will depend on the theoretical saturation achieved (Glaser & Strauss, 1967). Conducting this kind of sampling implies analyzing the collected data concomitantly.

The sample in the current study is building projects in Kuala Lumpur and Selangor States. The current study sets the following characteristics of the sample:

- Projects vary in type (e.g., education building, administration building, and so on).
- Projects are sizeable (i.e., value of projects is approximately RM50 million or above, to show some complexity to test the phenomenon on hand).
- Projects vary in terms of specialist individuals involved in the production process (i.e., number of specialized firms and professions involved is not less than five, depending on the construction stage).

Respondents or source of information (Bryman & Bell, 2007) for the in-depth interviews are managers and consultants involved in the construction process (i.e., production stage). The reason for choosing managers for the face-to-face interviews is their role in defining the team structure and engendering a culture of confidence, trust, safety, and mutual respect among members (Mosey, 2009). Conducting interviews with consultants is crucial to perceive how these individuals look at the learning process. Selection criteria of the interviewees are as follows:

- Directly involved in the construction process (i.e., must have conducted at least three construction projects);
- Possess sufficient experience in construction building projects (i.e., minimum 10 years); and
- Possess experience in project review and audit (optional).

4.2 Designing the Interview Questions and Protocol

The questions intend to explore more enablers of project learning within fragmentation. Altogether, the questionnaire comprises seven open-ended questions. The first and second questions are intended to perceive the interviewees' opinion on the situation of project learning and fragmentation in construction projects in Malaysia. The rest of the questions are intended for exploring the enablers. These questions are summarized in Table 4.1. The nature of in-depth interviews allows for expanding the discussion with the interviewees to explore the topic further. Therefore, the questions may be considered as a guideline for further questions.

Table 4.1: Questions for in-depth interviews

Question	**Purpose**
1. How do you evaluate the practice of project learning in Malaysia?	To observe how respondents perceive learning and to test their information about this topic
2. What is your perception about fragmentation in local projects?	To observe how respondents perceive fragmentation and to test their information about this topic
3. What increases trust, collaboration, and communication among project team?	To explore factor that overcome the negative impact of fragmentation
4. How to enable knowledge and experience sharing within fragmentation?	To explore the factors that enable achieving intra-project learning within fragmented project team
5. How to enable knowledge creation within fragmentation?	- Same as above -
6. How to enable knowledge transfer within fragmentation?	To explore the factors that enable achieving inter-project learning within fragmentation
7. What enables the practice of project learning within fragmentation?	To explore the factors that enable learning method within fragmentation

Prior to conducting the interviews, developing a protocol to collect data is advised (Creswell, 2008). The protocol is useful for structuring the interview and collecting the data carefully. It also serves as a reminder for the researcher during conducting the interviews. Simply, the protocol is a form that contains instruction to conduct the interviews, questions to be asked, and space to take notes (Creswell, 2008). According to Creswell (2009), interview questions shall start with an icebreaker question, followed by the questions related to the study and a concluding question. The following is the protocol for conducting the interview of the current study adapted from Creswell (2009):

1) Ice-breaker question;
2) Introductory questions: question related to the interviewee's experience in the field and question related to the awareness of the interviewee on project learning and fragmentation;
3) Researcher's explanation of the concepts of fragmentation and project learning to the interviewees;
4) Questions related to the study (refer to Table 4.1); and
5) Possible further comments of the interviewee.

4.3 Pilot Study

The purpose of the pilot study is to check the clarity of interview questions (Fellows & Liu, 2003). An academic was asked to examine the interview questions to verify clarity, accuracy, and flow, and provide suggestions for enhancing the questions generally. In addition, the first two interviews are considered as pilot study. However, findings from these interviews were added to the main results. During the two interviews, the researcher noted any possible problems related to the questions or the way the interview was conducted.

4.3.1 Results of the pilot study

The academic advised changing and/or explaining certain terms so it will be easier for industry practitioners to cope with the terms. Furthermore, the expert advised attaching one page of the research aims and objectives so interviewees will be able to see it on paper instead of merely hearing a verbal explanation.

Two interviews were conducted with a project manager and a project engineer in this pilot study. The researcher deemed it was necessary to modify the technique of asking questions because interviewees failed to understand the topic easily. For example, the interviewees faced difficulty in coping with terms such as fragmentation, project learning, and knowledge creation. Thus, the researcher employed terms such as separation of design and build process, lack of collaboration and cooperation, and lack of experience sharing across different stages of the project. The researcher replaced the term "knowledge creation" with "creating new ideas" and the term "tacit knowledge" with "experience" and "how to do things."

As the conversation commenced with the first two interviewees, the researcher realized the importance of flexibility in terms of asking the questions or expanding the topic. This is true with the in-depth interviews, where the interviewees are accorded freedom to explain the topic from their points of view. After further developing the interview questions, the researcher was able to start conducting the interviews with other individuals in the sample.

4.4 Choosing Projects and Interviewees

The study attempts to choose a mixture of different construction building projects to obtain data that are more comprehensive. The sample of the current study consists of six projects: an administration building, an education building, two hospitals, an airport, and a bank. The said projects were all in the construction stage when the study was conducted. Value of these projects ranged between 46 million to 997 million Malaysian Ringgit. Table 4.2 provides more details on these projects.

Table 4.2: Sample of qualitative study (details of construction building projects)

No.	Project type (specification)	Location	Value (RM million)	Completion percentage (%)	Contracting method
1	Administration building (10 stories)	UM (Kuala Lumpur)	61.0	65	Conventional
2	Education building (9 stories laboratory)	UM (Kuala Lumpur)	46.1	7	Conventional
3	Hospital (10 stories - pediatric building and 6 stories obstetric building)	UM (Kuala Lumpur)	173.0	85	Conventional
4	Hospital (13 stories - general hospital)	UM (Kuala Lumpur)	176.0	31	Conventional
5	Airport (the buildings package only)	KLIA	997.0	34	Design and build
6	Bank (1500 acre)	Brickfield (Kuala Lumpur)	500.0	30	Design and build

The approached interviewees were project directors, project managers, site engineer, a coordinator, and a consultant (Table 4.3). Interviewees with experience in project learning (e.g., post-mortem project and quality assurance) provided an extra advantage. Majority of interviewees were project managers with a minimum of 20 years of experience. The study envisaged to interview a variety of experts in the field of project management and construction. The variety of disciplines among interviewees enabled the study to obtain rich information and cover different views and opinions about the subject matter. Theoretical saturation (Bryman, 2004) was achieved at the 11th interview.

Table 4.3: Profile of interviewees

Interviewee	Date	Age	Gender	Education	Position	Experience (years)
X1	17/5/10	40	Male	Bachelor Degree	Project Manager	20
X2	17/5/10	38	Male	Bachelor Degree	Project Engineer	10
X3	21/5/10	37	Male	Master Degree	Project Manager	12
X4	22/5/10	49	Male	Master Degree	Project Manager	20
X5	31/5/10	50	Male	Bachelor Degree	Construction Manager	20+
X6	02/6/10	48	Male	Bachelor Degree	Director of Projects	20
X7	03/6/10	49	Male	Diploma	Consultant	20+
X8	07/6/10	55	Male	Bachelor Degree	Project Director	20+
X9	01/7/10	40	Male	Bachelor Degree	Project Coordinator	16
X10	08/7/10	42	Male	Bachelor Degree	Project Manager	15
X11	14/7/10	52	Male	Bachelor Degree	Project Manager	25+

4.5 Procedure of Data Collection and Analysis

Data may be collected using a recorder, in addition to direct writing during the interview (Bryman, 2004). These methods are called formal and informal methods of recording (Creswell, 2008). Using both methods is suggested so the informal method can be used as backup. After recording the interview, audiotaped data can be transcribed. Data transcription is the process of transferring audio to written text and storing it in a computer database (Creswell, 2008).

Each interview lasted an average of 25 minutes and was transcribed into approximately six pages. Analysis of interviews involves making a general sense of the data. According to Creswell (2008), analysis of interviews include the following features: it is inductive, that is, going from the particular to the general; it involves simultaneous and iterative data analysis and collection; it involves developing deeper understanding of data by reading them several times; it is interpretive and requires personal assessment; and it entails no single method. In addition, data analysis and interpretation involve six main steps: preparing and organizing data; exploring and coding the database; describing findings and forming themes; representing and reporting findings; interpreting the meaning of the findings; and validating the accuracy of findings (Creswell, 2008). These steps will be discussed in detail in the following paragraphs.

Preparing and organizing the data includes verbatim transcription of the audio interviews into text. After doing so, the researcher shall decide whether to use manual or computer software for the analysis. According to Creswell (2008), the decision to analyze data manually depends on the size of manuscript (less than 500 pages of single-spaced transcription); desire to be close to the data sans intrusion of a machine; and availability of time for hand analysis. The researcher decided to use manual analysis, as the size of manuscripts is not large.

Exploring and coding data is the first step in data analysis. According to Creswell (2008), this step involves reading the transcript; writing memos on the margin of the text of ideas, phrases, or hunches; and dividing the text into segments (defined as labeled sentences or paragraphs in the transcript that can explain the phenomena or answer the research questions). These segments shall be assigned certain codes. Codes can be *in vivo* codes that are the actual words of the participants, or they can be words in standards terms extracted from the literature (Creswell, 2008). Examples of *in vivo* codes are *Consultant Ego* and *Interfacing Meetings*. Other codes were obtained from the literature, such as *Incentives*. Typically, a manuscript of 20 pages entails 10 to 15 codes (Creswell, 2008). After coding the entire text, a list of all codes shall be arranged in a table to reduce similar and redundant codes. Afterward, the codes shall be collapsed to a fewer number of themes or categories (five to seven themes). Themes are similar codes aggregated together to form a major idea in the database (Creswell, 2008). Figure 4.1 illustrates the process of exploring and coding data.

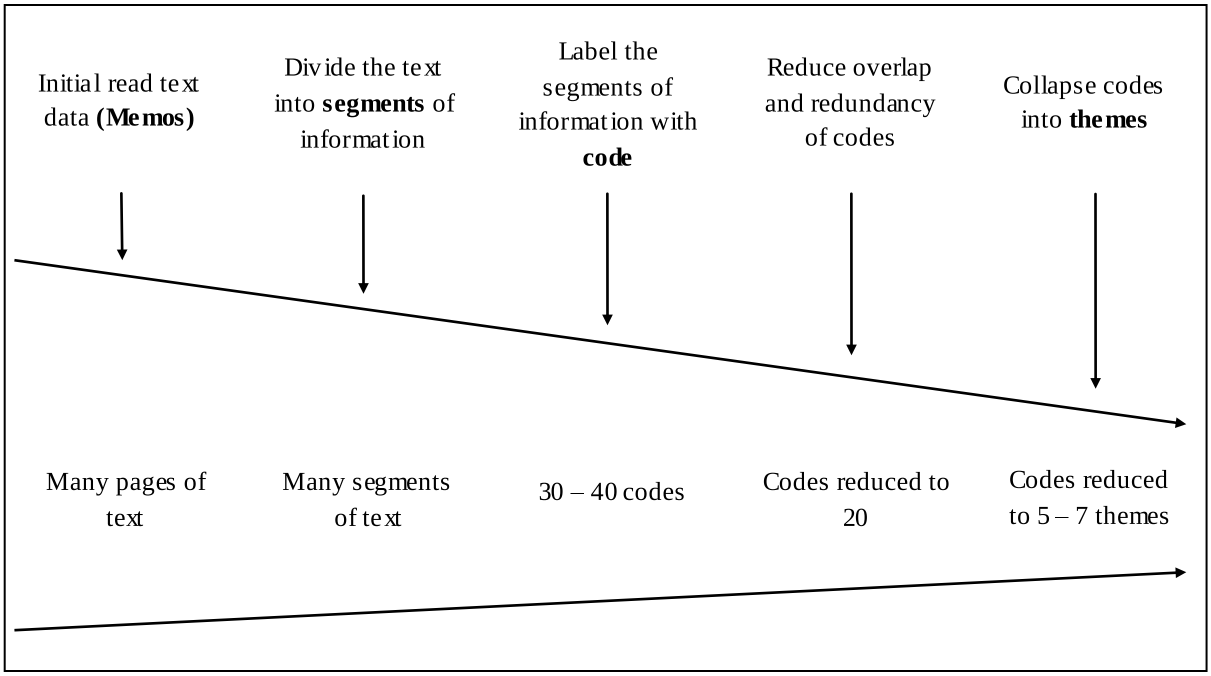


Figure 4.1: Exploring and coding data in qualitative study (Source: Creswell, 2008)

4.6 Verification of Findings

Qualitative data shall be verified to ensure that findings are accurate during data collection and analysis (Creswell, 2008). Data verification can be attained using one the following methods: triangulation, which entails data collection from different sources; member checking by asking one or more respondent (i.e., the same interviewees) to check the accuracy of findings; or external audit (academics, peers, etc.) who may review the different aspects of findings (Creswell, 2008).

The researcher asked two peers to check the wording of codes and whether they represent the segments (peer review) (Creswell, 2008). The peers were asked to check whether the codes provide sensible answers to the research questions. The codes were enhanced accordingly. In addition, in the following chapter, the quantitative study will be used to verify these findings.

4.7 Findings and Discussions

4.7.1 Project learning: Perception of the interviewees

The researcher observed that some interviewees were not very familiar with terms such as project learning and knowledge creation. This may indicate lack of implementation of such concepts within the project arena. For some interviewees, people can learn during a session of sharing new knowledge about certain issues using a presentation (e.g., coaching). However, other interviewees were aware of certain processes of project learning, which involves knowledge documentation and transfer to others within and across projects. These interviewees indicated that documented knowledge is mainly about budget, construction method (physical works), or problems that may occur during construction. Mainly, the documented knowledge of post-mortem project focuses on the financial aspect and examines whether or not the project obtains profits. These documents will be stored by the main contractor and will not be shared with other companies.

Majority of interviewees affirmed their willingness to share knowledge that facilitates the achievement of the project. Knowledge here is mostly in an explicit form, including information required to achieve the project such as drawings, specifications, and reports. Knowledge related to how to do things (tacit knowledge) can be shared freely when it helps to achieve the project. However, as a project manager commented, "*People will share knowledge if they asked to do so, but still they will not give full details*." The same interviewee stated that he would not share how to do things (tacit knowledge) with people he does not know, without some sort of incentives.

4.7.2 Fragmentation: Perspective of the interviewees

Majority of interviewees, especially builders, viewed fragmentation as a significant problem that may influence project performance and learning. However, an interviewee (consultant) disagreed that fragmentation hinders project learning, as consultants can meet and discuss with others any time if necessary. Another interviewee indicated that people do not hesitate to share their knowledge because they work in one project, where there is no competition that can affect knowledge sharing. However, majority agreed that fragmentation cannot be avoided. An interviewee stated that it is better to have more specialists involved in the project, but the problem would lie on how to coordinate between all those people. Another interviewee (a consultant) stated that fragmentation could be avoided by coordination among different people, specifically contractors and subcontractors. The said interviewee highlighted that fragmentation between main contractors and subcontractor (vertical) is more severe than fragmentation between consultants and contractor (horizontal). Other opinions and perceptions about project learning and fragmentation are summarized in Table 4.4.

Table 4.4: Results of interviews (situation of project learning and fragmentation)

Aspect	Feedback	Interviewee
Perception about project learning practice	Project reviews are mainly about construction method, completion time and cost. The purpose is to find the causes of problems. Some reasons for delay and over cost is lack of coordination	X9, X3
	Conducted by contractor company (team from the main office / HQ)	X9
	A committee of project director, coordinator etc. is assigned to conduct post project review	X9
	The content is like trade secrets or it is private and confidential (especially for pricing, not technical information). Other organizations cannot benefits from it. An alternative of post project review is seminars for the sub-contractors.	X9, X10
	In most projects, there is no development of lesson learned about specific problems … only normal correspondence letters.	X10
Perception about fragmentation within local projects	Fragmentation has no influence on knowledge sharing because people have to share their knowledge to complete the project. People are willing to share knowledge because they are working in the same project. Another reason for people willingness to share knowledge is because normally specialized companies have no competitors working in the same project.	X10
	Fragmentation influences project learning indirectly.	X9

4.7.3 Enablers of project learning within fragmentation

Enablers that facilitate knowledge creation among team members within fragmentation include technical meeting, discussions, informal gathering, encounters, and the role of senior manager in gathering people and creating new ideas from different specialists. Interviewees believed that sharing of experience and knowledge among different specialists has strong influence on knowledge creation. Trust appears important for the individual to share his or her tacit knowledge, although one interviewee indicated that people trust each other because they have "*nothing to hide*."

Relationship among project team members can be highlighted when addressing fragmentation. Consultants and builders may not get along very well. For example, several builders indicated that consultants are egoistic in sharing knowledge. Consultants, on the other hand, have a negative pre-impression that all the contractors always "cheat." The relationship between consultant and contractor is akin to "*forced marriage,*" as a project manager stated. However, what bonds team members is the common goal of achieving the project. Friendship is viewed as a factor that facilitates experience sharing. Some people find it difficult to share knowledge with "strangers" unless they are explicitly asked to do so.

On the other hand, communication does not appear to be a problem as team members conduct formal and informal meetings quite frequently. In addition, consultants can arrange for a meeting when necessary. Another factor that facilitates communication among people is the availability of IT and ICT in projects.

Respondents suggested several factors that increase trust and communication and enhance relationships between project team members, subsequently reducing the impact of fragmentation. These include participation, collaboration, off-site activities and informal gathering, and project leader role. Participation implies consultant involvement in different activities during construction. Participation and collaboration depend on people's attitude, as the interviews indicated. Off-site activities and informal gathering and encounters are believed to increase trust as well as build good relationship among team members. Moreover, the project leader can serve as a role model in fostering this behavior among members.

With regard to the procurement method, several interviewees (especially on the contractors' side) view design and build (D&B) as better in terms of knowledge sharing because the consultants and contractors will be working together in the early stage of the project, particularly in the design stage. However, majority of the interviewees perceive no difference between the two methods, with regard to knowledge sharing. Several interviewees prefer the conventional method, as D&B is saddled with disadvantages such as delay and low quality. In fact, trust between consultants and contractor may be affected in D&B due to payment related issues, as an interviewee affirmed.

The respondents highlighted several factors that facilitate knowledge transfer and achieve project learning: IT, lessons learned project documentation (e.g. project history and quality assurance systems), common goals of project team, and boundary object. Majority of interviewees agreed on the role of boundary crossing and boundary objects in enabling knowledge sharing and creation among project team members. These include IT (Forgues et al., 2009), construction contract (Koskinen & Mäkinen, 2009), and drawings, specifications, and reports (Phelps & Reddy, 2009). Information technology is used mainly to transfer knowledge via documentation of relevant information in a database.

Factors that enable knowledge sharing in this context include the following: meetings (e.g., coordination meetings), problem-solving sessions, brainstorming sessions, procurement method, spirit of project team and common goals, contract and owner role, and knowledge type (certain people experience difficulties in sharing all knowledge with others). Other factors that may have a less or indirect effect are documentation, transparency, commitment, incentives for knowledge sharing, attitude, and personal relationship. These findings are summarized in Table 4.5.

Table 4.5: Findings of the interviews (collapsed codes and themes of enablers of project learning)

Segments and Emerging Codes	Interviewee	Collapsed Codes	Themes
What increases trust, collaboration, and communication between project team?			
Consultants' participation in different construction activities (to avoid general contract and BQ at the same time increase trust) (Phelps & Reddy, 2009). Collaboration depends on people	X2, X9, X10	Participation of Consultant People attitude Contract Working Relationship ISO (9000) Manager & Coordinator's Role Off-site Activities Leader Role in creating appropriate working environment Leader as a Role Model Timing Factor Discussions & meetings (esp. informal)	- Participation - Attitude - Rules and regulation - Relationships (working & personal) - Leader's Role - Coordinator Role - Off-site Activities - Informal encounters and discussions - Timing factor
Contract (bond the relationship)	X4, X7		
Good working relationship (rather than partnering)	X7		
ISO system to enable coordination and systematic working between main contractor and sub-contractor	X7		
Project manager (to coordinate between consultants and contractors)	X6		
Coordinator role to interface between different people and companies (multi-discipline)	X9, X6		
Get people together and know each other (off site activities) (Koskinen & Makinen, 2009)	X6		
Project leader to create appropriate environment and to learn people how to learn Leader as a role model	X8		
Three factors to increase trust: time, discussions, and performance accordingly Meetings and informal encounters	X9, X10, X11		
What are the enablers of knowledge sharing within fragmentation?			
Regular meetings / coordination meetings	X1, X3, X7, X6, X8, X11	Regular Meetings (coordination) Discussions & Seminars Memos Brain Storming & Problem solving Sessions Attitude of Leaders ISO Record file form Procurement Method (D&B) Spirit of Project Team Transparency and openness Commitment Motivation & Incentives Knowledge as a trade secret Contract Client Request Method Statement Responsibility Objectives of achieving the project Leaders Role Personal Relationships	- Meetings - Problem-solving Sessions - Attitude - Documentation - Procurement Method - Spirit of Project Team - Openness - Commitment - Incentives for knowledge sharing - Knowledge Type - Contract - Owner's Role - Common Goal - Leader's Role - Relationships
Discussions, seminars and site memos	X3, X7, X6, X11		
Brain storming and problem solving	X8		
Attitude of the main players	X3, X9		
ISO system	X3		
Strong writing up and record file form	X2, X1		
Spirit of project team	X2, X11		
Transparency and openness	X11		
Contractor commitment for acquisition of knowledge	X1		
Monetary incentives	X4		
Don't share everything as some types of knowledge is treated as a 'trade secret'	X4		
Construction contract	X4		
Client may request sharing some necessary information	X4		
Method statement (documentation)	X4, X8, X5		
Interfacing meetings (coordination meetings), courses and training, and D&B	X5		
Motivation	X6		
Individuals to take responsibility and commitment	X8		
People will share knowledge regardless of fragmentation because they are doing business 'forced marriage'	X8		
Leaders role	X8		
Consultants' attitude	X9		
'Buddies' relationships	X4		
What are the enablers of knowledge creation within fragmentation?			
Regular technical meetings	X2, X7, X6, X11	Technical Meetings Frequent Discussions Project & Senior Manager Role Informal Meetings	- Meetings & Discussions - Management Role - Informal
Frequent discussions	X3, X7		
Project manager to allows for openness	X6, X11		
Senior mangers role	X11		
Informal meetings and getting people together	X4, X7, X6		

Table 4.5: Results of the interviews (Cont'd)

Experience sharing (of specialists)	X8	Experience Sharing	Encounters - Knowledge Sharing
What enables knowledge transfer within fragmentation?			
IT databases (e.g. infostore)	X7, X5, X6	IT Project Learning Quality Assurance	- IT - Project review - <u>Regulation of the organization</u>
Project review and post project mortem	X3, X6		
Lessons learned	X3, X6		
Project history	X7		
Quality assurance system	X7		
What enables the practice of project learning in fragmented project?			
Attitude of facilitator (project manager)	X3	Attitude of Leader IT Drawings & Contract Common Goals	- <u>Attitude of Leaders</u> - Boundary Objects - Common Goals
Boundary objects (IT, drawings, contract)	(Most of the interviewees)		
Common goal of achieving the project	(Several interviewees)		

Note: <u>Underscored fonts</u> of the themes indicate new discovered enablers. Normal fonts are enablers identified from the literature and emphasized by the interviewees.

4.8 The Developed Model of Project Learning

Figure 4.2 presents the theoretical model proposed previously in Chapter 3. This model indicates the new factors that enable project learning. These include roles of project manager and senior manager, meetings (including technical meetings and problem-solving sessions), attitude, knowledge type, incentives for knowledge sharing, and company rules and regulations. Other factors that may have been indicated in literature and emphasized by the interviewees include the following: knowledge documentation, procurement methods, openness, commitment, informal encounters and relationships, spirit of project team, common goals and objectives, and boundary crossing and boundary objects. Further testing of these enablers and other elements in the model will be conducted in the quantitative study in the following chapter.

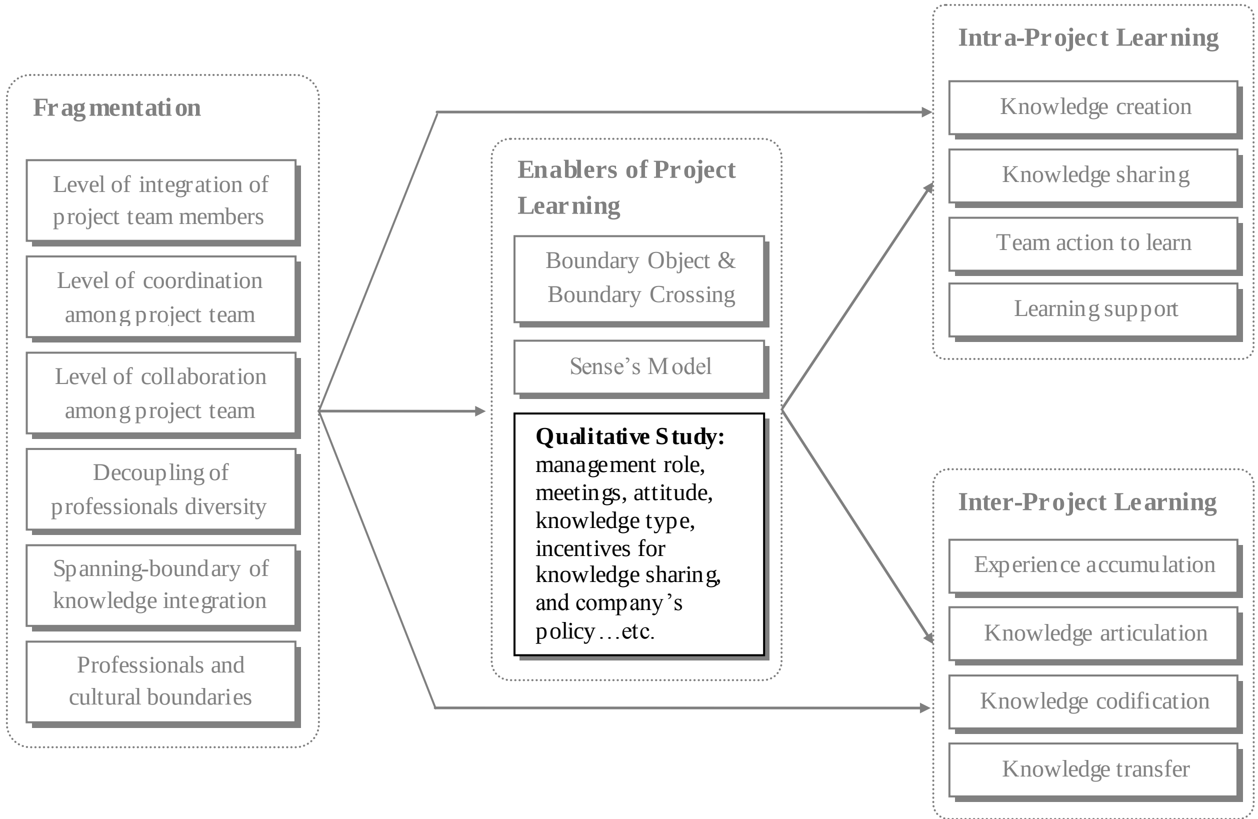


Figure 4.2: Developed theoretical model of project learning (adding the results of the qualitative study)

4.9 Summary

This chapter presented the procedures for qualitative data collection, analysis, and discussion. The chapter presented the findings of 11 in-depth interviews with individuals involved in construction building projects. The study explored new factors that facilitate the learning process within fragmentation. Certain findings confirmed the variables extracted from the literature. These finding were used to develop the theoretical framework proposed in the previous chapter. The next chapter will verify these findings and test the whole model of project learning.

CHAPTER 5: QUANTITATIVE STUDY

5.0 Introduction

This chapter intends to develop and test the project learning model proposed in Chapters 3 and 4. A questionnaire survey will be used to answer the research questions and test the hypotheses. This chapter is divided into two sections. The first gives a comprehensive background of the process of developing the measurement scale and collecting and analyzing data. The second section presents the results of the analyses.

This chapter illustrates the development of the questionnaire, including conceptualization, operationalization, and measurement of latent constructs (i.e., fragmentation and project learning) (Cavana et al., 2001). In addition, this chapter discusses two types of measurement models, namely, reflective and formative measurements. Furthermore, it highlights the identification of these measurements as hierarchical models.

Data collection involves non-probability sampling design, which suits the exploratory nature of the current study. This sampling method can be used as well when a study requires certain criteria set by the researcher (Cavana et al., 2001). Principal component analysis (PCA), confirmatory factor analysis (CFA), and path modeling approach of partial least squares (PLS-PM) will be used to analyze data. PCA can summarize the variables and identify their structure into components, while CFA can validate the results of PCA. PLS-

PM offers advantages over other similar approaches and cope with special conditions, including theoretical, measurement, and practical conditions. In addition, this approach allows building the hierarchical models easily and analyzing structural and measurement model simultaneously.

The results include descriptive analysis of respondents and projects. The results likewise include parallel analysis, PCA, CFA, and the results of PLS-PM using SmartPLS package. Quality of the full model is presented as well, including several tests to ascertain internal reliability, multicollinearity (of fragmentation), discriminant validity, convergent validity, and goodness-of-fit. Lastly, the results of mediating test of enablers are presented.

SECTION I: MEASUREMENT AND METHOD OF ANALYSIS

5.1 Steps of Developing the Measurement Scale

Developing a measurement scale of latent variables includes conceptualization, operationalization of the concept, item measurement, and scaling (Babbie, 2010; Cavana et al., 2001). Latent (or nebulous) variables are phenomena of theoretical interest, which cannot be measured directly without certain indicators or manifest observable measures (Diamantopoulos et al., 2008; Hair et al., 2006).

Defining an appropriate scale is the next step in developing the measurement. Scales can be nominal, ordinal, interval, or ratio (Babbie, 2010; Cavana et al., 2001). The current study will use the interval scale to suit multivariate analysis (Hair et al., 2006). In developing a measurement scale, it is important to ensure that the scale is stable and it measures the concepts on hand adequately. This is called goodness of measurement (Cavana et al., 2001), which consists of item analysis, reliability, and validity. All these steps will be discussed in other sections in this chapter.

5.2 Conceptualization, Operationalization, and Measurement

Conceptualization, according to Babbie (2010, p. 131), “gives definite meaning to a concept by specifying one or more indicators of what we have in mind.” The advantage of conceptualization is that it provides the imprecise notions more specific, precise, and clear meaning (Babbie, 2010). Chapter 2 elaborated the conceptual definitions of fragmentation, project learning, and enablers.

On the other hand, “operationalizing the concept involves reducing the abstract notions to observable behavior and characteristic, which then can be translated into observable and measureable elements to form an index of measures of the concept” (Cavana et al., 2001, p. 188). Furthermore, operationalization represents the development of specific research procedures (operation) that will result in empirical observations representing those concepts in the real world (Babbie, 2010). In addition, Cavana et al. (2001) related operationalization to the process of examining dimensions, facets, or properties denoted by the notion.

For example, project learning consists of two main dimensions: intra-project and inter-project learning. Intra-project learning, in turn, involves three dimensions, namely, knowledge creation, knowledge sharing, and team’s action to learn. To measure these dimensions, there is a need to operationalize them by identifying their measurement items or indicators (refer to the theoretical framework in Chapter 3). In fact, conceptualization involves refinement processes of a concept (Babbie, 2010). Therefore, it is important to mention that the indicators presented in Chapter 3 will be confirmed by further analysis.

Concepts or dimensions can be measured by direct observation, indirect observation or by using constructs (Kaplan, 1964). Constructs, as indicated by (Diamantopoulos, 2010, p. 92), are abstraction that are discussed in literature in several theories; it is the role of the researcher to define them conceptually. This implies that the same construct's name can have a different meaning or definition (Babbie, 2010). For example, the concepts of fragmentation and project learning are latent or unobservable constructs. Thus, determining these concepts require conceptual definitions based on their indicators.

In measurement development, it is important to specify the measurement type. Indicators of the latent variables can be either reflective or formative (Diamantopoulos et al., 2008; Jarvis et al., 2003). Reflective indicators are affected by the latent variable, while formative indicators cause formation or changes in the latent variable (Haenlein & Kaplan, 2004). The following section elaborates these two types.

5.3 Measurement Models: Reflective vs. Formative

Measurement models can be described as the relationships between a construct and its measures (also called items, indicators, or manifest variables). It is important to specify the measurement model properly, specifically to identify whether the model is reflective or formative. According to Jarvis et al. (2003), specifying the measurement model as reflective or formative is an important step in developing the measurement model. Misspecification of the model (e.g., specifying the model as reflective but by right it should be formative) may result in considerable problems. These include the following: incorrect theoretical conclusion; incorrect answer to the research questions and misleading direction of theory development; illusion view that the model fits the data (that results in erroneous inferences); inflated measurement model (over-estimated) if the reflected construct is misspecified; and deflated measurement model (under-estimated) if the formative construct is misspecified (Baxter, 2009; Jarvis et al., 2003; MacKenzie, 2003).

Model misspecification may result from discrepancy between conceptualization (conceptual definition of constructs) and operationalization (specifying measurement models) (Diamantopoulos, 2010). To avoid model misspecification, Diamantopoulos (2010) advised the following: observe caution when developing the models during research design, provide a clear conceptual definition of constructs, recognize the differences between reflective and formative measurements, and employ a measurement development procedure that is consistent with the constructs.

In the reflective measurement, variables are used to **measure** the construct; in particular, the arrow goes from the construct to the manifest variable. Conversely, variables are used to **indicate** the latent construct; the arrow goes from the manifest variable to the construct in the formative measurement. Figure 5.1 illustrates the difference between these two measurements. Other differences between reflective and formative measurements are adapted from (Jarvis et al., 2003) and summarized in Table 5.1. Equations of the reflective and formative measurements can be given as follows (Diamantopoulos et al., 2008):

Reflective:

$\chi_i = \lambda_i \eta + \varepsilon_i$ ……………………………………………………………(5.1)

where χ_i is the indicator of latent construct η; ε_i is the measurement error for χ; and λ_i is the coefficient or loading capturing the effect of η on χ_i.

Formative:

$\eta = \sum_{i=1}^{n} \gamma_i \chi_i + \zeta$ ……………………………………………………………(5.2)

where χ_i is the indicator of the latent construct η; ζ is a disturbance term; and γ_i is the coefficient of the effect of χ_i on η.

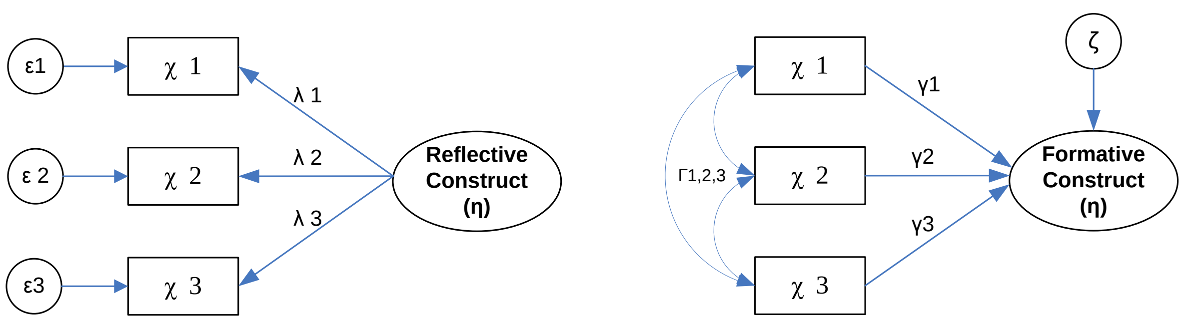


Figure 5.1: Reflective measures vs. formative measures
(Source: Diamantopoulos et al., 2008)

Table 5.1: Difference between reflective and formative measurements

Aspect	Reflective measurement	Formative measurement
Direction of causality	Direction of causality is from construct to indicators (effect)	Direction of causality is from indicators to construct (cause)
Indicators	Indicators or variables are regarded as measurements or items (**loading** should be considered)	Indicators or variables are regarded as indexes (**weight** should be considered)
Removing items from the model	Dropping any variable does not affect the nature of the construct (interchangeable items)	Dropping any variable will omit a part of the construct (not interchangeable items)
Correlation among indicators	High correlation is expected	Not expected (however, multi-collinearity issue shall be addressed)
Reliability	Internal consistency is required to ascertain reliability	Does not require internal consistency for reliability
Measurement error	Takes measurement error into account at the item level (called error term)	Takes measurement error at the construct level (called disturbance and is more problematic to assess)
Identifying the model	Model can be defined in isolation (stand-alone model)	Model cannot be defined or estimated in isolation

Adapted from (Jarvis et al., 2003)

5.3.1 Specifying the measurement models

According to Jarvis et al. (2003), decision to specify a measurement model as reflective or formative depends on causality direction, interchangeability of indicators, relationship among indicators, and nomological net of indicators. The following elaborate each of these points.

In the reflective model, indicators are the manifestation of the construct; changes in the indicator should not cause a change in the construct, and changes in the construct do cause changes the indicators. While in the formative model, indicators are defining characteristics of the construct, change in the indicators should cause change in the construct, and changes in the construct do not cause changes in the indicators.

Interchangeability of indicators in the reflective model is possible and indicators should share a common theme. Dropping an indicator should not alter the conceptual domain of the construct. Meanwhile, indicators in formative model need not be interchangeable; they need not have the same or similar content, nor a common theme. Dropping an indicator may alter the conceptual domain of the construct.

Covariation among indicators in the reflective model is expected, and change in one indicator should be associated with change in other indicators. In the formative model, it is not necessary for indicators to covary with each other and a change in one indicator does not necessarily need to be associated with change in other indicators.

Lastly, in the reflective model, nomological net for the indicators should not differ, and indicators are required to have the same antecedents and consequences. In the formative model, meanwhile, nomological net for the indicators may differ and indicators are not required to have the same antecedents and consequences.

5.3.2 Deficiencies of formative measurements

Although utilizing the formative measurements in social science has increased recently, they continue to suffer from fundamental shortcomings. These include controversial issues related to reliability and validity (Baxter, 2009; Diamantopoulos et al., 2008). A recent study conducted by Edwards (2011) was quite extreme in criticizing this kind of measurement, concluding that viability of formative measurements is a fallacy. Edwards (2011) advised to use **hierarchical** or multi-dimensional model that replaces formative measures with facet constructs, where first-order constructs are identified as reflective measurements and connected to the second-order construct formatively. In fact, the hierarchical model suggested by Edwards was proposed previously by Jarvis et al. (2003) and later on by Diamantopoulos et al. (2008). Next section will elaborate the hierarchical measurement models.

To recall, fragmentation consists of certain dimensions as level of integration and so on. These dimensions require certain indicators to measure them. The concept of fragmentation, therefore, can be defined in a hierarchical relationship. Project learning can be defined in a hierarchical relationship as well. In addition, fragmentation is measured formatively, while intra- and inter-project learning are measured reflectively. Therefore, to optimize between the advantages and drawbacks of formative measurements, the current study identifies fragmentation measurement as Type II second-order model (presented in Figure 5.3 in the next section). On the other hand, project learning can be identified as a second-order reflective measurement called Type I (presented in Figure 5.2 in the next section).

5.4 Hierarchical (Higher-order) Models

As mentioned previously, latent construct can be measured using certain indicators. However, there are cases where the main latent construct consists of "sub-constructs." In particular, the main construct consists of another level of latent constructs that are measured by another set of indicators. According to Diamantopoulos et al. (2008, p. 1205), hierarchical or higher-order model "consists of number of interrelated attributes or dimensions that are conceptualized under an overall abstraction and it is theoretically meaningful and parsimonious to use this overall abstraction as a representation of the dimension…" Specifying the model to include more than one dimension or level offers the advantage of overcoming the abstract definition of one level measurement (Wetzels et al., 2009). Another advantage is to overcome several shortcomings of formative measurement, as indicated previously in (Edwards, 2011).

Models can be specified to include more than two levels of constructs; i.e., three or even four levels (e.g. Wetzels et al., 2009). However, the most common type is the second-order construct (two levels). For example, intra-project learning by definition consists mainly of knowledge sharing and knowledge creation. These two dimensions cannot be measured directly, but require certain indicators (i.e., manifest variables). Constructs of knowledge sharing and creation and their indicators constitute a first-order model, and construct of project learning with its indicators constitute a second-order model.

It is important to specify the relationship between the first-order and second-order models (i.e., from indicators to dimensions to latent constructs) (Diamantopoulos et al., 2008). Jarvis et al. (2003) identified four types of second-order measurement model, depending on the measurement specification, as reflective or formative. These include Type I (reflective first-order, reflective second-order); Type II (reflective first-order, formative second-order); Type III (formative first-order, reflective second-order); and Type IV (formative first-order, formative second-order). The current study is concerned about the first and second types of second-order model, namely, Type I and Type II (Figures 5.2 and 5.3). As discussed in the previous section, intra- and inter-project learning can be specified as Type I second-order model, while fragmentation can be specified as Type II second-order model.

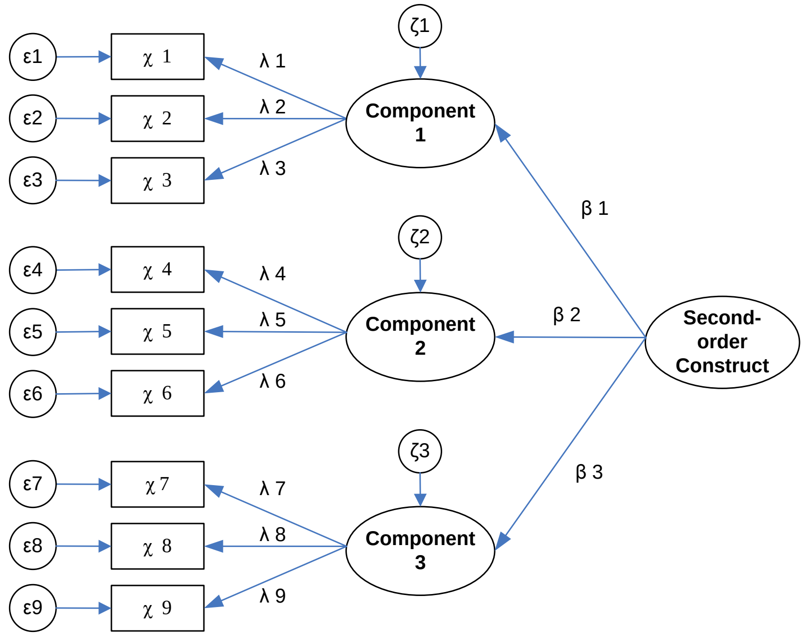


Figure 5.2: Type I second-order model (to specify intra- and inter-project learning)
(Source: Jarvis et al., 2003)

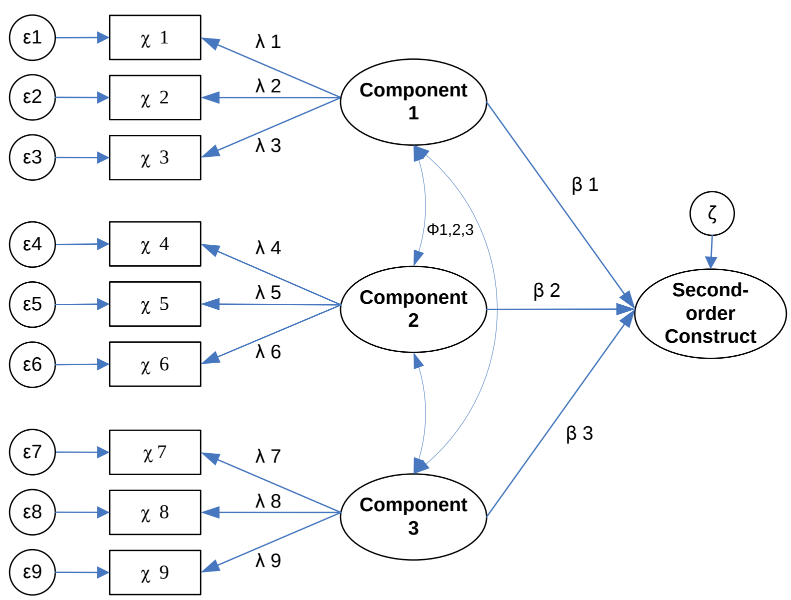


Figure 5.3: Type II second-order model (to specify fragmentation)
(Source: Jarvis et al., 2003)

5.5 Method of Analysis

This section intends to highlight different methods of analyzing data. Principal component analysis (PCA) will be conducted to summarize the number of variables in the instrument and to identify the underlying structure of the main constructs. Confirmatory factor analysis (CFA) will be conducted afterward to validate the results of PCA. All these analyses will be used to refine and develop the measurement scales of fragmentation, project learning and enablers of learning.

Among various techniques to analyze multivariate data (refer to the model of Hair et al. (2006), pp. 14-15 about choosing the appropriate technique for analyzing multivariate data), structural equation modeling (SEM) appears to be the most appropriate technique for the current study. This is because project learning model consists of metric data in multiple dependence relationships. On the other hand, this model consists of measurement models and structural model in a hierarchical relationship. SEM allows the examination of all the relationships in both measurement and structural model simultaneously (Haenlein & Kaplan, 2004). Partial least squares-path modeling (PLS-PM) is one of the approaches of SEM and it is appropriate for the current study, as will be discussed in some other sections.

5.6 Principal Component Analysis (PCA)

According to Hair et al. (2006), the purpose of principal component analysis (PCA) is to define the underlying structure among correlated variables and to summarize or reduce data. The current study utilizes PCA to reduce the number of variables used to measure the constructs (total number of metric variables in the current study is 99). In addition, PCA can be used to identify the underlying components or dimensions for each construct. This will help in developing comprehensive measurement models for the current study. Hair et al. (2006) identified two conditions to which we can decide whether to choose PCA or other technique of factor analysis as common factor analysis, based on the following:

1) Objective of factor analysis: PCA can be used to reduce variables, while common factor analysis can be used to identify the latent dimensions between variables.
2) Prior knowledge about variance among variables: Little specific and error variance suggest using component analysis, while large or unknown specific or error variance suggests using common factor analysis. Total variance is the sum of three variances, namely, common (shared) variance, specific (unique) variance, and error variance. PCA does not discriminate between common or specific variance (Costello & Osborne, 2005). In addition, common factor analysis can be used in case of little knowledge on the amount of specific or error variance.

A third condition is to consider whether the technique is compatible with PLS analysis. According Chin (1995) and Sosik et al. (2009), PCA is aligned with PLS. On the other hand, common factor analysis method may suffer from factor indeterminacy or invalid value of communality (greater than 1 or less than 0) (Hair et al., 2006). The previous conditions demonstrate that PCA is more suitable than common factor analysis for the current study.

According to Hair et al. (2006), there are conceptual and statistical issues that shall be considered while conducting PCA. Conceptual issues can be evaluated by the researcher. The researcher shall observe any pattern and structure among variables that are valid conceptually. The researcher shall also ensure that the sample is homogenous (i.e., there are no group differences). If there is a group difference in the sample, then factor analysis should be performed separately for each group. Second, correlation among variables should be more than 0.30. Bartlett test of sphericity can be considered to determine the appropriateness of PCA of the entire correlation matrix (Hair et al., 2006). Empirical evidence from the analysis to identify the number of components depends on one or more of the following criteria:

- Latent root (eigenvalue should be > 1);
- Percentage of variance (.60 or higher);
- Scree test (beyond the cut-off point in the graph where the curve flattens out); and
- Parallel analysis to identify the appropriate number of extracted variables (Tsplot) (O'Connor, 2000).

O'Connor (2000) developed a syntax that can be used in the SPSS software for parallel analysis. The purpose of this analysis is to determine the number of extracted factors/component either in component analysis or common factor analysis. The syntax produces a Tsplot that is a “modified” scree plot used to identify the optimum number of factors representing a set of variables.

5.6.1 Identifying and interpreting components of PCA

Identifying factors/components requires strong conceptual foundation for the structure and its rationale. This stage consists of three processes: estimation of factor matrix, factor rotation, and factor interpretation and respecification (Hair et al., 2006).

First, the output of PCA is a matrix consisting of variables and components with factor loadings. Factor loading is the correlation between variables and factors. High factor loading means high correspondence between variables and factor, indicating high representative of the factor (Hair et al., 2006). Second, we may decide to rotate the factors to obtain better interpretation of the factor, better underlying structure, and more theoretical solution (Hair et al., 2006). There are two types of rotation, namely, orthogonal and oblique. The current study utilizes the second type. Oblique rotation is more realistic and allows for correlated factors instead of maintaining independence between the rotated factors (Hair et al., 2006). Examples of oblique rotation application include direct oblimin, quartimin, and promax. Lastly, practical steps in interpreting the factor matrix and respecifying the factorial model, as suggested in (Hair et al., 2006), are as follows:

1) Observe factor loadings to assess the significance level of factors. The minimal level of factor loading for structure interpretation is ± 0.30 to ± 0.40. In addition, loading of ± 0.50 or greater indicates a significant structure. Meanwhile, loading more than 0.70 indicates a well-defined structure. Finally, the significance of factor loading decreases with large sample size. For example, the significance level of a 200 sample size is 0.40.
2) Identify any cross-loading variable; that is, one variable shares a significance level factor loading between more than one factor.
3) Assess communality of variables, that is, the amount of variance accounted for by the factor solution for each variable (less than 0.50 communality is not significant).
4) Respecify the factor model, if needed (will be discussed in the following paragraph).

5) Label the factors using a variable with the highest loading as the most representative factor. Labeling likewise can be performed by reflecting accurately the whole set of variables representing the factor.

The researcher may decide to respecify the solution model when one of three problems occurs: no significant loading of a variable; low communality between variables; and cross-loading variables. There are several remedies for these problems, and choosing one of them depends on the researcher's judgment, objectives of study, and conceptual foundation underlying the analysis (Hair et al., 2006):

- Ignore these problems and interpret solution as it is.
- Evaluate variables for possible deletion.
- Use alternative rotation method.
- Decrease/increase the number of factors retained.
- Modify the type of model used (e.g., using common factor analysis instead of component analysis).

5.6.2 Validation of PCA

Confirmatory factor analysis (CFA) through structural equation modeling (SEM) is one of the ways to validate the results of factor analysis (Hair et al., 2006). In addition, Costello and Osborne (2005) highlighted the importance of conducting CFA to draw a comprehensive conclusion. The detailed procedure of CFA will be shown in the results section after conducting PCA.

5.7 Structural Equation Modeling (SEM)

Structural equation modeling or models (SEM) is "a family of statistical models that seek to explain the relationships among multiple variables" (Hair et al., 2006, p. 711). SEM intends to estimate causal relationships among latent variables, which are defined according to a theoretical model and measured through some observable indicators (Vinzi et al., 2010). Furthermore, SEM uses two familiar techniques: factor analysis and multiple regression analysis (Hair et al., 2006); thus it can examine simultaneously the relationship between indicators and constructs as well as the interrelationships among constructs in the structural model.

Analysis of latent variables in SEM can be divided into two main approaches: covariance-based SEM or CBSEM (also known as covariance structure analysis or LISREL) and partial least squares-path modeling or PLS-PM (Haenlein & Kaplan, 2004; Hair et al., 2006; Tenenhaus et al., 2005). Both approaches were developed at the same time during late 1960s, but covariance-based SEM was more popular possibly due to ease-of-use software packages and methodological options (Temme et al., 2010). With the recent advances in software packages, PLS-PM approach is attaining growing interest. PLS and CBSEM have two fundamental differences: in the objectives (prediction vs. theory testing) and in the approach (variance vs. covariance) (Chin & Newsted, 1999). The current study utilizes PLS-PM to analyze data because of its advantages and due to certain conditions, which will be discussed in the following section.

5.8 Partial Least Squares (PLS)

According to Dijkstra (2010), partial least squares (PLS) was created and developed during the 1960s, 1970s, and 1980s by Herman Wold with main concern on prediction, which is the interest in fields of inquiry such as social science. PLS consists of two approaches, namely, PLS regression (PLS-R) and PLS path modeling (PLS-PM) (known also as PLS approach to SEM or components-based SEM) (Tenenhaus et al., 2005; Vinzi et al., 2010). The current study focuses only on the second approach. After this, PLS-PM may be indicated as PLS only.

According to Vinzi et al. (2010), PLS-PM was extended from the principle of PLS for principal component analysis in four major works, including those of Wold (1975, 1982, 1985); Lohmöller (1987, 1989); Chin (1998b); and Tenenhaus et al. (2005). PLS-PM consists of "interdependent equations" of simple and multiple regressions to estimate the interrelationships among the latent variables (i.e., structural or inner model) and the links between the manifest variables and their own latent variables (i.e., measurement or outer model) (Vinzi et al., 2010).

PLS is preferred in cases of small sample, too many variables (as in the case of the current study), and data with non-normal or unknown distribution (Chin & Dibbern, 2010; Chin & Newsted, 1999; Fornell & Bookstein, 1982). In fact, PLS uses nonparametric methods (e.g., bootstrapping), thus it is free of the assumptions of normal distribution and other assumptions (Guenzi et al., 2009). PLS-PM does not require strong assumptions regarding the measurement scale; therefore, it is considered as a "soft modeling" technique (Vinzi et al., 2010). In addition, PLS-PM explains, at best, the residual variance of the latent variables and indicators in the model. This is why it is considered more suitable for exploratory research (Vinzi et al., 2010).

In general, PLS is preferred when the purpose of research is to determine the relative relationship among latent variables and when the path model is an objective rather than the overall model fit (Barclay et al., 1995; Éthier et al., 2006; Hulland et al., 2010). PLS, unlike CBSEM, can be used for causal-predictive analysis with complex situation and where there is a low theoretical information (Jöreskog & Wold, 1982). Hence, covariance-based SEM is useful where the objective of study is to test a theory, while PLS is useful for predictive applications and theory development (Anderson & Gerbing, 1988; Chin & Newsted, 1999). PLS is preferable for prediction because it provides the estimates based on maximizing explained variance (Chin & Dibbern, 2010; Hair et al., 2006). Lastly, PLS is suitable when the phenomenon under study is new or changing (i.e., theoretical framework is not yet fully crystallized), when the model is relatively complex (i.e., large number of manifest and latent variables), and when formative constructs are included in the conceptual framework (Wetzels et al., 2009, p. 180).

5.8.1 Advantages of PLS over CBSEM

Using PLS has been proven to offer similar or, in some cases, more accurate results compared with CBSEM (Hulland et al., 2010). Vilares et al. (2010) compared PLS with maximum likelihood (ML) estimates, which is a CBSEM method, and concluded that PLS estimates are generally better than ML estimates. In general, PLS produces better estimates of the measurement model (i.e., outer model) than ML, but ML produces better estimates of the structural model (i.e., inner model) than PLS (Tenenhaus et al., 2005). Chin and Dibbern (2010) observed no difference in results between PLS and AMOS for the analysis of convergent validity. The advantages of PLS-PM compared with CBSEM are summarized in Table 5.2.

Table 5.2: Advantages of partial least squares over covariance-based SEM

No.	Advantages of PLS-PM compared with CBSEM	Reference
1	PLS is preferred in the case of small sample, too many variables, and data with non-normal or unknown distribution	(Chin & Dibbern, 2010; Chin & Newsted, 1999; Fornell & Bookstein, 1982; Hulland et al., 2010)
2	"ML [CBSEM] is theory-oriented, and emphasizes the transition from exploratory to confirmatory analysis. PLS is primarily intended for causal-predictive analysis in situations of high complexity but low theoretical information"	(Jöreskog & Wold, 1982, p. 270)
3	PLS provides measurement assessment of the new developed measures. It is ideal for the early stages of theory development.	(Guenzi et al., 2009); (Wetzels et al., 2009); (Sosik et al., 2009)
4	PLS has the ability to build model with single- or two-item measurement. In the case of measurement theory failing to stand the scrutiny of a CFA and convergent validity, PLS still provides estimates of relationships in the model.	(Hair et al., 2006)
5	PLS is considered better in estimating higher-order models, while CBSEM may suffer difficulties in mathematical identification or underidentification.	(Wetzels et al., 2009)
6	PLS is ideal for complex models and allows for latent constructs to be modeled as reflective, formative, or mixed.	(Duarte & Raposo, 2010; Éthier et al., 2006; Vinzi et al., 2010)
7	PLS provides better estimates of formative measurements and when the number of measurement variables is small. In addition, it is useful to obtain indicator weights and produce the prediction of latent variables (or called the outer loading), while CBSEM are useful to obtain model coefficient (inner model).	(Vilares et al., 2010); (Tenenhaus et al., 2005)
8	PLS can overcome problem encountered by improper solutions in CBSEM as negative error variances and standardized loadings greater than 1.	(Wilson, 2010)

5.8.2 Evaluating the appropriateness of PLS for the current study

There are four conditions to evaluate the appropriateness of PLS compared with covariance-based SEM, namely: theoretical conditions, measurement conditions, distributional conditions, and practical conditions (Falk & Miller, 1992).

From a theoretical perspective, the relationship between fragmentation and project learning is not very clear. In addition, no strong theoretical or empirical explanation for this relationship is currently available. As the purpose of the study is to determine (i.e., predict) the extent of fragmentation influence on project learning, PLS is considered more suitable. Hair et al. (2006) recommended a ratio of 1:5 or 1:20 of variables to cases (i.e., respondents). However, achieving this ratio of cases is probably not applicable for the current study as number of variables is huge (i.e., 99 variables as we will see later on in this study). Lastly, identifying the measurement models of the current study as hierarchical Type I and Type II makes PLS approach more practical. These conditions, in addition to the advantages of PLS-PM discussed above, encouraged the researcher to use this approach for analyzing data and testing the model and hypotheses.

5.8.3 Limitations of PLS

Regardless of the advantages of PLS highlighted previously, there are limitations to this approach. Estimations of error measurements of PLS are typically biased to a certain degree compared with CBSEM (Dijkstra, 1983). In addition, PLS does not impose any restrictions on data. Therefore, no overall test of model fit is available (Temme et al., 2010). However, quality of the model can be tested by global goodness-of-fit (Tenenhaus et al., 2005).

5.9 SmartPLS

The interest of utilizing PLS-PM has increased with the advances in software packages. User-friendly software packages have been developed, including the first package (LVPLS) developed by Lohmöller (1987). Temme et al. (2010) reviewed several packages of PLS, including SmartPLS, and compared them in terms of requirements, methodological options, and ease-of-use. SmartPLS will be used in the current study because it has extra features, which will be discussed in the succeeding paragraphs.

SmartPLS (Ringle et al., 2005) is a java-based software; it is independent from the user's operating system that can analyze raw data only. Models in SmartPLS can be specified by drawing the structural model for the latent variables and by assigning the indicators (measurement model) to the latent variables via "drag and drop" (Temme et al., 2010). SmartPLS, similar to other packages, enables the simultaneous analysis of measurement and structural models. Moreover, SmartPLS has the following features (Temme et al., 2010):

- Output can be provided in different formats, such as HTML, Excel, or Latex.
- It is provided with special feature called finite mixture routine (FIMIX), which is used to identify any unobserved heterogeneity in the data.
- It offers user-friendly advantages such as supporting the estimation of interaction effects and helpful export options.
- It offers two options regarding missing data analysis: substitute the mean over all cases or delete cases with missing data (case-wise deletion).

- Resampling methods such as bootstrapping and blindfolding can be used for cross-validated communality and redundancy, and other validations.
- It provides correction procedures for errors resulting from bootstrapping procedure (calculates the confidence intervals from bootstrapping).
- It offers different estimating methods or schemes, including centroid-, factor-, or path-weighting to calculate the inner [and outer] model.

A drawback of Smart-PLS is that it does not address the problem of multicollinearity. Therefore, another software package, such as SPSS, can be used to address this problem when needed.

A newly developed software called WarpPLS has been released recently (Kock, 2011), offering additional advantages over the previous packages such estimating the model fit and VIF of multiconllinearity (the software is available at http://www.scriptwarp.com/warppls/). Regardless of these advantages, the researcher decided not to use WarpPLS because, unlike SmartPLS, it is not considerably supported by literature and this may affect the reliability of the software. In addition, SmartPLS is more user-friendly compared with WarpPLS.

5.10 Identification of Hierarchical Models in PLS

As indicated previously, the current study uses two types of second-order measurement models: Type II for fragmentation and Type I for project learning and enablers (Jarvis et al., 2003).

There are three ways to identify the higher-order models in PLS: 1) repeated indicators approach or hierarchical component, which is also known as superblock approach (Tenenhaus et al., 2005); 2) two-stage approach; and 3) hybrid approach (Wilson & Henseler, 2007). The most popular approach in hierarchical models is the repeated indicators approach, which will be adopted by the current study.

According to Wilson and Henseler (2007), the repeated indicators approach was suggested by Wold (1982). In this approach, the manifest variables of the first-order constructs will be repeated in the second-order construct. Thus, the manifest variables are used twice in the second-order models, or many times depending on the hierarchical level. For example, lack of integration (as a first-order measurement) consists of 10 manifest variables. These variables will be repeated in the second-order measurement to measure fragmentation. Loadings of the first-order manifest variables are called "primary" loadings, while loadings of the second-order construct are called "secondary" loading (Wetzels et al., 2009). However, Wilson and Henseler (2007) indicated that this approach may suffer from bias in the estimation as the exogenous variables in the first-order construct become endogenous variables in the second-order construct.

5.11 Choosing the Appropriate Weighting Scheme

SmartPLS is provided with three schemes for estimating algorithm: centroid scheme, factor scheme, and path scheme. Centroid weighting scheme considers the sign of correlations between a latent variable and its adjacent latent variables, while factor scheme uses the correlations (Henseler, 2010). Therefore, these two schemes are preferable for confirmatory factor analyses (CFA), as they imply the existence (rather than the direction) of relationship between latent variables (Tenenhaus & Hanafi, 2010). Specifically, centroid scheme is preferably used when there is a strong correlation between the manifest variables, while factor scheme is preferable for the weaker correlations (Vinzi et al., 2010). Lastly, the path weighting scheme takes into account the arrow (directional) orientation in the path model (Henseler, 2010). Vinzi et al. (2010, p. 53) recommended the path scheme among the other two schemes as it "explicitly considers the direction of relationship as specified in the prediction path model." Lastly, Tenenhaus and Hanafi (2010) used path weighting scheme for calculating the interrelationships, and used centroid weighting scheme for CFA. The current study follows Tenenhaus and Hanafi's approach.

5.12 Quality of PLS Model

Quality of PLS-PM model can be attained by two means: quality of the measurement model (i.e., relationship between the manifest variables and the constructs they are measuring, also called outer model) and quality of the structural model (i.e., relationship among constructs, also called inner model) (Tenenhaus et al., 2005). In the first approach, reliability and validity are the two dominant criteria for examining the quality of the model. These include items' loadings, reliability of measurement, communality, discriminant validity, and convergent validity. Second, quality of the structural model can be attained by means of how the relationship among constructs is theoretically sound and via the model's goodness-of-fit and cross-validated redundancy. The following section elaborates the two approaches.

5.12.1 Quality of measurement models

Goodness of the measurement instrument can be examined in three ways: item analysis, reliability, and validity (Cavana et al., 2001; Churchill, 1979). Specifically, the current study considers items' loading, internal consistency, discriminant validity, and convergent validity.

1. Item loading: This should not be less than 0.55 (i.e., 30%) (Falk & Miller, 1992). However, if the purpose is to examine item weight of formative measurements, then 0.1 is the minimum figure (Chin, 1998b).

2. Internal consistency: This can be examined using composite reliability index (0.6 to 0.7 is the threshold) (Bagozzi & Yi, 1988; Fornell & Larcker, 1981; Hair et al., 2006). Cronbach's alpha can be used as well to examine the reliability of scale, where the accepted value of alpha should be above 0.6 (Girden, 2001; Malhotra, 2003).

3. Discriminant validity: This indicates the extent to which a given construct is different from other latent constructs. The cut-off threshold of average variance extracted (AVE) is 0.5 (Fornell & Larcker, 1981). AVE "attempts to measure the amount of variance which a latent variable component captures from its indicators relative to the amount due to measurement error" (Chin, 2010, p. 670). The **square root** of the AVE can be compared with the correlations among all constructs. If constructs have stronger correlations with their own measures rather than with any other construct in the model, this indicates good discriminant validity (Fornell & Larcker, 1981). The magnitude of items' **cross loading** can be used to indicate the discriminant validity. Indicators shall show higher loadings with their respective constructs than with any other construct (Chin, 1998b; Wetzels et al., 2009).

4. Convergent validity: This is defined as "the extent to which blocks of items strongly agree (i.e., converge) in their representation of the underlying construct they were created to measure. In other words, how high are each of the loadings and are they more or less similar?" (Chin, 2010, p. 674). This can be established by examining the range among highest and lowest items' loading of a construct. The less the range (or difference) among items is, the more will be the convergent validity (Chin & Dibbern, 2010). Cross-loading test (inter-construct correlations) can be used to assess convergent validity as well as discriminant validity (e.g. Turel et al., 2007).

5.12.2 Quality of structural model

On the other hand, quality of PLS structural model can be achieved by means of how the relationship among constructs are theoretically sound (Chin, 1998b), global goodness-of-fit (GoF), standard error, cross-validated redundancy (also called Stone-Geisser test represented by Q^2 or F^2), and cross-validated communality (H^2) (Tenenhaus et al., 2005). The latter actually indicates the quality of measurement model.

1. Good theoretically sound model: Indicators of good theoretically sound model include estimating the external validity (Bagozzi, 1994). This can be attained by assessing the strength of relationship among constructs (i.e., structural path) as hypothesized and by calculating the prediction of endogenous constructs represented by the coefficient of determination (R^2) (Bagozzi, 1994; Chin, 1998b). Path coefficient indicates the strength of the relationship, but the significance of this relationship must be calculated using bootstrapping procedure. The ideal standardized path coefficient is 0.30 (C. Liu et al., 2008). For the endogenous construct, R^2 should be greater than 0.24 to indicate good prediction in PLS-PM model (Tenenhaus & Hanafi, 2010).

2. Goodness-of-fit: Goodness-of-fit (GoF) can be used to validate the PLS model globally (Guenzi et al., 2009, p. 306). Value of GoF can be calculated using the root square of both the geometric mean of average communality multiplied by the average R^2, as shown in the following equation (Tenenhaus et al., 2005):

$$\text{GoF} = \sqrt{\overline{\text{communality}} * \overline{R^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.3)$$

However, Tenenhaus and colleagues did not indicate the threshold of GoF. Wetzels et al. (2009) proposed three values to indicate the threshold of GoF, including 0.1, 0.25, and 0.36, representing small, medium, and large GoFs, respectively. Hence, a value of GoF larger than 0.36 can indicate good global model.

3. Cross-validated communality and cross-validated redundancy: Cross-validated communality (cv-com) or H^2 "measures the capacity of the path model to predict the manifest variables directly from their own latent variable by cross validation" (Guenzi et al., 2009, p. 307). Cv-com indicates the quality of measurement model (outer model) if means of indexes are positive for all blocks (Tenenhaus et al., 2005). On the other hand, cross-validated redundancy (cv-red) or F^2 or Q^2 can be used to measure the quality of structure model (i.e., inner model) if means of indexes are positive (i.e., > zero) for all endogenous blocks (Tenenhaus et al., 2005). When $F^2 > 1$, then the observed endogenous variables can be perfectly predicted by the model (Fornell & Bookstein, 1982). Value of the Stone-Geisser (Q^2) should be greater than zero to indicate that the model has predictive relevance (Chin, 1998b). However, Chin (2010) indicated that endogenous construct with Q^2 above 0.50 shows good structural model. On the other hand, if H^2 and F^2 are negative values, then this is an indicator of a bad estimation of the corresponding latent variables (Tenenhaus et al., 2005). Both cv-com and cv-red can be calculated using a blindfolding procedure, which is available in SmartPLS (e.g. Guenzi et al., 2009). Cross-validated communality and cross-validated redundancy can be calculated using the following formulas (Tenenhaus et al., 2005):

$$H^2 = 1- \frac{\text{SSE}}{\text{SSO}} \quad \text{(5.4)}$$

where SSE is the sum of squared prediction errors for a block and SSO is the sum of squares of observations for a block.

$$F^2 = 1- \frac{\text{SSE}'}{\text{SSO}} \quad \text{(5.5)}$$

where SSÉ is the sum of squared prediction errors for an endogenous block and SSO is the sum of squares of observations for a block.

5.13 Bootstrapping and Blindfolding in PLS

Bootstrapping is a resampling method that replaces the original sample to produce samples consisting of the same number of units as in the original sample (Tenenhaus et al., 2005). According to Gray and Meister (2006), bootstrapping is a nonparametric approach for estimating the precision of paths. In addition, bootstrapping is used to assess the psychometric properties of the latent variables and structural relationships (Wetzels et al., 2009). Thus, it permits hypothesis testing. Furthermore, bootstrapping offers advantages over other resampling methods, such as jackknifing, as it allows for calculating confidence intervals other than those calculated from a normal distribution and permits the use of a larger number of samples (Chin, 1998a).

Conducting bootstrapping using SmartPLS results in the following: weight and loading of outer (measurement) and inner (structural) models, path coefficient, total effect, T-statistics, standard deviation, and standard error (Guenzi et al., 2009; Wetzels et al., 2009). Number of resamples can be specified as 100 or higher (e.g., 200) to obtain more reasonable standard error estimates (Tenenhaus et al., 2005). Estimating parameters of bootstrapping include three methods that are available in SmartPLS: standard, individual sign changes, and construct level changes.

1. Standard (called "no sign change" in SmartPLS): In this choice, the software will calculate the equation without considering the sign change in each variable. For example, if certain items in the questionnaire are worded negatively, the calculation will be affected. Tenenhaus et al. (2005) did not recommend the use of this parameter because it may yield very high standard errors and, consequently, low t-value.

2. *Individual sign changes:* Tenenhaus et al. (2005) did not recommend this choice also because the sign in each resample is consistent with that in the original sample without ensuring a global coherence. However, this parameter "seems to be a good procedure in the case where all signs in the same block are equal, at the original sample level" (Tenenhaus et al., 2005, p. 177).

3. *Construct level changes (default in SmartPLS):* This parameter is preferred to avoid the shortcomings of the previous two parameters; however, it has some shortcomings when used with formative measurements (Tenenhaus et al., 2005).

The researcher tested the effect of changing the parameters on the results of bootstrapping. The influence of changing parameters on decoupling of diversity construct (part of fragmentation) was observed. With "no sign change," the t-value was very low at 0.99 while standard error was quite high at 0.7. When choosing "construct level changes," the t-value increased dramatically to 19 with a considerably lower standard error of 0.04. Given this, it may be interpreted that some items that measure decoupling of diversity were worded negatively. Thus, the current study utilized construct level change for the bootstrapping procedure.

Blindfolding, on the other hand, involves omitting "one case at a time and reestimating the model parameters based on the remaining cases, and predicting the omitted case values on the basis of the remaining parameters" (Duarte & Raposo, 2010, p. 471). This procedure can be used to calculate the cv-com and cv-red (Duarte & Raposo, 2010; Guenzi et al., 2009), which indicate the quality of outer and inner models as stated previously.

The procedure of blindfolding in SmartPLS involves identifying the "omission distance" or G value. A values of G between 5 and 10 is feasible (Chin, 1998b). Tenenhaus et al. (2005, p. 174) stated that Wold recommended G = 7, which is also the default in SmartPLS. However, Duarte and Raposo (2010) indicated that a larger value of G shall be used with complex models.

5.14 Mediating Test

The current study will test the influence of enablers as mediating or intervening variables between fragmentation and project learning. According to Hair et al. (2006, p. 866) "mediating effect is created when a third variable/construct intervenes between two other related constructs." To test whether enablers are really mediating constructs, as assumed in the theoretical model, the current study follows the procedures presented in (Cohen & Cohen, 1983 cited in Hair et al., 2006).

The procedure involves observing the influence of the mediator once it is included in the model. If the relationship between fragmentation and both intra- and inter-project learning remains significant and unchanged once enablers (i.e., mediators) are included in the model as an additional predictor, then mediation is not supported. If the relationships between fragmentation and both intra- and inter-project learning are reduced but remain significant when enablers are included in the model, then partial mediation is supported. Lastly, if the relationships between fragmentation and both intra- and inter-project learning are reduced to a point where it is not significantly different from zero after the enablers are included, then full mediation is supported. In fact, this technique is similar to that proposed by Baron and Kenny (1986). Examples of studies used this technique in PLS include Wetzels et al. (2009) and Guenzi et al. (2009). Wetzels et al. (2009) adopted the procedure of Baron and Kenny (1986) and Holmbeck (1997), and conducted the following steps:

1) Estimating a model that contains only the direct relationship (independent latent variable and dependent latent variable);
2) Estimating the indirect effect of mediating variable;
3) Observing the magnitude difference between direct and indirect effect (β, z, and p);
4) Conducting the incremental *F* to test whether including the direct effect of IV on DV significantly increases the explained variance for DV;
5) Estimating standard error using bootstrapping, which appears to be more appropriate than the method proposed by (Sobel, 1982); and
6) Reporting the results (i.e., stating whether the mediator has no, partial, or full mediating effect).

SECTION II: DATA COLLECTION AND RESULTS

5.15 Sampling Design

The current study utilizes purposive sampling categorized under non-probability sampling (Babbie, 2010; Cavana et al., 2001). Using this type of sampling suits the exploratory nature of research and involves several advantages, such as ease of identifying sample and collecting data (Cavana et al., 2001). Purposive or judgmental sampling can be selected based on the purpose of the study and knowledge about the population and its elements

(Babbie, 2008). Unlike probability sampling, generalizing the finding of this kind of sampling to the population is difficult (Bryman, 2004). However, purposive sampling can provide a general understanding of the topic on hand (Babbie, 2010).

Purposive sampling can be used when the sample possesses desirable information and conforms to some criteria set by the researcher, as stated by (Cavana et al., 2001). This sampling is suitable when the population of the study is difficult to identify (Babbie, 2010) or when there is a trade-off between time and cost (Cavana et al., 2001).

Sample size of non-probability sampling does not appear to follow a rigorous procedure. This is because the purpose of sampling in this case is not to ensure a representative of the sample to the population. Method of data analysis can affect sample size. For example, Cavana et al. (2001) recommended that the sample size should be several time the number of variables in the study. Hair et al. (2006) recommended a minimum ratio of 1:5 variables to cases (i.e., respondents). However, number of cases should not be less than 100 to run multivariate analysis, specifically factor analysis (Hair et al., 2006). However, partial least squares (PLS) does not require a large sample size to run the analysis because it involves a non-parametric test (Chin & Dibbern, 2010; Chin & Newsted, 1999; Fornell & Bookstein, 1982; Hulland et al., 2010).

5.15.1 Choosing the sample

Samples of the current study include selected building projects, which were at the construction stage during the course of the current study. These projects are expected to show some complexity in terms of size, number of professionals involved, and diversity of specializations. These features permit testing the phenomenon of the current study. Thus, the selected projects are that undertaken by Grade 7 (G7) contractors. Contractors under this grade are eligible to procure for projects with no limited value (CIDB, 2011).

The researcher decided to approach projects in Kuala Lumpur and Selangor states, which were convenient to access. The CIDB website (http://www.cidb.gov.my/v6/) provided some information that indicated the characteristics of G7 projects. These projects were categorized into residential, commercial, social amenities, industrial, administration, security buildings, mix development, and others (CIDB, 2011).

In addition, the projects can be categorized according to the source of funding: government, private, and mixed. They can also be categorized according to the procurement method: conventional (traditional); design and build; turnkey; build, operate, and transfer (BOT); and so on. It is noted that majority of projects are residential, funded by private developers, and most are procured using the conventional method.

The target respondents (unit of analysis) of the questionnaire survey are professionals working in project sites. The said professionals include project managers, project engineers, project consultants, and other professionals in the site. Further explanation on the respondents can be found in another section in this chapter.

5.16 Developing and Pre-testing the Questionnaire Survey

Prior to distributing the final questionnaire to respondents, conducting a pre-test is important. Pre-test of the questionnaire, a process of developing the measurement instrument, includes **content validity**, **face validity**, and **pilot study** (Cavana et al., 2001; Creswell, 2008). Content validity refers to the extent to which content of the used items are related to the construct/variable they are assigned to (Straub et al., 2004). According to Dunn et al. (1994), items in the survey could be derived from existing literature to ensure high content validity. The purpose of face validity is to ensure that items are clear and understandable, and to check whether items appear to measure the concepts being investigated. On the other hand, the purpose of the pilot study is to ensure that the instrument as a whole functions effectively (Bryman & Bell, 2007). Further elaboration of content validity, face validity, and pilot study is provided in the following sections.

5.16.1 Content validity

According to Cavana et al. (2001), the purpose of content validity is to ensure that the instrument adequately measures the concept according to three ways: relevant literature or theories, previous research, and judgment of experts and the researcher. All items in the instrument of the current study were gathered from two main sources: previous relevant literature and qualitative study (refer to Chapters 3 and 4). The researcher further validated the adequacy of items to measure the concepts by seeking the judgment of experts (Cavana et al., 2001). As illustrated in Appendix (B), the researcher sought the opinion of four academics in the field to validate the content of instrument. The academics were asked to provide their opinion on the adequacy of each item to measure the four constructs of the study (i.e., fragmentation, intra-project learning, inter-project learning, and enablers of project learning). They were asked to rate each item in terms of relevance and importance based on a four-point scale: "neither relevant nor important"; "relevant"; "important"; or "relevant and important." Lastly, the academics were asked to add any missing item to the questionnaire that they deem relevant and important. Based on the results of content validity, some items in the questionnaire were eliminated or added.

5.16.2 Face validity

Face validity may be conducted in line with the pilot study (Cavana et al., 2001). The questionnaire survey of the pilot study was self-administered (i.e., distributed and collected by the researcher). This allowed the researcher to ask respondents about clarity and accuracy of each item. Upon conducting face validity, the researcher decided either to change the wording of some questions or to delete/replace redundant items.

5.16.3 Pilot study

The purpose of the pilot study is to test whether respondents are capable of completing the survey and whether they can understand the questions (Creswell, 2008). According to Bryman and Bell (2007), the pilot study should be carried out on respondents who are not part of the sample. Respondents should be a small set of comparable members of the population to avoid the effect of sample representativeness (Bryman & Bell, 2007).

The researcher distributed the questionnaire survey on February 16, 2011. After exactly one month, the researcher collected 31 valid questionnaires from 15 construction projects in the Kuala Lumpur and Selangor territories. Table 5.3 illustrates the characteristics of the sample of the pilot study. Variety of the sample may show different patterns of learning within these projects. Respondents from these projects included project managers, project engineers, consultants, and project coordinators. Variety of respondents is important to obtain a better understanding of learning activities in projects from different perspectives and opinions. Table 5.4 illustrates the respondents' criteria.

Table 5.3: Characteristics of sample of the pilot study

No.	Acronym-Location	No. of Respondents	Category	Procurement Method	Type of Project	Value (RM m.)	Completion percentage %
1	Faculty Building-KL	3	Gov.	Conventional	Social Amenities	50-100	41-60
2	Hospital -KL	3	Gov.	Conventional	Social Amenities	100-300	61-80
3	Administration Building-KL	2	Gov.	Conventional	Non-Residential	50-100	61-80
4	Faculty Building-KL	2	Gov.	Conventional	Social Amenities	50-100	61-80
5	Hospital-KL	1	Gov.	Conventional	Social Amenities	100-300	More than 80
6	Stadium-KL	1	Gov.	Design & Build	Social Amenities	10-50	21-40
7	Condominium-Selangor	2	Private	Conventional	Residential	10-50	More than 80
8	Primary & secondary school-Selangor	2	Gov.	Conventional	Social Amenities	50-100	41-60
9	Bank-KL	1	Private	Design & Build	Non-Residential	500-1,000	21-40
10	Office Building-KL	1	Private	Conventional	Non-Residential	- [no answer]	61-80
11	Sport complex-KL	2	Gov.	Conventional	Social Amenities	10-50	21-40
12	Administration building-KL	4	Gov.	Conventional	Non-Residential	50-100	41-60
13	Library-Selangor	1	Gov.	Conventional	Social Amenities	Less than 10	More than 80
14	Hotel-KL	2	Private	Conventional	Non-Residential	10-50	Less than 20
15	Bank-KL	4	Mix	Turnkey	Non-Residential	100-300	21-40
Total Respondents		**31**					

Table 5.4: Characteristics of respondents of the pilot study

Respondent	Age Category	Gender	Education Level	Position in project	Exp. Construction	Profession
R 1	between 40-49	Male	Bachelor degree	Project Engineer	- [no answer]	-
R 2	between 30-39	Male	Bachelor degree	Project Engineer	Between 11-15 years	-
R 3	between 40-49	Male	Bachelor degree	Project Engineer	Between 11-15 years	-
R 4	less than 30	Female	Bachelor degree	Project Coordinator	Less than 5 years	Architect
R 5	between 50-59	Male	Bachelor degree	Project Coordinator	Between 16 - 20 years	-
R 6	between 40-49	Male	Bachelor degree	Project Manager	More than 25 years	-
R 7	between 30-39	Male	Bachelor degree	Project Consultant	Between 6-10 years	-
R 8	between 30-39	Male	Bachelor degree	Other	Between 6-10 years	-
R 9	between 40-49	Male	Bachelor degree	Project Manager	Between 16 - 20 years	-
R 10	between 30-39	Male	Bachelor degree	Project Coordinator	Between 6-10 years	-
R 11	between 40-49	Male	Bachelor degree	Project Manager	Between 16 - 20 years	-
R 12	between 40-49	Male	High school	Other	Between 16 - 20 years	-
R 13	between 30-39	Male	Bachelor degree	Project Manager	Between 11-15 years	Civil
R 14	between 40-49	Male	High school	Project Manager	More than 25 years	Architect
R 15	between 50-59	Male	PhD	Project Consultant	Between 16 - 20 years	QS
R 16	between 30-39	Female	Master degree	Project Consultant	Between 6-10 years	QS
R 17	between 50-59	Male	Bachelor degree	Project Consultant	More than 25 years	Civil
R 18	between 30-39	Female	PhD	Project Consultant	Between 11-15 years	QS
R 19	less than 30	Male	Others	Other	Less than 5 years	QS
R 20	between 40-49	Male	Bachelor degree	Other	Between 16 - 20 years	Civil
R 21	between 40-49	Male	Master degree	Project Manager	Between 16 - 20 years	Civil
R 22	between 30-39	Male	Bachelor degree	Other	-	Safety Officer
R 23	between 30-39	Male	Bachelor degree	Project Manager	Between 11-15 years	Civil
R 24	between 40-49	Male	Master degree	Project Consultant	More than 25 years	Civil
R 25	between 30-39	Male	Master degree	Project Consultant	Between 6-10 years	-
R 26	less than 30	Female	Bachelor degree	Project Engineer	Less than 5 years	QA/QC Eng.
R 27	between 30-39	Male	Bachelor degree	Project Engineer	Between 6-10 years	Civil
R 28	between 40-49	Male	Master degree	Project Director	Between 16 - 20 years	Civil
R 29	between 40-49	Male	Bachelor degree	Project Coordinator	Between 11-15 years	Civil
R 30	between 40-49	Male	Bachelor degree	Project Manager	Between 21 - 25 years	Civil
R 31	between 40-49	Male	Bachelor degree	Other	Between 11-15 years	Civil

5.16.4 Reliability of pilot study

Test of reliability was performed to check the internal consistency and stability of the instrument (Cavana et al., 2001). In other words, this tested whether the instrument would yield consistent answers when repeated. Test of reliability of the pilot study was conducted using Cronbach's alpha available in the SPSS package (version 19). The results revealed that reliability of the whole instrument (including the four constructs) was high at .853. If item deleted, scores of scales of fragmentation (FRAG), intra-project learning (INTRA), inter-project learning (INTER), and enablers (SUP) are .817, .758, .801, and .869, respectively (refer to Table 5.5). According to Malhotra (2003), Cronbach's alpha of .60 and above indicates good reliability. These results are encouraging to develop the final measurement instrument.

Table 5.5: Reliability of questionnaire survey of the pilot study

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
FRAG	11.2246	.969	.684	**.817**
INTRA	11.0628	.929	.824	**.758**
INTER	11.1174	.981	.724	**.801**
SUP	11.2512	1.052	.560	**.869**
The scale (all items)				**.853**

5.17 Measurement Instrument

After conducting face validity, content validity, and pilot study, the final instrument was developed. The final questionnaire form consists of a cover letter and an introduction to the topic showing the aim of the survey and definition of terms. As illustrated in Appendix (C), the questionnaire consists of a cover letter and five sections. Section I contains demographic information about the respondents, including age, education level, years of experience, gender, and so on. All questions in this section are categorical or dichotomous questions. Section II includes 29 items that indicate fragmentation. Section III consists of

26 items that measure intra-project learning, while Section IV consists of 17 items that measure inter-project learning. Section V consists of 27 items that measure enablers of project learning.

Table 5.6 lists all items of these four constructs. All these items are rated using a five-point Likert scale, ranging from 1 = Totally Disagree to 5 = Totally Agree (with the statement). The respondents shall write down a number between 1 to 5 by each statement. Each questionnaire survey requires 15 to 20 minutes to answer. Appendix C shows the questionnaire survey form.

A single separated sheet was distributed to the project manager to obtain general information about each project visited. This sheet consisted of general questions about the project, including the name (if possible), location, grade of main contractor, type of project, procurement method used, value of the project, and other information (refer to Appendix C).

Table 5.6: Measurement items of fragmentation, intra-project learning, inter-project learning, and enablers

No.	Indicator/Variable	Statement
Construct 1. FRAGMENTATION (indicators = 29)		
1. Integration		
1.1	Mutual objectives	In this project me and other team members have the same objective and focus (no individual objectives)
1.2	Seamless operation with no organizational boundaries	I form a single team with others though they come from different companies
1.3	Mutually beneficial outcomes	Project's outcomes and benefits will consider the whole project team rather than individuals working in this project
1.4	Increased time and cost predictability	I can easily access to information related to design and construction cost of this project
1.5	Unrestricted cross-sharing of information	Information related to this project are well managed

Table 5.6: Measurement items of fragmentation, intra-project learning, inter-project learning, and enablers (Cont'd)

No.	Indicator/Variable	Statement
1.6	Creation of single and collocated team	I work with all team members in one common site office
1.7	Equal opportunity for project inputs	In this project all team members have the same chance to contribute in making decisions about the work
1.8	Equitable team relationships and respect for all	In this project all team members are treated as having equal professional capability
1.9	No blame culture	There is no blame for individuals if a problem happen (group will take responsibility)
1.10		Problems will be solved by project team together rather than individuals
2. Coordination		
2.1	Lateral Relationship	In this project, I can directly call other team members (for example designer and other consultants)
2.2		I often have meetings with other team members (for example designer and other consultants)
2.3	Information Technology	Information Technology (IT) facilitates the coordination my work that is related to other members
2.4	Interpersonal Relationships	I have long-term business relationship with most of the team members
2.5	Coordinator Role	The coordinator of this project plays important role to bring different people together
3. Collaboration		
3.1	Trust (relational)	I trust other team members working in this project though they come from different companies
3.2	Focus on the end-user needs	I, and other team member, focus on the need of the owner of this project
3.3	Self-governing team	In this project, I and other team members have the freedom to organize our work for better outcomes
4. Boundaries		
4.1	Expertise boundaries	In this project, I feel there are barriers between me and other professionals who have different background
4.2	Cultural boundaries	There are cultural barriers between me and other team members (especially those from different ethnic groups)
4.3	Language boundaries	There is a language barrier between me and other team members (especially those from different ethnic groups)
4.4	Organizational boundaries	I feel there is a barriers between me and other team members come from other companies
5. Decoupling of Diversity		
5.1	Diversity	My contact with members who come from different background or discipline is limited
5.2	Participation	I, with members from different background, can participate in different tasks to make appropriate decision-making (for example to solve a problem related to design)
5.3	Design clashes	Clashes and discrepancies (omissions / errors of design) are difficult to resolve in this project
5.4	Good relationship	I have good relationship with most of project team (including contractor's team and consultants)
6. Spanning boundaries (for integrating diverse knowledge)		
6.1	Spanning project knowledge boundaries – Contextual Knowledge	I need to get sufficient information from previous phases
6.2		I need to get sufficient information from other project consultants
6.3		It is difficult for me to understand some information from other occupational or disciplinary group
Construct 2. INTRA-PROJECT LEARNING (indicators = 26)		
1. Knowledge Creation		
1.1	Informal dialogue	I often have informal dialogue with other team members (example a discussion over coffee break)
1.2	Contact external consultant	I often contact external consultant if there is a new idea or problem to discuss
1.3	Face-to-face interaction	I communicate with experts face-to-face (in-person) to get some experience or information
1.4	Periodic meetings	I attend frequent meetings with experts to discuss issue related to this project
1.5	Group discussion	Normally I attend group discussions about certain issues or problems related to this project
2. Collective Learning		

Table 5.6: Measurement items of fragmentation, intra-project learning, inter-project learning, and enablers (Cont'd)

No.	Indicator/Variable	Statement
2.1	Opportunities for inquiry	I am always encouraged to ask questions about issues related to the project
2.2	Mistake admission	I can tell about mistakes I do freely
2.3	Problem solving	I consider that solving problems in this project is efficient (example resolving design clashes or omissions)
2.4		When problem happen we will report to upper management
2.5	Understanding	In this project, we have to identify the causes of problems happen in the site
2.6	Absorb new technology	In this project, I have implemented new technology / technique
3. Knowledge Sharing		
3.1	Trust (knowledge sharing)	I trust other team members so I can share my experience with them freely
3.2	Communication	I have been able to directly contact all people in this project
3.3	ICT	Information Communication Tools (ICT) facilitates my communications with other members in this project
4. Environment / Leader Support		
4.1	Delegation	Project leader delegate some of his work to me and to other team members
4.2	Supporting collaboration	I am encouraged to collaborate with new colleagues
4.3		It is always appreciated when we collaborate with people from other companies
4.4	Learning from mistakes	We need to learn from mistake and not to be punished for trying new things
4.5	Second chance	We deserve to have second chance if we made mistakes
5. Openness and influence		
5.1	Open discussions	I can have an open (frank) discussion about issues or problems related to this project
5.2	Alternative working method	We always try to find alternative ways of working method
5.3	Telling others' mistakes	I always tell persons people see doing wrong or using insufficient method
6. Ibert's Theory		
6.1	Knowledge in action	In this project, interaction with other team members has polished my experience
6.2	Decoupling of routines	We always follow the common routines/standards of doing work in this project
6.3	Task commitment	I feel that this project is a challenging task for me
6.4		I am committed to the main objective of this project
Construct 3. INTER-PROJECT LEARNING (indicators = 17)		
1. Experience Accumulation		
1.1	Person-to-person communication	In this project, mostly we communicate face-to-face other than other ways (e.g. telephone, email etc.)
1.2	Informal encounters	Usually I see team members off-the-project for informal gathering or activities
1.3	Imitation	I use some ideas/techniques from other projects and implement it in this project
2. Knowledge Articulation		
2.1	Intra-project correspondents	Usually I contact people in other project to discuss about certain issues related to this project
2.2	Debriefing meetings	We conduct special meetings to obtain some useful information oabout the project
2.3	Brainstorming sessions	I attend brainstorming sessions with colleagues to discuss certain problems
2.4	Formal project reviews	In this project we conduct investigation to review some problems and identify their causes
2.5	Ad hoc meetings	Other than the regular meetings, I attend meetings when something urgent need to be discussed
2.6	Lessons learnt sessions	I attend meetings/activities to develop lessons that can be learned from this project
3. Knowledge Codification		
3.1	Project plan/audit	Project plans are recorded clearly so can be kept for future usage
3.2	Milestone deadlines	Important information as project milestones are recorded clearly
3.3	Meeting minutes	Meeting minutes in this project will be kept for future usage
3.4	Project history files	This project has a compiled record of 'project history'
3.5	Intra-project database	There is a database in this project so I can record important issue or lesson that can be learned in future projects
4. Networking		
4.1	Visiting other projects	I visited other projects during this project
4.2	Transfer ideas to main office	I contact some colleagues in the main office in the company
4.3	Communication with others	It is easy to find people in this project or other project to answer my inquiries
Construct 4. ENABLERS OF PROJECT LEARNING WITHIN FRAGMENTATION (indicators = 27)		
1. Results of the qualitative study		

Table 5.6: Measurement items of fragmentation, intra-project learning, inter-project learning, and enablers (Cont'd)

No.	Indicator/Variable	Statement
1.1	Meetings	I need to attend more meetings to share experience and exchange knowledge
1.2	Spirit of project team	There is a need for everybody to feel the spirit of one project team
1.3	Organizational policy	Being open to everybody in the project is one of my company's policies
1.4	Client role	Project owner has important role to play in getting different project team together
1.5	Incentives	I am willing to share my experience if I get appropriate incentive (monetary incentive for example)
1.6	Business relationship	I share my experience only with people who I have long-term business relationship
1.7	Sharing with friends	I share my experience with my friends only
1.8	Mutual benefits	I share my experience with other members if there are benefits for all of us and for the project
1.9	Learning as project's goal	It is important to set learning as one of the project's goals
1.10	Supporting dialogue, conversation and discussion	This project needs more support from project leader for dialogue, conversations and open discussions with everybody
1.11	Leader as a role model	Our leader should show role model in open communication, honesty and show how to trust others
1.12	Attitude of project manager	Project manager attitude can influence my relationship with people from other companies in this project
1.13	Supporting good relationship	Project manager/leader has to encourage us to build up good relationship with every team members
1.14	Project culture	We need to be committed to respect each other's views
2. Boundary Crossing Objects (BCO)		
2.1	Institutionalized BCO to build up shared meaning	Drawings and specification of this project play important role to facilitate ideas and experience sharing
2.2		Construction contract can play important role to obligate experience sharing between project team
2.3	Non-institutionalized BCO to build up shared meaning	We need more support to be trusted by other team members especially those from other companies
2.4		I need to feel that my experience is valuable for other team members
2.5	IT / ICT	ICT tools (as video conferencing etc.) will be useful for better communication with other project team (e.g. the designer)
3. Sense's Model (Situated Learning Theory)		
3.1	Learning relationships	I think it is important to know each other's experience and abilities so we can share knowledge better
3.2	Cognitive style	I prefer to learn by thinking of different ways of doing things and like to challenge the current standards in this project
3.3		I prefer to learn by looking at how things are being done and I found changing the existing standards very difficult
3.4	Learning mandate	The setting of site office allow for better communication with everybody
3.5		I have enough time to discuss and share experience with other team members
3.6		This project has the appropriate resources for learning
3.7	Pyramid of authority	I understand my role in sharing experience and learning in this project
3.8		I like to make decisions about the way I can learn from this project

5.18 Data Collection

The sample used for the pilot study was excluded from this stage. Data collection lasted for three months, starting from April 12, 2011 until July 15, 2011. The researcher distributed the questionnaire survey to building projects granted access and conducted by G7 contractors in Kuala Lumpur and Selangor. The study targeted only professionals working in the project site to record their opinion on the practice of project learning as well as the influence of fragmentation. Data collection was self-administered; the researcher visited, distributed, and collected the questionnaire by hand. Reaching respondents within the construction site was difficult to achieve using mail or e-mail. A number of questionnaires were distributed and collected by two enumerators. This expedited the process of data collection.

The total number of respondents approached was approximately 650 in the project sample. However, only **203** valid questionnaires were collected. This represents a respondent rate of approximately 31%. Questionnaires were collected from **36** accessed projects. On average, approximately six respondents in each project answered the questionnaire survey.

Prior to conducting the analyses, satisfying certain requirements of multivariate data analysis is important (Hair et al., 2006). The following elaborates the examination of data for multivariate analysis.

5.19 Examining Data for Multivariate Analysis

Multivariate analysis involves simultaneous analyses of three or more variables (Bryman, 2004). Examining collected data is essential before commencing the multivariate analysis. Data examination helps to obtain truly valid and accurate results and include, but not limited to the following: missing data, outliers, and test of normality (Hair et al., 2006). The following paragraphs elaborate these in detail.

5.19.1 Missing data

Missing data can serve as threat to the distribution of data and quality of results. In some questionnaire forms, there must be some lift-out questions that respondents forget or decline to answer or to tick the appropriate response. According to Hair et al. (2006), understanding the causes of missing data before selecting an appropriate remedy is important. Hair et al. (2006) identified the following steps to manage missing data:

1. Determine type of missing data: This process involves understanding the causes of missing data. Some missing data are ignorable; in such cases, no specific remedy is required. Other missing data can be categorized as known and unknown. According to Hair et al. (2006), known reasons include procedural factors such as errors in data entry, disclosure restriction, failure to complete the entire questionnaire, or even morbidity of respondents. Remedies for this type of missing data are applicable if missing data are found to be random. Unknown missing data processes are related to respondents. For example, respondents refuse to respond or possess insufficient knowledge. Both known and unknown missing data were found in the data set of the current study. Errors in data entry (known reason) were corrected accordingly. Remedies for unknown missing data will be illustrated in the following steps.

2. Determine the extent of missing data: The extent of missing data can be examined by considering the percentage of variables and number of cases with missing data. Less than 10% of missing data for individual cases can be ignored, unless it occurs in specific nonrandom manner, while cases with 50% or more shall be deleted (Hair et al., 2006). In the current study, all cases have less than 10% missing data for each individual case (refer to Appendix D for table on missing data analysis). The extremist case has only five missing data, which account for merely 4% of overall data. The low percentage of missing data is affected possibly by the design of questionnaire (itemized scale requests the respondents to write down a number instead of ticking on a box). Hence, the researcher decided to retain all cases with missing data and conduct the appropriate remedy. In addition, 14.9% of non-factual variables have missing data. The researcher decided not to delete any variable, but rather to utilize the suitable imputation method, as will be shown in the following paragraphs.

3. Diagnose the randomness of missing data: According to Hair et al. (2006), there are two levels of randomness: missing at random (MAR) and missing completely at random (MCAR). As the level of missing data for each case was not sufficient to warrant action (only 4%), the researcher decided to consider the missing data as MCAR. The next step is to choose the appropriate imputation method for missing data remedy.

4. Select the imputation method: There are several methods for managing missing completely at random (MCAR) data. These include imputation using only valid data (including complete case approach and using all-available data) and imputation by using replacement values (including using known replacement values and calculating replacement values) (Hair et al., 2006).

The researcher decided to use the all-available data imputation method to analyze the missing data. In SPSS, PAIRWISE represents this method. The decision was also made based on the following criteria:

- Level of missing data is relatively low.
- Sample size is not large enough to call for other methods that exclude missing data from the analysis (e.g., LISTWISE).
- The relationship between variables is considered to be moderated (no need to use methods that depend on using replacement values as the mean).

5.19.2 Outliers

Outliers can be defined as observation with a unique combination of characteristics that differ from other observations (Hair et al., 2006). Outliers, in some cases, can be caused by errors in data entry. Boxplots can be used to identify any outlier that occurred due to errors in data entry or other errors. The plot can show any value ranging beyond the normal range of the scale, particularly above 5 or below 1, except the pre-defined values of missing data (e.g., 99).

According to Hair et al. (2006), outliers can be classified into procedural error (must be corrected), extraordinary event, extraordinary observation (has no explanation and can be omitted unless it represents the population), and unique in their combination of value across the variables. There are three methods to detect outliers: univariate detection, bivariate detection, and multivariate detection (Hair et al., 2006). This study used both univariate detection and multivariate detection. Bivariate detection was not considered as scatterplots, which are used to demonstrate the relationship between pairs of variables, require a significant number of plots.

1. Univariate detection: Detecting univariate outliers involves converting data values to standard scores with a mean of 0 and standard deviation of 1 (Hair et al., 2006). The following steps demonstrate how data in the current study were converted into standard score using SPSS (version 19):

- From Analyze, choose Descriptive Statistics, then choose Descriptives.
- Choose all the metric variables and tick on the box "*Save standardized values as variables*".
- In data view, we can observe that the program adds new variables starting with the letter Z followed by the original name of our variables (e.g., ZFrag1).

Standardized variables with values up to ± 4 were considered as probable outliers (Hair et al., 2006). The researcher identified 15 probable univariate outliers within 11 cases. The decision to eliminate outlier cases will depend on whether these cases are aberrant and do not represent the population (Hair et al., 2006). The researcher decided to eliminate cases that have more than one outlier, and whose respondents are non-experts (i.e., respondents who are below 30 years old, do not have a degree, or have less than five years of experience in construction). Thus, six cases were eliminated from the data set.

2. Multivariate detection: The researcher used Mahalanobis D^2 measure to detect any outlier of multivariate combination of variables. The value that resulted from dividing the D^2 by the number of variables involved (i.e., D^2/df) should be less than 3 or 4 in large samples with significance level of .005 or .001 (Hair et al., 2006). SPSS produced a variable called (MAH_1) that showed the scores of D^2. The researcher computed the probability of MAH_1 using the compute command in SPSS (version 19), as shown in the following:

- From Transform, choose Compute Variable.
- Choose **Cdf.Chisq** from Function Group.
- Assign (MAH_1) to this function, followed by comma, followed by the number of dependent variables.
- Choose a name for the new computed variable in the Target Variable (e.g., P_MAH_1).
- Click on OK and notice the new added variable (P_ MAH_1) in the Data View.

The current study identified three cases that have probable multivariate outliers. The researcher observed that outliers of multivariate variables were not the same as univariate variables. The decision to eliminate or keep these outliers again depended on whether these cases were aberrant and did not represent the population. Respondents of these three cases had little experience and their answers were not highly consistent. Therefore, the researcher decided to eliminate these from the analysis.

Thus, the total number of eliminated cases was nine. This reduced the number of the sample from **203** to **194** cases. The researcher believes eliminating these cases will not influence the results as they represent a trivial percentage of the total number of cases.

5.19.3 Test of normality

Test of normality is important because large non-normality distribution results in invalid statistical tests (Hair et al., 2006). Some tests of normality include Shapiro-Wilks and Kolmogorov-Smirnov tests. In addition, normality can be tested statistically using the following equations (Hair et al., 2006):

$$Z_{sk} = \frac{Skewness}{\sqrt{6}/N} \quad \text{..}(5.6)$$

(value of Z_{sk} should be ± 2.58.)

$$Z_{ku} = \frac{Kurtosis}{\sqrt{24}/N} \quad \text{..}(5.7)$$

(value of Z_{ku} should be ± 1.96.)

The current study will not perform rigorous tests of normality. This is because partial least squares-path modeling (PLS-PM) analysis does not necessitate normal distribution of the sample (Chin & Dibbern, 2010; Chin & Newsted, 1999; Fornell & Bookstein, 1982). More discussion on this point can be found in a previous section on PLS in this chapter.

5.20 Reliability of Measurement Scale

Test of reliability of the final instrument was conducted using SPSS (version 19). The whole scale obtained quite a high result of .842 of Cronbach's alpha. This indicated a good reliability of measurement scale. For fragmentation scale, the result of Cronbach's alpha was quite satisfactory. Fragmentation (FRAG) obtained .768, as shown in Table 5.7. On the other hand, intra-project learning (INTRA-PL) and inter-project learning (INTER-PL) obtained higher results at .858 and .852, respectively. The last measurement scale, enablers of project learning (SUPP), obtained the highest results among the other scales with .880 of Cronbach's alpha.

Table 5.7: Reliability of the questionnaire survey

Construct	N of Items	Cronbach's Alpha
FRAG	29	.768
INTRA-PL	26	.858
INTER-PL	17	.852
SUPP	27	.880
The scale (all items)	99	.842

5.21 Descriptive Analysis

This section intends to show a general picture of the data. This includes frequencies of projects (i.e., sample) and frequencies of respondents (i.e., unit of analysis). Descriptive statistics include describing single variables and/or the associations between variables (Babbie, 2010). Univariate analysis denotes describing single variables, while bivariate analysis is concerned about analyzing two variables to uncover their relationship (Bryman & Bell, 2007). The current study shows the univariate descriptive statistics of each categorical variable only.

5.21.1 Frequencies of projects

For the survey, the total number of selected projects is 36 building projects. All projects were undertaken by G7 contractors. Table 5.8 provides information about the projects, which included project sectors, procurement method used, and other information. Value of projects, number of firms, and number of team members can indicate the size and complexity of projects. Table 5.9 summarizes the frequency of all projects. Appendix (E) shows the distribution of the projects in plot-form.

Table 5.8: Information of the sample projects

No.	Project's Acronym	Sector	Procurement Method	Completion Percentage %	Category	Value (RM m)	No. of Firms	No. of team members
1	Hotel & Office	Private	Conventional	Less than 20	Mix development	between 501-1000	between 5-14	11
2	Administration Building	Government	D&B	Less than 20	Non residential	between 301-500	between 15-24	20
3	Shopping Mall	Private	Conventional	More than 81	Non residential	between 101-300m.	between 5-14	30
4	Office Building	Government	Conventional	Between 21-40	Social amenities	between 51-100	between 35-44	5
5	Opuleria	Private	Others	Less than 20	Infrastructure			8
6	Bank	Private	D&B	Between 21-40	Non residential	between 301-500	between 5-14	26
7	Apartment & shop	Mixed	Turnkey	Between 61-80	Residential	between 51-100	between 15-24	10
8	Hospital	Government	Turnkey	Less than 20	Social amenities	between 301-500	more than 45	50
9	Condominium	Private	D&B	Between 21-40	Residential	between 301-500	between 15-24	16
10	Condominium	Private	D&B	More than 81	Residential	between 301-500	between 15-24	20
11	Condominium	Private	Conventional	Less than 20	Residential	between 101-300	between 5-14	15
12	Central Park	Private	Conventional	Less than 20	Mix development	between 101-300	between 5-14	13
13	Condominium	Private	D&B	Between 41-60	Residential	between 301-500	between 15-24	15
14	Boulevard Plaza	Private	D&B	Between 41-60	Non residential	between 101-300	between 5-14	20
15	Condominium	Private	Conventional	Between 41-60	Residential	between 51-100	between 5-14	20
16	Office	Private	Conventional	Between 21-40	Non residential	between 10-50	between 5-14	10
17	Airport	Mixed	D&B	Between 21-40	Infrastructure	between 501-1000		60
18	Condominium	Private	Conventional	Less than 20	Residential	between 101-300	between 15-24	8
19	Condominium	Private	Conventional	Between 61-80	Residential	between 501-1000	between 25-34	15
20	Commercial Building	Private	D&B	Between 21-40	Mix development	between 101-300	between 5-14	10
21	Hotel	Private	Conventional	Between 41-60	Non residential	between 51-100	more than 45	30
22	Education Building	Government	Conventional	More than 81	Social amenities	between 101-300	between 5-14	15
23	Faculty	Government	Conventional	More than 81	Social amenities	between 51-100	between 5-14	10

Table 5.8: Information of the sample projects (Cont'd)

No.	Project's Acronym	Sector	Procurement Method	Completion Percentage %	Category	Value (RM m)	No. of Firms	No. of team members
24	Office Tower	Private	Conventional	Between 41-60	Non residential	between 101-300	between 5-14	25
25	Condominium	Private	D&B	Less than 20	Residential	between 301-500	between 5-14	10
26	Condominium & Shopping Mall	Mixed	D&B	Between 61-80	Mix development	between 51-100	between 15-24	
27	Condominium	Private	Conventional	Between 41-60	Residential	between 101-300	between 15-24	25
28	Hospital	Government	D&B	Between 61-80	Social amenities	between 101-300	between 25-34	40
29	Office	Mixed	Conventional	Less than 20	Non residential	between 501-1000	between 25-34	30
30	Commercial Retails & Hotel	Private	Conventional	Between 41-60	Mix development	between 301-500	between 5-14	15
31	Condominium & Shopping Mall	Private	Conventional	Between 21-40	Mix development	between 101-300	between 5-14	8
32	Condominium & Shopping Mall	Private	Conventional	Between 21-40	Mix development	between 51-100		13
33	Residential Units	Private	D&B	Between 21-40	Residential	between 51-100	between 5-14	15
34	Condominium	Private	Conventional	Between 41-60	Residential	between 101-300	between 5-14	2
35	Complex Centre	Private	Conventional	Between 41-60	Social amenities	between 51-100	between 5-14	10
36	Residential Units	Private	Conventional	Between 41-60	Residential	between 101-300	between 25-34	20 (**Total** ≈ 650)

*Blank fields indicate missing data

Table 5.9: A summary of distribution and frequencies of the selected projects

Project Information	Details [Frequency]					Total
Sector	Private **[26]**	Government **[6]**	Mixed **[4]**			**36**
Procurement method	Conventional **[21]**	Design and Build **[12]**	Turnkey **[2]**	Build, Operate, Transfer **[0]**	Others **[1]**	**36**
Completion percentage	Less than 20% **[9]**	Between 21-40% **[9]**	Between 41-60% **[10]**	Between 61-80% **[4]**	More than 81% **[4]**	**36**
Type	Residential **[13]**	Non Residential **[8]**	Social Amenities **[6]**	Mix Development **[7]**	Others **[2]**	**36**
Value (RM Million)	Between 10-50 **[1]**	Between 51-100 **[9]**	Between 101-300 **[13]**	Between 301-500 **[8]**	Between 501-1000 **[4]**	**34** (2 missing)
No. of firms in projects	Between 5-14 **[18]**	Between 15-24 **[8]**	Between 25-34 **[4]**	Between 35-44 **[1]**	More than 45 **[2]**	**33** (3 missing)

5.21.2 Frequencies of respondents

The total number of valid questionnaires is 203. However, after eliminating the outliers, as indicated previously, the number of final cases was reduced to 194. Table 5.10 shows the profile of respondents including age, years of experience, gender, position in the project, background of respondents and experience in project review or audit. Most of the respondents are aged between 40-49 (34.5%) and majority of them hold a bachelor's degree (58.8%). Most respondents have working experience between 11-15 years in the construction industry. The respondents are a homogenous sample of project managers, consultants, project engineers, resident engineers, and other professionals with different backgrounds. Appendix (E) shows the distribution of respondents in scatter plot.

Table 5.10: Frequencies of respondents

Age of respondent					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 30	36	18.6	18.6	18.6
	between 30-39	60	30.9	30.9	49.5
	between 40-49	67	34.5	34.5	84.0
	between 50-59	30	15.5	15.5	99.5
	more than 59	1	.5	.5	100.0
	Total	194	100.0	100.0	
Education level of respondent					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	High school	9	4.6	4.7	4.7
	Bachelor degree	114	58.8	59.1	63.7
	Master degree	55	28.4	28.5	92.2
	PhD	2	1.0	1.0	93.3
	Other	13	6.7	6.7	100.0
	Total	193	99.5	100.0	
Missing	99	1	.5		
Total		194	100.0		
Years of experience in construction industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5 years	36	18.6	18.6	18.6
	Between 6-10 years	42	21.6	21.6	40.2
	Between 11-15 years	48	24.7	24.7	64.9
	Between 16 - 20 years	43	22.2	22.2	87.1
	Between 21 - 25 years	15	7.7	7.7	94.8
	More than 25 years	10	5.2	5.2	100.0
	Total	194	100.0	100.0	
Gender of respondent					

Table 5.10: Frequencies of respondents (Cont'd)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	174	89.7	89.7	89.7
	Female	20	10.3	10.3	100.0
	Total	194	100.0	100.0	
Position in the project					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Project Manager	26	13.4	13.5	13.5
	Manager Assistant	18	9.3	9.4	22.9
	Project Consultant	17	8.8	8.9	31.8
	Project Engineer	46	23.7	24.0	55.7
	Resident Engineer	30	15.5	15.6	71.4
	Resident Architect	18	9.3	9.4	80.7
	Other	37	19.1	19.3	100.0
	Total	192	99.0	100.0	
Missing	99	2	1.0		
Total		194	100.0		
Background					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Civil engineering	74	38.1	38.9	38.9
	Architecture	54	27.8	28.4	67.4
	QS	12	6.2	6.3	73.7
	Mechanical engineering	37	19.1	19.5	93.2
	Others	13	6.7	6.8	100.0
	Total	190	97.9	100.0	
Missing	99	4	2.1		
Total		194	100.0		
Experience in project reviews / audit					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	68	35.1	35.4	35.4
	No	124	63.9	64.6	100.0
	Total	192	99.0	100.0	
Missing	99	2	1.0		
Total		194	100.0		

5.22 Principal Component Analysis Procedures and Results

As stated previously, principal component analysis (PCA) was selected to extract factors/components and summarize variables of each construct. It must be emphasized that this method is aligned with the PLS approach (Chin, 1995). Collectively, there are four main constructs, each being measured by number of variables. PCA analyses will be conducted for each construct separately.

Different tests will be conducted to assess the appropriateness of factor analysis, which include Kaiser-Meyer-Olkin (KMO), Bartlett, and goodness-of-fit (Hair et al., 2006). The threshold of KMO is .60 (Tabachnick & Fidell, 1989). Bartlett's test of sphericity determined if the correlation matrix is an identity matrix, which implies meaningless factor analysis (Field, 2000). The results should reveal the appropriate significance level.

5.22.1 Parallel analysis

This analysis will be conducted prior to PCA to identify the appropriate number of extracted components. Traditional methods to determine the number of components include identifying all factors that have eigenvalues equal to one or above, or observing the cut-off point in the scree plot (Hair et al., 2006). As stated previously, O'Connor (2000) developed a syntax for SPSS based on parallel analysis (Horn, 1965) to determine the number of extracted factors either for PCA or for exploratory factor analysis. Appendix (F) shows O'Connor's syntax and the steps of conducting this analysis using SPSS. The output of this analysis contains a plot called "Tsplot," which is similar to scree plot but with near horizontal lines crossing the main line of the eigenvalue. Factors above these crossing lines will be determined as the appropriate number of extracted factors. Results of parallel analysis and PCA of the four measurement models – namely, fragmentation, intra-project learning, inter-project learning, and enablers – are shown in the following paragraphs.

5.22.2 Parallel analysis and PCA of fragmentation

The results of parallel analysis indicated four components of fragmentation as a fixed number to be extracted when conducting PCA later on. As shown in the following Tsplot, factors above the extraction line will be considered. Y-axis represents the eignenvalue while X-axis represents the number of variables. The full output of parallel analysis can be found in Appendix F (example is inter-project learning).

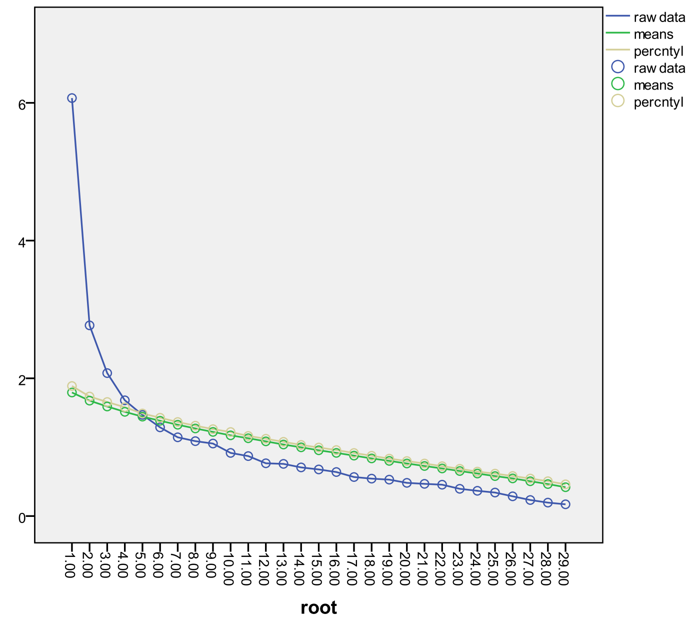


Figure 5.4: Tsplot of fragmentation

After determining the appropriate number of components to be extracted, principal component analysis was conducted using SPSS (version 19). Criteria used to extract factors of fragmentation using SPSS are as follows:

- Extraction method: principal component analysis – number of extracted factor was restricted by the results of parallel analysis (4 components);
- Rotation method: Oblique (Promax – kappa = 4);
- Missing data: excluding cases Pairwise; and
- Factor loading $\geq .40$ (Hair et al., 2006).

These criteria yielded good results of communalities, total variance extracted, and pattern matrix. Results of KMO, Bartlett's test, goodness-of-fit, and rotated pattern matrix are illustrated in Table 5.11. The KMO result was .784, which is above the threshold. The result of Bartlett's test of sphericity was 1858.91, with a significance level of .000. These results indicated the appropriateness of conducting factor analysis. The four extracted factors can explain 43.4% of the total variance. Commonalities of variables were generally good at above .50 for most variables; however, some variables loaded less than .50 but not less than .20, and that is generally satisfactory. Loadings of the extracted factors are illustrated in the pattern matrix in Table 5.12. There is only one cross-factor variable shared between Components 1 and 4. The researcher decided to eliminate this variable from Component 1 and retain it in Component 4. This is because this variable shares some theoretical aspects with other variables under this component.

Table 5.11: KMO and Bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.784
Bartlett's Test of Sphericity	Approx. Chi-Square	1858.909
	df	406
	Sig.	.000

Table 5.12: Pattern matrix of fragmentation (rotated matrix of PCA)

Pattern Matrix[a]					
Variable	Label	Component's Loading			
		1	2	3	4
Frag28	Insufficient information from previous stages	-.829			
Frag29	Insufficient information from other consultants	-.819			
Frag14	Long term relationship	.715			
Frag27	Understanding other professionals	~~-.671~~			.444
Frag9	No blame culture	.578			
Frag4	Access information easily	.533			
Frag8	Equality	.531			

Table 5.12: Pattern matrix of fragmentation (rotated matrix of PCA) (Cont'd)

Frag5	Well managed information	.525			
Frag13	Role of IT	.478			
Frag23	Good relationship with others	.404			
Frag7	*Contribution* [b]				
Frag2	*Single team*				
Frag10	*Collective problem solving*				
Frag25	Participation		.577		
Frag1	Common objectives		.561		
Frag12	Regular meetings		.531		
Frag17	Focus on project owner's needs		.496		
Frag6	Common site office		.475		
Frag3	Project's outcomes consider whole team		.462		
Frag11	Contact others directly		.456		
Frag18	Freedom for self organizing team		.408		
Frag16	*Trust*				
Frag20	Organizational barriers			.819	
Frag22	Cultural barriers			.808	
Frag21	Language barriers			.801	
Frag19	Professionals barriers			.749	
Frag24	Contact with other professionals				.739
Frag26	Solving discrepancies - clashes				.723
Frag15	*Role of coordinator*				

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 7 iterations
b. The variables in italic font will be eliminated from further analysis as they score less than .40

Out of 29 variables indicating fragmentation, 24 were extracted under four components. Names of the new components can be retained or changed according to the variables loaded to them. According to Hair et al. (2006), a component can be assigned a name according to the highest variable loaded to it. In addition, the name can be assigned according to the whole set of variables representing the component. It is worth mentioning that PCA changed the grouping of some variables under other components. For example, some variables of integration, collaboration, and coordination were grouped under one component, which may be named "Integration" as it contained majority of integration variables.

Component 1 can be called "Spanning Knowledge across Boundary" (SKB) as variables under this component indicate attributes of information and knowledge across different stages of project and boundaries. Component 2 may be named "Integration" (INTEG) as it involves majority of the variables of integration as in the theoretical framework. Component 3 may be assigned the name "Barriers" (BARRIER) as it involves all variables of the original construct in the theoretical framework. Lastly, Component 4 may be named "Decoupling of Diversity" (DoD) as it also involves some items in the original construct.

5.22.3 Parallel analysis and PCA of intra-project learning

The results of parallel analysis of intra-project learning suggested one component as a fixed number for extraction (refer to Figure 5.5). However, one factor or component does not provide enough variance for the construct, so the decision was made to extract two components to obtain better results.

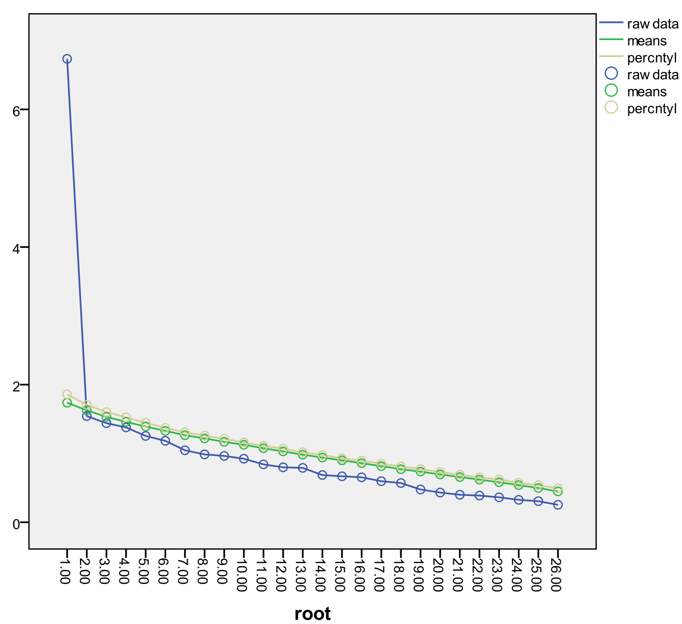


Figure 5.5: Tsplot of intra-project learning

Principal factor analysis of intra-project learning construct was conducted using the following criteria:

- Extraction method: principal component analysis – number of extracted factor (2 components);
- Rotation method: Oblique (Promax – kappa = 4);
- Missing data: excluding cases Pairwise; and
- Factor loading ≥ .40.

The results of KMO, Bartlett's test, and pattern matrix are shown as follows:

Table 5.13: KMO and Bartlett's test of intra-project learning

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.833
Bartlett's Test of Sphericity	Approx. Chi-Square	1416.899
	df	325
	Sig.	.000

Table 5.14: Pattern matrix of intra-project learning (PCA results)

Pattern Matrix [a]			
Variable	Label	Component	
		1	2
IntraPL21	Commitment to main objectives of project	.813	
IntraPL19	Collaboration support	.602	
IntraPL26	Project as challenging task	.597	
IntraPL1	Trust- knowledge sharing	.536	
IntraPL3	Face-to-face communication	.525	
IntraPL8	Group discussions	.517	
IntraPL5	Contact team members directly	.512	

Table 5.14: Pattern matrix of intra-project learning (PCA results) (Cont'd)

IntraPL9	Asking others	.509	
IntraPL2	Informal dialogue	.453	
IntraPL15	Identifying problem reasons	.421	
IntraPL11	Open discussion	.400	
IntraPL20	*Collaboration with people from other companies* [b]		
IntraPL16	*Report problems to upper management*		
IntraPL24	*Interaction to polish knowledge*		
IntraPL13	*Alternative ways of doing things*		
IntraPL17	Implement new technology or methods		.772
IntraPL10	Mistakes admission		.764
IntraPL4	Contact external consultant		.660
IntraPL12	Tell others doing wrong		.533
IntraPL6	Role of ICT		.523
IntraPL25	Following the common routine of work		-.454
IntraPL18	Delegate works		.434
IntraPL14	Efficient problem solving		.424
IntraPL22	*No punishment for trying new things*		
IntraPL7	*Frequent meetings*		
IntraPL23	*Second chance*		

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 3 iterations.
b. The variables in italic font will be eliminated from further analysis as they score less than .40

Out of 26 variables in the original measurement, 19 variables were extracted to measure intra-project learning. The new components may be named "(INTRAPL-1)" and "(INTRAPL-2)," or any other name representing variables under each component. The first component represents the "social" aspects of learning, such as face-to-face communication, discussion, and so on. Meanwhile, the second component involves "technical" aspects of learning, such as implementing new technology, problem solving, and so on.

5.22.4 Parallel analysis and PCA of inter-project learning

The same criteria of fragmentation and intra-project learning were used to determine the number of components for inter-project learning. The results of parallel analysis suggested two components of inter-project learning that should be extracted. As shown in the following Tsplot, factors above the extraction line will be determined.

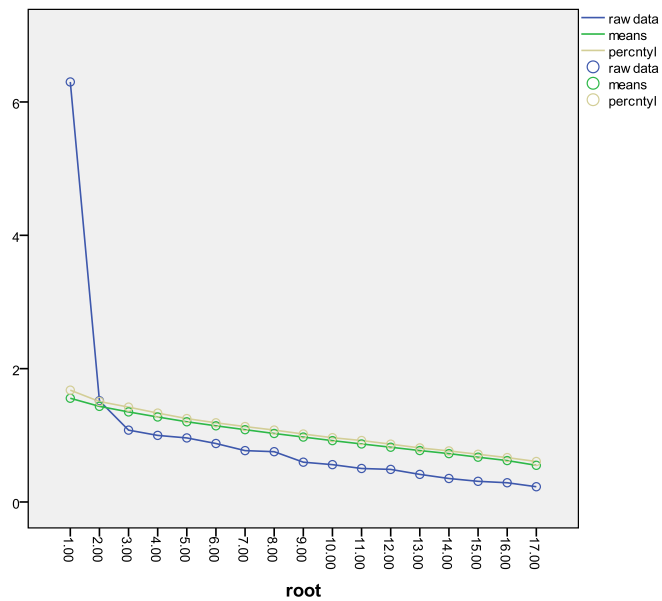


Figure 5.6: Tsplot of inter-project learning

Principal factor analysis of inter-project learning construct was conducted using the same criteria as the ones employed in fragmentation and intra-project learning. The only difference is the number of components to be extracted (two components). The results of KMO, Bartlett's test, and pattern matrix are shown in Tables 5.15 and 5.16.

Table 5.15: KMO and Bartlett's test of inter-project learning

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.859
Bartlett's Test of Sphericity	Approx. Chi-Square	1248.744
	df	136
	Sig.	.000

Table 5.16: Pattern matrix of inter-project learning (PCA results)

Pattern Matrix [a]			
Variable	Label	Component	
		1	2
InterPL16	Visiting other projects	.855	
InterPL5	Communication with people from other projects	.853	
InterPL2	Informal gathering off the project	.769	
InterPL7	Brainstorming sessions	.688	
InterPL6	Debriefing meetings	.636	
InterPL14	Project history	.594	
InterPL3	Networking	.582	
InterPL17	Transfer knowledge to main office	.565	
InterPL4	Using knowledge from other projects	.488	
InterPL10	Lessons learned sessions	.449	
InterPL15	*Lessons learned database* [b]		
InterPL1	*Face-to-face communication*		
InterPL12	Storage of important information		.903
InterPL11	Storage of project plans		.797
InterPL8	Review sessions		.637
InterPL9	Ad hoc meetings		.584
InterPL13	Storage of meeting minutes		.451

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 3 iterations.
b. The variables in italic font will be eliminated from further analysis as they score less than .40

The results of PCA indicated 15 variables of inter-project learning. Only two variables have been eliminated from further analysis as they scored loading of less than .40. Similar to intra-project learning, the two components may be named (INTERPL-1) and (INTERPL-2). Essentially, the first component represents the process of experience accumulation to knowledge articulation. Meanwhile, the second component represents the process of knowledge articulation to knowledge codification. This indicates the continuity and intertwined process of inter-project learning. These findings will be discussed further in the next chapter.

5.22.5 Parallel analysis and PCA of enablers

The criteria for determining the number of components of enablers of project learning using parallel analysis are similar to the previous procedure. The results of parallel analysis suggested three components of enablers of project learning to be extracted, as shown in the following Tsplot.

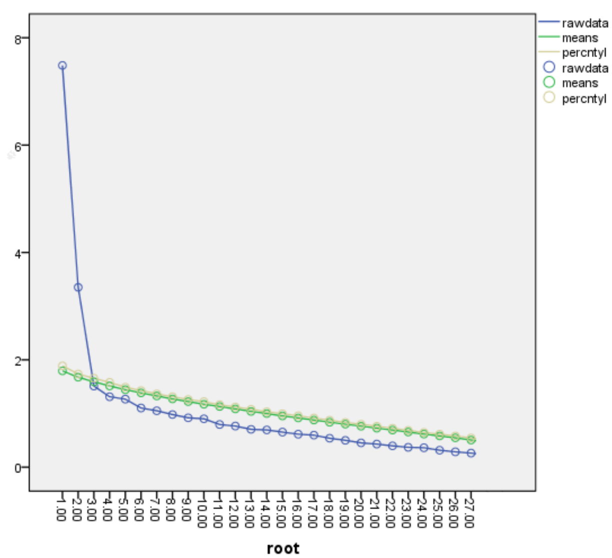


Figure 5.7: Tsplot of enablers of project learning

Lastly, PCA of enablers of project learning construct was conducted using the same criteria as above. The number of extracted components was restricted by three components. The results of KMO, Bartlett's test, and pattern matrix are shown in the tables below.

Table 5.17: KMO and Bartlett's test of enablers of project learning

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.845
Bartlett's Test of Sphericity	Approx. Chi-Square	1734.034
	df	351
	Sig.	.000

Table 5.18: Pattern matrix of enablers of project learning (PCA results)

Pattern Matrix[a]				
Variable	Label	Component		
		1	2	3
SupPL1	More meetings	.829		
SupPL3	Company's policy to support openness	.821		
SupPL5	Individuals' role in learning	.699		
SupPL13	Trust support	.616		
SupPL30	Making decision about the way of learning	.613		
SupPL2	Spirit of project team	.584		
SupPL6	Enough resources for learning	.583		
SupPL15	Role of ICT tools	.570		
SupPL16	Setting learning as one of project's goals	.551		
SupPL27	Enough time for learning	.460		
SupPL23	Innovative way of learning	.400		
SupPL17	*Role of leader to support dialogue*			
SupPL10	*Sharing knowledge returned benefits*			
SupPL14	*Valuing each other's experience*			
SupPL4	*Role of project owner*			
SupPL12	*BCO-contract*			
SupPL20	Role of leader to support good relationship		.770	
SupPL19	Leader's attitude		.724	
SupPL21	Respect each others' views		.611	
SupPL18	Leader as a role model		.596	
SupPL26	Setting of site office		.562	
SupPL11	BCO-drawings and specifications		.528	
SupPL22	Knowing each others' abilities		.451	
SupPL7	Incentives for knowledge sharing			.860
SupPL9	Friendship relations to facilitate knowledge sharing			.828
SupPL8	Relationship between companies to enable KS			.819
SupPL24	*Adaptive way of learning*			

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

b. The variables in italic font will be eliminated from further analysis as their score is less than .40

Out of the 27 variables measuring the enablers construct, 23 variables were extracted under three components. These components will be assigned new names other than the original constructs' names in the theoretical framework. Component 1 may be named "Managerial Support" (MANAG SUPP); Component 2 may be named "Knowledge Sharing Support" (KS SUPP); and Component 3 may be named "Project Culture" (PRO CULT).

5.23 Confirmatory Factor Analysis Using PLS-PM Approach

The next step after conducting PCA is further examination of the extracted variables. Confirmatory factor analysis (CFA) can be accomplished using partial least squares-path modeling (e.g. Barroso et al., 2010; Tenenhaus & Hanafi, 2010). As indicated previously, CFA is one way to validate the results of PCA (Hair et al., 2006).

SmartPLS does not offer the double-headed arrows of correlation. Therefore, to conduct CFA, we shall choose algorithm options that do not consider the directional relationship but only their existence. These include centroid scheme and factorial scheme (Tenenhaus & Hanafi, 2010). As indicated previously, the current study followed Tenenhaus and Hanafi's approach to CFA by utilizing the **centroid scheme**. Factor weighting scheme can be problematic as it overestimates the effects (Wilson & Henseler, 2007).

5.23.1 Confirmatory factor analysis of fragmentation

SmartPLS was used to build the second type hierarchical measurement model based on the results of PCA. The first-order constructs were identified as reflective measurements. Meanwhile, the second-order construct (FRAG) was identified as formative measurement.

FRAG was built using the repeated indicators approach (Tenenhaus et al., 2005; Wilson & Henseler, 2007). In this approach, all manifest variables of the four components will be assigned to the second-order construct formatively. Variables with low loading (less than .55) will be eliminated from the first-order constructs to yield a better model quality, called scale purification (Chin, 1998b). The final model of CFA of fragmentation contains 16 variables altogether, as illustrated in Figure 5.8. Results of correlation between constructs are shown in Table 5.19.

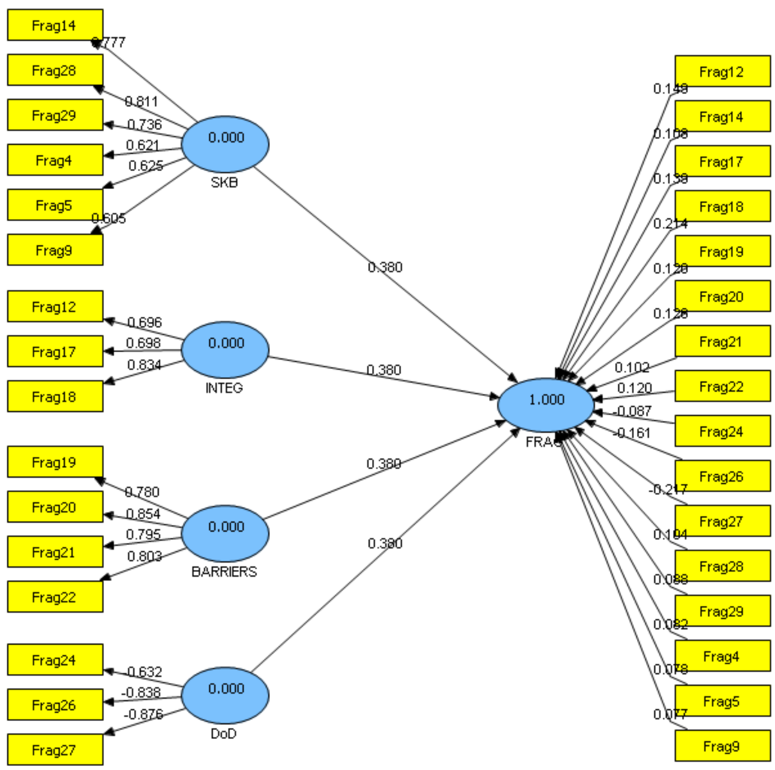


Figure 5.8: Confirmatory factor analysis of fragmentation using SmartPLS (Type II hierarchical model)

Table 5.19: Correlations among first- and second-order constructs of fragmentation

	BARRIERS	DoD	FRAG	INTEG	SKB
BARRIERS	1.0000				
DoD	0.0023	1.0000			
FRAG	0.5021	0.6730	1.0000		
INTEG	0.1971	0.2031	0.6746	1.0000	
SKB	0.1234	0.5678	0.7851	0.3773	1.0000

Table 5.20 shows the loading, weight, and cross-loading of all manifest variables. These loadings are also shown in the previous figure (Figure 5.8). Values in bold font illustrate loadings that are above 0.55. The table shows one cross-loading variable, namely Frag27, between the constructs DoD and SKB. Eliminating this variable from the model will be the extremist remedy, while accepting this variable as it is can also be one of the solutions, but this requires some interpretation (Hair et al., 2006). The variable shares some variance as they measure the same construct (fragmentation); this may cause the cross-loading.

Table 5.20: Cross loadings of fragmentation

	BARRIERS	DoD	INTEG	SKB
Frag12	0.0525	0.1799	**0.6964**	0.2245
Frag14	0.1592	0.4688	0.3277	**0.7770**
Frag17	0.0287	0.0899	**0.6980**	0.2600
Frag18	0.2949	0.1764	**0.8344**	0.3437
Frag19	**0.7804**	0.1358	0.1367	0.0367
Frag20	**0.8544**	0.0002	0.1937	0.0959
Frag21	**0.7947**	-0.1055	0.1533	0.0882
Frag22	**0.8033**	-0.0384	0.1518	0.1770
Frag24	0.0913	**-0.6321**	-0.0492	-0.1396
Frag26	-0.0289	**-0.8379**	-0.1195	-0.3603
Frag27	-0.0194	**-0.8762**	-0.2474	**-0.6714**
Frag28	0.0628	0.5454	0.2468	**0.8108**
Frag29	0.0408	0.4441	0.1824	**0.7364**
Frag4	0.0731	0.3005	0.3177	**0.6214**
Frag5	0.0359	0.2731	0.3202	**0.6249**
Frag9	0.1388	0.2991	0.1935	**0.6048**

5.23.2 Assessing quality of fragmentation model

Quality criteria of fragmentation include average variance extracted (AVE), reliability, communality, and goodness-of-fit (GoF). These results are shown in Table 5.21. All values indicated acceptable to good results. As discussed in the previous section of this chapter, GoF of the model was calculated depending on the Equation 5.3 presented previously (Tenenhaus et al., 2005). As recommended by Wetzels et al. (2009), the GoF value of 0.36 will represent the cut-off point of good quality model. The value of GoF has been calculated based on the root square of the average of communality and R^2 (Table 5.21). The value of GoF is **0.718**, which is significantly higher than the cut-off point of 0.36.

Table 5.21: Quality criteria of CFA of fragmentation model

	AVE	Composite Reliability	R Squared	Cronbachs Alpha	Communality	Redundancy
FRAG			1.0000		0.2519	0.0498
BARRIERS	0.6540	0.8830		0.8236	0.6540	
DoD	0.6231	0.8296		0.7139	0.6231	
INTEG	0.5562	0.7886		0.6069	0.5562	
SKB	0.4910	0.8509		0.7887	0.4910	
Average	-	-	*1.0000*	-	*0.5152*	-
GoF	√ 1.000*0.5152 = **0.718**					

Other ways to assess the quality of formative measurement model include checking the significant of weights and multicollinearity test (Chin, 1998b). In fact, weight "provides information about the composition and relative importance of each indicator in the creation/formation of the construct" (Duarte & Raposo, 2010, p. 462). Weights of formative variables of fragmentation are illustrated in Table 5.22. The table likewise shows the contribution of each variable to fragmentation (without considering the negative sign).

The table shows also the ranking of each manifest variable according to its weight. Weights less than 0.1 are considered trivial (Chin, 1998b). However, these cannot be eliminated from the formative measurement model of fragmentation.

Table 5.22: Weight of indicators of fragmentation

Rank	Variables (Construct)	Label	Loading / Weight
1	Frag27 (DoD)	Understanding information from people from other background	-0.2818
14	Frag26 (DoD)	Solving discrepancies – clashes	0.0261
15	Frag24 (DoD)	Contact with other professionals	-0.0191
2	Frag5 (SKB)	Well managed information	0.2732
3	Frag14 (SKB)	Long term relationship	0.2099
6	Frag4 (SKB)	Access information easily	0.1342
7	Frag29 (SKB)	Insufficient information from other consultants	0.1201
12	Frag28 (SKB)	Insufficient information from previous stages	0.0340
10	Frag9 (SKB)	No blame culture	0.0770
4	Frag18 (INTEG)	Freedom for self-organizing team/work	0.1786
5	Frag17 (INTEG)	Focus on project owner's requirements	0.1737
9	Frag12 (INTEG)	Irregular meetings	0.1055
8	Frag19 (BARR)	Professional barriers	0.1080
11	Frag20 (BARR)	Organizational barriers	0.0748
12	Frag22 (BARR)	Barriers between different ethnic groups	0.0618
16	Frag21 (BARR)	Language barriers	-0.0023

5.23.3 Multicollinearity of fragmentation

Multicollinearity can be referred to as a situation in which there is an exact, or almost exact, linear relation between two or more variables (Hocking & Pendleton, 1983). Assessing multicollinearity level is one way to check the validity of formative measurement (Chin, 1998b). Multicollinearity of second-order fragmentation construct can be conducted to ensure that there is no substantial correlation among the formative manifest variables. Multicollinearity is a problematic situation because it may produce unstable estimates of standard errors and p-values (Gordon, 1968). Moreover, multicollinearity indicates redundant information due to high linear inter-correlations (Diamantopoulos et al., 2008). Therefore, high multicollinearity of fragmentation measurement is unfavorable situation.

Variance inflation factor (VIF) can be used to assess the level of multicollinearity (Marquardt, 1970). The cut-off threshold of VIF is 10 (Kleinbaum et al., 2007). Another way of evaluating overall multicollinearity is to observe condition index and condition number. Condition index is the root square of the highest eigenvalue divided by the lowest eigenvalue in the matrix (Alin, 2010). The condition number is the highest value of the condition index. According to Alin (2010), values of condition index between 5–10 indicate weak multicollinearity and 30–100 indicate moderate to strong multicollinearity. However, Cohen (2003) emphasized that choosing 30 as a threshold for multicollinearity is not based on strong statistical rationale.

The test was performed using linear regression in SPSS (version 19) to obtain the values of VIF and condition index. To run the linear correlation, one of the manifest variables of fragmentation was assigned randomly as a dependent variable. To ensure that this dependent variable would not have collinearity with other variables under fragmentation, the test was conducted again by assigning a different variable as dependent. No considerable difference in VIF value and condition number was observed in the two tests. The results of VIF and condition number indicated low multicollinearity level among the variables of fragmentation (Tables 5.23 and 5.24).

Table 5.23: Multicollinearity test of fragmentation: VIF results

Model	Correlations			Collinearity Statistics	
	Zero-order	Partial	Part	Tolerance	VIF
Well managed information	.027	.157	.131	.666	**1.502**
No blame culture	-.044	.049	.041	.693	**1.443**
Irregular meetings	-.096	-.075	-.062	.782	**1.279**
Short-term relationship	-.161	-.050	-.042	.494	**2.025**
Project owner's needs	-.027	-.027	-.022	.731	**1.368**
Self organizing team	-.003	.057	.048	.661	**1.512**
Professionals barriers	-.091	-.083	-.069	.432	**2.312**
Organizational barriers	.032	-.014	-.012	.382	**2.615**
Language barriers	.209	.129	.108	.372	**2.686**
Cultural barriers	.167	.042	.035	.375	**2.666**
Discrepancies - clashes	.481	.313	.273	.609	**1.641**
Understanding among professionals	.348	.169	.142	.422	**2.371**
Insufficient information from previous stages	-.174	-.006	-.005	.415	**2.409**
Insufficient information from other consultants	-.125	.053	.044	.511	**1.957**
Access to information	-.065	-.011	-.009	.698	**1.432**

Note: Dependent variable: Contact among professionals

Table 5.24: Multicollinearity test of fragmentation: eigenvalue and condition index

Dimension	Eigenvalue	Condition Index
1	14.234	1.000
2	.453	5.606
3	.278	7.151
4	.168	9.215
5	.139	10.134
6	.124	10.729
7	.111	11.333
8	.100	11.924
9	.084	13.006
10	.077	13.569
11	.063	15.081
12	.051	16.771
13	.044	18.005
14	.038	19.454
15	.028	22.598
16	.010	(condition number) **37.688**

5.23.4 Confirmatory factor analysis of intra-project learning

Similar criteria of fragmentation were followed to perform the CFA of intra-project learning construct (INTRAPL). However, first- and second-order constructs are reflective. Centroid weighting scheme of algorithm was followed to determine the loadings as well as the quality of the model. Figure 5.9 illustrates the result of CFA obtained from SmartPLS.

Collectively, 10 variables remained after eliminating the variables with low loadings. Tables 5.25 and 5.26 show the results of correlations, loading, and cross-loading of variables. Goodness-of-fit was calculated depending on the previous GoF index (see Table 5.26). GoF value is **0.57**, which is above the cut-off point for good quality model (Wetzels et al., 2009).

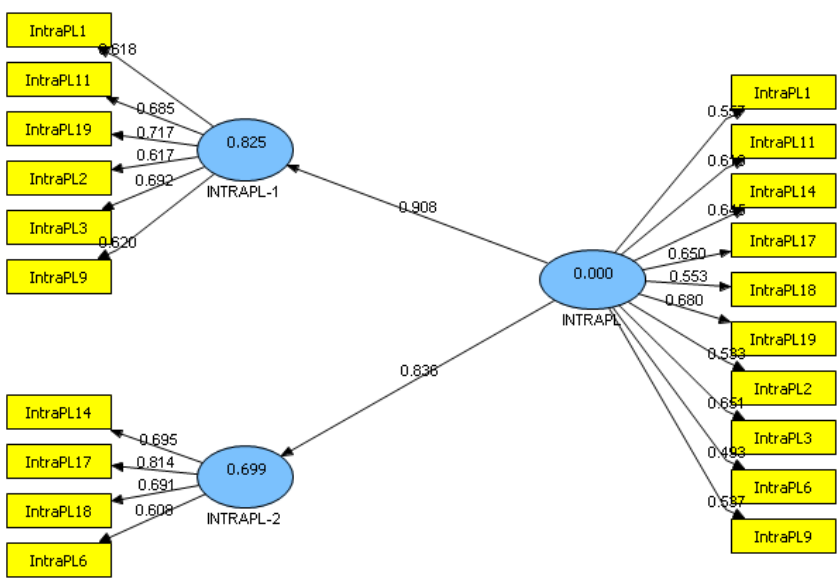


Figure 5.9: Confirmatory factor analysis of intra-project learning (Type I hierarchical model)

Table 5.25: Manifest variables' loading and cross-loadings of Intra-PL

	INTRAPL-1	**INTRAPL-2**
IntraPL1	**0.6180**	0.3187
IntraPL11	**0.6845**	0.3514
IntraPL14	0.4697	**0.6945**
IntraPL17	0.3822	**0.8135**
IntraPL18	0.3255	**0.6910**
IntraPL19	**0.7165**	0.4371
IntraPL2	**0.6173**	0.2721
IntraPL3	**0.6917**	0.4117
IntraPL6	0.2977	**0.6076**
IntraPL9	**0.6203**	0.2763

Table 5.26: Quality criteria of the model and correlation among constructs

	AVE	**Composite Reliability**	**R Squared**	**Cronbachs Alpha**	**Communality**	**Redundancy**	**INTRAPL**	**INTRAPL-1**	**INTRAPL-2**
INTRAPL	0.3534	0.8439		0.7942	0.3534		1.0000		
INTRAPL-1	0.4347	0.8213	0.8246	0.7394	0.4347	0.3575	0.9080	1.0000	
INTRAPL-2	0.4977	0.7967	0.6991	0.6589	0.4977	0.3450	0.8361	0.5295	1.0000
Average			*0.7618*		*0.4286*				
GoF	√0.7618*0.4286 = **0.571**								

5.23.5 Confirmatory factor analysis of inter-project learning

The following figure demonstrates the results of CFA of inter-project learning. This is a reflective second-order model as well. Collectively, 14 variables remained after conducting the CFA. Results of correlations, cross-loading and model quality, and goodness-of-fit are shown in the tables to follow (see Tables 5.27 and 5.28). Goodness-of-fit was calculated depending on the previous GoF index. GoF value is **0.600**, which indicates a good-global quality model (Wetzels et al., 2009).

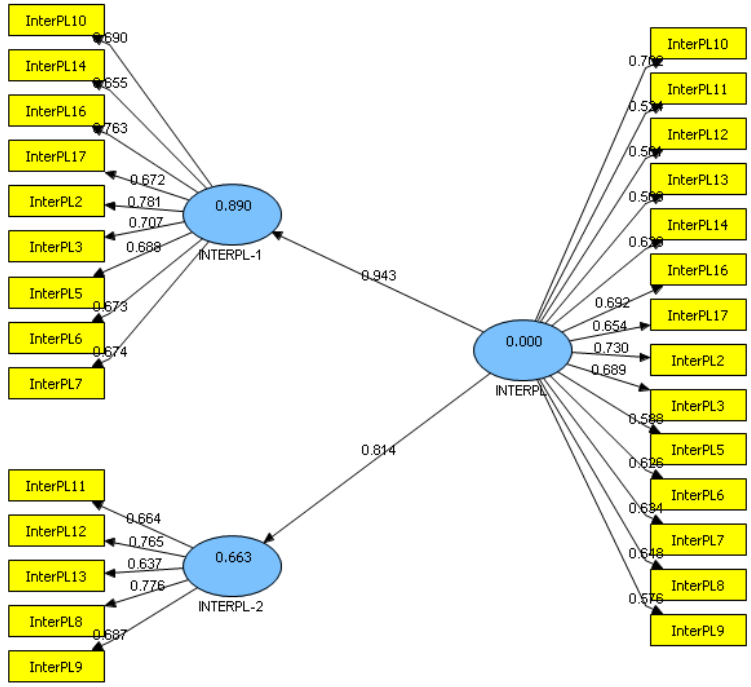


Figure 5.10: Confirmatory factor analysis of inter-project learning

Table 5.27: Manifest variables' loading and cross-loadings of inter-project learning

	INTERPL-1	**INTERPL-2**
InterPL10	**0.6901**	0.5186
InterPL11	0.3561	**0.6644**
InterPL12	0.3510	**0.7652**
InterPL13	0.4280	**0.6366**
InterPL14	**0.6550**	0.3815
InterPL16	**0.7627**	0.3737
InterPL17	**0.6722**	0.4323
InterPL2	**0.7807**	0.4346
InterPL3	**0.7068**	0.4592
InterPL5	**0.6877**	0.2520
InterPL6	**0.6725**	0.3661
InterPL7	**0.6736**	0.3857
InterPL8	0.4701	**0.7760**
InterPL9	0.4190	**0.6866**

Table 5.28: Quality criteria of inter-project learning and correlation among constructs

	AVE	Composite Reliability	R Squared	Cronbachs Alpha	Communality	Redundancy	INTERPL	INTERPL-1	INTERPL-2
INTERPL	0.3990	0.9020		0.8825	0.3990		1.0000		
INTERPL-1	0.4919	0.8967	0.8899	0.8701	0.4919	0.4360	0.9433	1.0000	
INTERPL-2	0.5012	0.8331	0.6626	0.7488	0.5012	0.3295	0.8140	0.5753	1.0000
Average			*0.776*		*0.4640*				
GoF	$\sqrt{0.776*0.464}$ = **0.600**								

5.23.6 Confirmatory factor analysis of enablers of project learning

The same procedure was followed in analyzing the enablers of project learning. The difference here is that enablers are not a hierarchical model, as the objective of the current study is to investigate the effect of each component in the full model individually. Figure 5.11 illustrates the results of CFA of the three components (i.e., MANAG SUPP, KS SUPP, and PRO CULT) that comprise enablers.

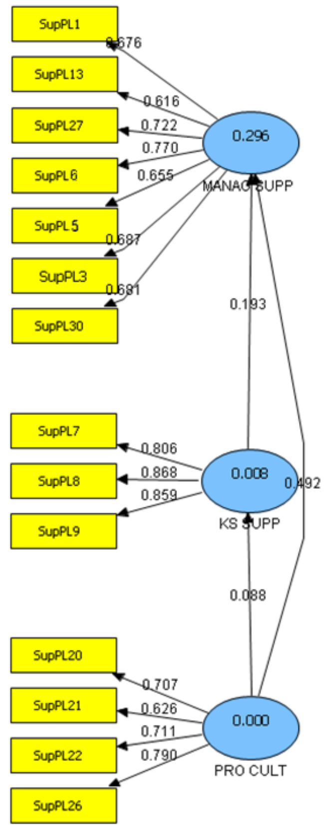


Figure 5.11: Confirmatory factor analysis of enablers of project learning

It is important to note that the arrow in this model does not imply any causal effect; rather, it indicates a correlation (Tenenhaus & Hanafi, 2010). This is can be attained when choosing Centroid Weighting Scheme option in SmartPLS to estimate the algorithm. Unlike the Path Weighting Scheme, this option, as mentioned previously, will not consider the relationship effect among the three constructs. Results of correlations, model quality, loadings, and goodness-of-fit are shown in the following tables. GoF of the model is **0.298**, which indicates moderate good- global quality model (Wetzels et al., 2009).

Table 5.29: Manifest variables' loading and cross loadings of enablers

	KS SUPP	MANAG SUPP	PRO CULT
SupPL1	0.2329	**0.6755**	0.2264
SupPL13	0.1608	**0.6163**	0.3156
SupPL20	0.0184	0.2612	**0.7065**
SupPL21	0.0114	0.3079	**0.6256**
SupPL22	0.0259	0.3820	**0.7114**
SupPL26	0.1400	0.4402	**0.7896**
SupPL27	0.1896	**0.7219**	0.4398
SupPL6	0.2858	**0.7698**	0.3524
SupPL5	0.0678	**0.6548**	0.3512
SupPL3	0.0559	**0.6870**	0.3507
SupPL30	0.0746	**0.6805**	0.3965
SupPL7	**0.8060**	0.1396	0.0692
SupPL8	**0.8679**	0.2068	0.1041
SupPL9	**0.8594**	0.2376	0.0460

Table 5.30: Quality criteria and correlation among constructs of enablers of project learning model

	AVE	Composite Reliability	R Squared	Cronbachs Alpha	Communality	Redundancy	KS SUPP	MANAG SUPP	PRO CULT
KS SUPP	0.7138	0.8820	0.0570	0.8025	0.7138	0.0378	1.0000		
MANAG SUPP	0.4734	0.8623		0.8155	0.4734		0.2359	1.0000	
PRO CULT	0.5050	0.8021	0.2586	0.6875	0.5050	0.1228	0.0878	0.5085	1.0000
Average			*0.1578*		*0.5641*				
GoF	√0.1578*0.5641 = **0.2984**								

5.24 Full Model of Project Learning

The full model was depicted using SmartPLS by connecting all constructs according to the theoretical model. Manifest variables were assigned to their latent constructs according to the results of the previous analyses. The current study used the following criteria to run the algorithm in SmartPLS to obtain the results of the full model:

- Weighting Scheme: Path weighting scheme (Tenenhaus & Hanafi, 2010; Vinzi et al., 2010);
- Data Metric: Mean 0, Var 1(the default in the program, to ensure normality);
- Maximum Iterations: 300 (the default in the program);
- Abort Criterion: 1.0E-5 (the default in the program);
- Initial Weight: 1 (the default in the program).

As stated previously, path weighting scheme is the only scheme that considers the direction of relationship as specified in the model (Vinzi et al., 2010, p. 53). In addition, this scheme takes into consideration the direction of the arrow in the model (Tenenhaus & Hanafi, 2010), thus, it is considered more appropriate in path modeling assessment.

Figure 5.12 shows the full model consists of both measurement and structural models. Measurement models (i.e., outer models) indicate the relationship between the manifest variables (i.e., rectangular shape) and their own constructs (i.e., oval shape). The structural model (i.e., inner model) indicates the relationship among the constructs (e.g., FRAG and MANAG SUPP, etc.).

Fragmentation construct (FRAG) is a second-order construct measured formatively by four first-order constructs: spanning knowledge boundaries (SKB); integration (INTEG); barriers (BARRIERS); and decoupling of diversity (DoD). These constructs are measured by reflectively. Both intra-project learning (INTRA-PL) and inter-project learning (INTER-PL) are second-order constructs each measured reflectively by two first-order constructs. FRAG influences both INTRA-PL and INTER-PL via three mediating constructs, namely, managerial support (MANAG SUPP), knowledge-sharing support (KS SUPP), and project culture (PRO CULT). The model shows the strength and direction of the relationship among constructs (i.e., path coefficient) on the arrows connecting them. The explained variance (R^2) is the value inside the latent constructs (oval shape). Loadings or weights are the values on arrows that connect constructs to variables. For the purpose of clarity, SmartPLS provides the option to hide or show the manifest variables, as shown in Figure 5.13.

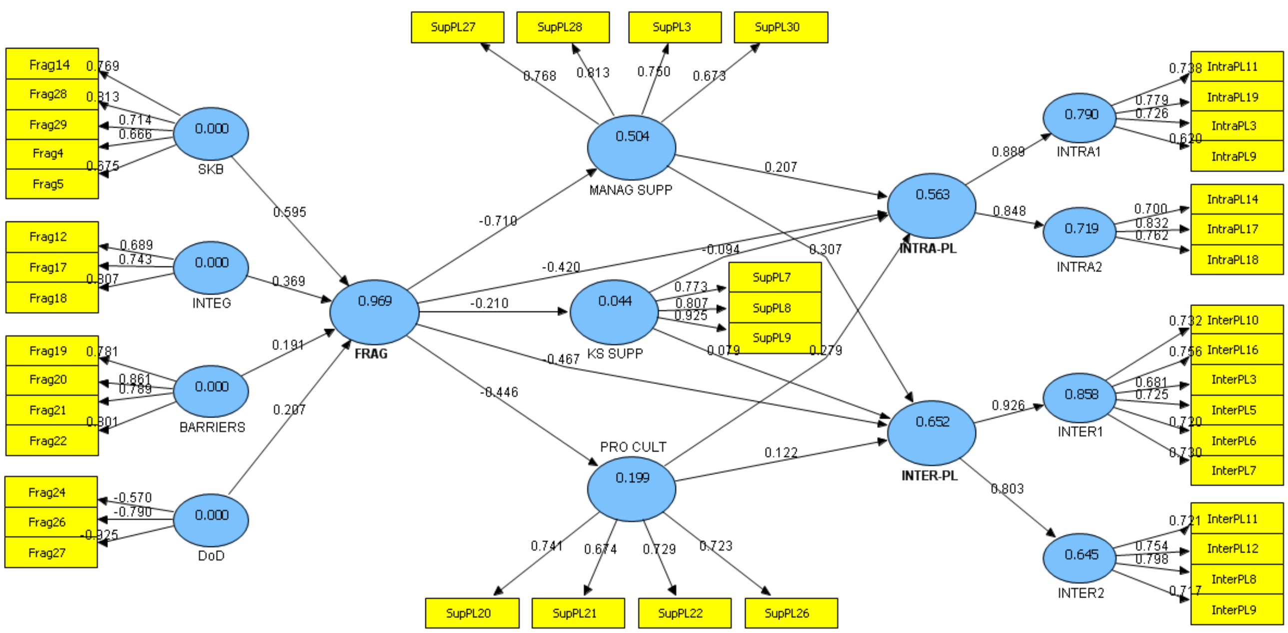


Figure 5.12: Full model of project learning (inner and outer models)

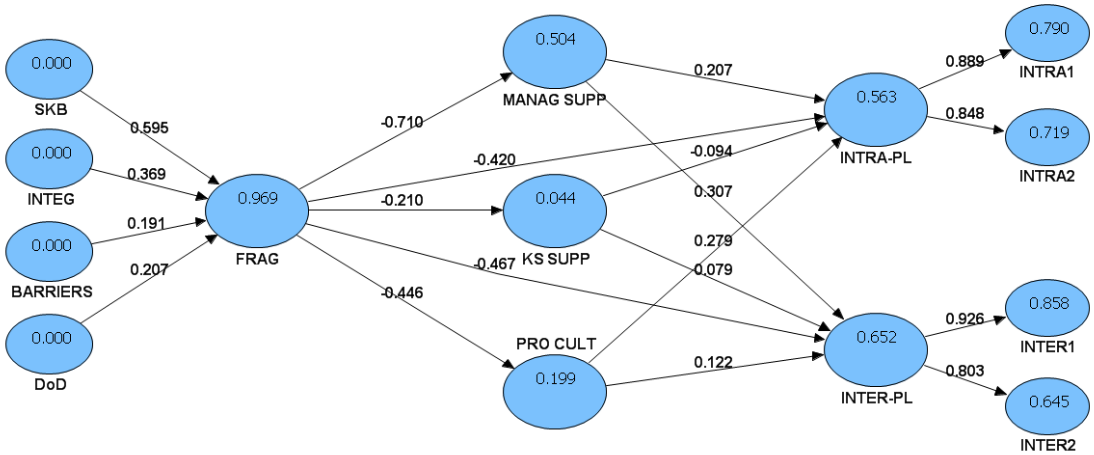


Figure 5.13: Full model of project learning (hiding the manifest variables)

5.25 Assessment of Full Model's Quality

Assessment of the full model can be performed at two levels: measurement model level and structural model level (Fornell & Larcker, 1981; Tenenhaus et al., 2005). This can be achieved by assessing validity, reliability, redundancy, and communality, and evaluating structural regression equations (via cross-validated redundancy – F^2) and quality of the measurement model (via cross-validated communality – H^2) (Tenenhaus et al., 2005).

Cross-loading test was conducted to check whether a variable of a certain construct shares loading with other constructs across the model (refer to Appendix G). Based on this test, some variables were eliminated from the model (Hair et al., 2006). Eliminating the cross-loaded variables enhances the discriminant validity of the model.

5.25.1 Assessment of measurement models

Assessment of the reflective latent constructs involves evaluating reliability and validity of the measurement (i.e., multi-item scales) (Churchill, 1979). Several steps were taken to ensure reliability and validity of the scale, including principal component analysis and confirmatory factor analysis (Churchill, 1979; Hair et al., 2006). Detailed steps of evaluating the measurement models (some mentioned previously) include the following:

- Ensure the significance of items loading and weight [threshold is 0.55 for reflective measures (Falk & Miller, 1992) and 0.1 for formative measures (Chin, 1998b)].
- Calculate the internal consistency indicated by Cronbach's alphas or composite reliability [threshold is 0.70 (Nunnally, 1978)].
- Ascertain the convergent validity by observing the range of items loading and cross-loading (Chin, 2010).
- Ascertain the discriminant validity by calculating the average variance extracted (AVE) [threshold of AVE is 0.50 (Fornell & Larcker, 1981)]. This can be attained by comparing the square root of AVE with all the correlations between constructs. The square root of AVE should be greater than all the correlations to establish the discriminant validity (Fornell & Larcker, 1981).
- Ensure that the cv-com is above zero for all constructs (Tenenhaus et al., 2005).

Tables 5.31 and 5.32 show the assessment of the measurement models in terms of factor loadings or weights of fragmentation, enablers, intra-project learning and inter-project learning. All loadings of variables are above the threshold of 0.55.

Table 5.31: Outer model (weights or loadings) of fragmentation and enablers

	FRAG (1st-order)	**BARRIERS**	**DoD**	**INTEG**	**SKB**	**KS SUPP**	**MANAG SUPP**	**PRO CULT**
Frag17	0.1737			0.7428				
Frag18	0.1786			0.8065				
Frag12	0.1055			0.6888				
Frag19	0.1080	0.7809						
Frag20	0.0748	0.8610						
Frag21	-0.0023	0.7888						
Frag22	0.0618	0.8006						
Frag24	-0.0191		-0.5704					
Frag26	0.0261		-0.7896					
Frag27	-0.2818		-0.9252					
Frag28	0.0340				0.8126			
Frag29	0.1201				0.7137			
Frag4	0.1342				0.6661			
Frag5	0.2732				0.6746			
Frag14	0.2099				0.7693			
SupPL20								0.7408
SupPL21								0.6743
SupPL22								0.7288
SupPL26								0.7230
SupPL27							0.7676	
SupPL28							0.8129	
SupPL3							0.7503	
SupPL30							0.6728	
SupPL7						0.7727		
SupPL8						0.8073		
SupPL9						0.9247		

Table 5.32: Outer model (weights or loadings) of intra- and inter-project learning

	INTER-PL (1st-order)	**INTER1**	**INTER2**	**INTRA-PL** (1st-order)	**INTRA1**	**INTRA2**
InterPL16	0.6815	0.7563				
InterPL3	0.6675	0.6806				
InterPL5	0.6037	0.7253				
InterPL6	0.6521	0.7196				
InterPL7	0.6689	0.7304				
InterPL10	0.7386	0.7323				
InterPL8	0.6643		0.7981			
InterPL9	0.6018		0.7165			
InterPL11	0.5641		0.7207			
InterPL12	0.5650		0.7543			
IntraPL14				0.6516		0.7002
IntraPL17				0.6734		0.8316
IntraPL18				0.6204		0.7620
IntraPL19				0.7209	0.7785	
IntraPL3				0.6649	0.7258	
IntraPL9				0.5086	0.6197	
IntraPL11				0.6362	0.7379	

Tables 5.33 and 5.34 present the quality criteria of the outer model, which include AVE, composite reliability, Cronbach's alpha, communality, redundancy, cv-com, and discriminant validity. All results are good and above the recommended thresholds.

Table 5.33: Quality criteria (overall) and GoF of the full model

	AVE	Composite Reliability	R Squared	Cronbachs Alpha	Communality	Redundancy	cv-red	cv-com
BARRIERS	0.6536	0.8828		0.8236	0.6536		0.419	0.419
DoD	0.6017	0.8138		0.7139	0.6017		0.271	0.271
FRAG*			0.9691		0.2508	0.0239	0.252	0.167
INTEG	0.5589	0.7910		0.6069	0.5589		0.143	0.143
INTER-PL*	0.4134	0.8750	0.6522	0.8408	0.4134	0.2020	0.255	0.279
INTER1	0.5249	0.8688	0.8583	0.8188	0.5249	0.4471	0.456	0.308
INTER2	0.5597	0.8353	0.6451	0.7375	0.5597	0.3595	0.367	0.282
INTRA-PL*	0.4126	0.8297	0.5634	0.7602	0.4126	0.1589	0.212	0.217
INTRA1	0.5154	0.8086	0.7900	0.6854	0.5154	0.4054	0.414	0.205
INTRA2	0.5875	0.8096	0.7194	0.6451	0.5875	0.4193	0.441	0.195
KS SUPP	0.7013	0.8750	0.0440	0.8025	0.7013	0.0236	0.016	0.402
MANAG SUPP	0.5664	0.8387	0.5042	0.7427	0.5664	0.2850	0.259	0.283
PRO CULT	0.5143	0.8088	0.1987	0.6875	0.5143	0.0972	0.098	0.199
SKB	0.5321	0.8496		0.7780	0.5321		0.267	0.267
Average			*0.5944*		*0.5281*		*0.276*	*0.260*
GoF	$\sqrt{0.5944*0.5281}$ = **0.5603**							

* Indicates second-order construct

Table 5.34: Correlations among latent constructs and discriminant validity of the model

	BARR	DoD	INTEG	INTER 1	INTER 2	INTRA 1	INTRA 2	KS SUPP	MANAG SUPP	PRO CULT	SKB
BARRIERS	**(0.808)**										
DoD	0.008	**(0.776)**									
INTEG	0.185	0.214	**(0.748)**								
INTER1	-0.206	-0.590	-0.431	**(0.724)**							
INTER2	-0.196	-0.239	-0.406	0.520	**(0.748)**						
INTRA1	-0.219	-0.166	-0.451	0.481	0.510	**(0.718)**					
INTRA2	-0.214	-0.463	-0.381	0.624	0.456	0.511	**(0.766)**				
KS SUPP	0.085	-0.265	-0.079	0.288	0.108	0.015	0.085	**(0.837)**			
MANAG SUPP	-0.225	-0.499	-0.416	0.704	0.508	0.445	0.654	0.208	**(0.753)**		
PRO CULT	-0.177	-0.182	-0.410	0.378	0.509	0.548	0.422	0.066	0.495	**(0.717)**	
SKB	0.105	0.597	0.387	-0.707	-0.424	-0.450	-0.557	-0.238	-0.633	-0.296	**(0.729)**

Notes: correlations of the second-order constructs are not included in this table.
Values between parentheses on the diagonal are the square root of AVE, while values off the diagonal are the correlations between constructs. Discriminant validity can be established when the values on the diagonal are higher than any value off the diagonal.

However, the AVE of some second-order constructs, namely, INTER-PL and INTRA-PL was slightly low. These are hierarchical models and were identified by repeating all items of the first-order constructs. These items may have lower correlation among each other. This can be considered one of the shortcomings of the hierarchical models.

5.25.2 Assessment of structural model and hypotheses testing

The model's goodness-of-fit (GoF) can be calculated according to the formula presented in (Tenenhaus et al, 2005). The threshold of GoF was adopted from Wetzels et al. (2009), who proposed a threshold of 0.36 (as explained previously). GoF of the full model is 0.560, which is above the threshold of goodness-of-fit model (Table 5.33 above). In addition, redundancy of the whole model, indicated by cv-red, is positive for all constructs (Table 5.33).

The structural model can be assessed using algorithm and bootstrapping calculations. First, the algorithm procedure indicated the total effect (i.e., direct and indirect) of all exogenous constructs on endogenous constructs, as illustrated in Table 5.35.

Table 5.35: Total effect among all latent constructs in the full model

	FRAG	**INTER-PL**	**INTER1**	**INTER2**	**INTRA-PL**	**INTRA1**	**INTRA2**	**KS SUPP**	**MANAG SUPP**	**PRO CULT**
BARRIERS	0.1908	-0.1442	-0.1336	-0.1158	-0.1281	-0.1139	-0.1087	-0.0400	-0.1354	-0.0850
DoD	0.2072	-0.1566	-0.1451	-0.1258	-0.1391	-0.1237	-0.1180	-0.0435	-0.1471	-0.0923
FRAG*		-0.7562	-0.7006	-0.6073	-0.6717	-0.5971	-0.5698	-0.2099	-0.7101	-0.4457
INTEG	0.3685	-0.2786	-0.2581	-0.2238	-0.2475	-0.2200	-0.2099	-0.0773	-0.2616	-0.1642
INTER-PL*			0.9264	0.8032						
INTRA-PL*						0.8888	0.8482			
KS SUPP		0.0789	0.0731	0.0634	-0.0940	-0.0835	-0.0797			
MANAG SUPP		0.3067	0.2842	0.2464	0.2070	0.1840	0.1756			
PRO CULT		0.1224	0.1134	0.0983	0.2794	0.2484	0.2370			
SKB	0.5949	-0.4498	-0.4167	-0.3613	-0.3996	-0.3552	-0.3389	-0.1249	-0.4224	-0.2651

* Indicates second-order construct

Second, bootstrapping was performed to obtain the T-statistics, standard error, and standard deviation. The procedure can be used to assess the psychometric properties of the structural relationships (Wetzels et al., 2009), including the hypotheses testing. Figure 5.14 shows the results of bootstrapping. Values on the arrows indicate the T-statistics of constructs' effect. The current study used the following criteria to conduct bootstrapping in SmartPLS:

- Sign Changes: Construct level changes [recommended by (Tenenhaus et al., 2005)];
- Cases: 194 (number of cases in the current study);
- Samples: 300 [recommended by (Chin, 1998b)].

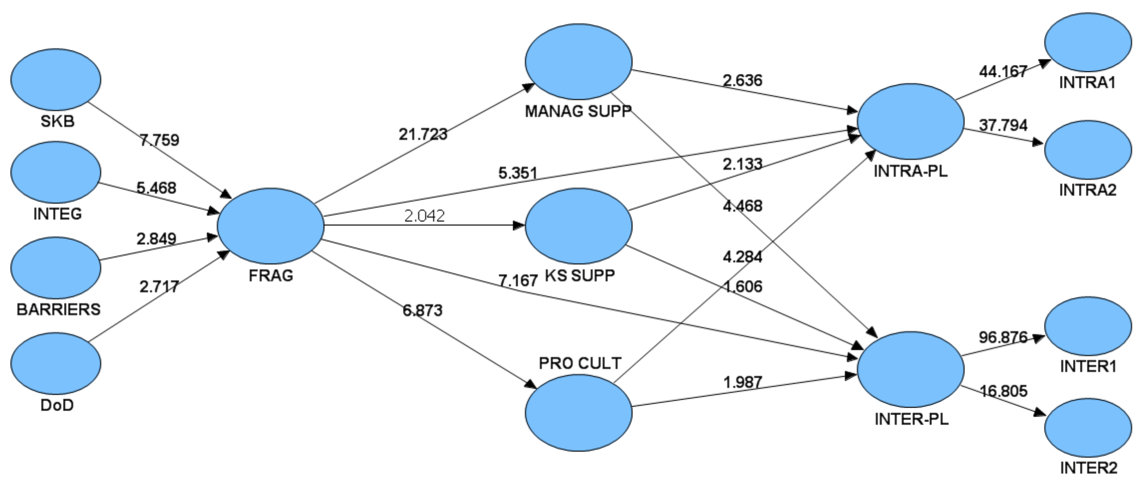


Figure 5.14: Results of bootstrapping of the full model

Results of path coefficient of the original sample, sample mean, standard deviation/standard error, T-statistics, and hypotheses testing are illustrated in Table 5.36. Hypotheses will be supported at a significant level of 5% or less ($p \leq 0.05$) (Malhotra, 2003). The significance level was calculated using T-statistics and degree of freedom (df). Value of T-statistics equal or above 1.64 indicates significance level of 5% or less (for one tail). All hypotheses, including the relationship between the first- and second-order constructs, were supported, except the relationship between KS SUPP and INTER-PL.

Table 5.36: Path coefficients (mean, STDEV, t-values) and test of hypotheses

	Path Coefficient of Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)	Significant Level (p-value)	Hypothesis Supported?
BARRIERS -> FRAG	0.1908	0.1903	0.0669	0.0669	2.8491	0.0049	Yes
DoD -> FRAG	0.2072	0.2069	0.0762	0.0762	2.7171	0.0072	Yes
FRAG -> INTER-PL	-0.4672	-0.4966	0.0651	0.0651	7.1670	0.0001	Yes
FRAG -> INTRA-PL	-0.4199	-0.4433	0.0784	0.0784	5.3513	0.0001	Yes
FRAG -> KS SUPP	-0.2099	-0.2163	0.1028	0.1028	2.0418	0.0425	Yes
FRAG -> MANAG SUPP	-0.7101	-0.7247	0.0326	0.0326	21.7225	0.0001	Yes
FRAG -> PRO CULT	-0.4457	-0.4651	0.0648	0.0648	6.8732	0.0001	Yes
INTEG -> FRAG	0.3685	0.3612	0.0673	0.0673	5.4679	0.0001	Yes
INTER-PL -> INTER1	0.9264	0.9279	0.0095	0.0095	96.8760	0.0001	Yes
INTER-PL -> INTER2	0.8032	0.7986	0.0477	0.0477	16.8046	0.0001	Yes
INTRA-PL -> INTRA1	0.8888	0.8886	0.0201	0.0201	44.1668	0.0001	Yes
INTRA-PL -> INTRA2	0.8482	0.8503	0.0224	0.0224	37.7936	0.0001	Yes
KS SUPP -> INTER-PL	0.0789	0.0799	0.0491	0.0491	1.6055	0.1100	No
KS SUPP -> INTRA-PL	-0.0940	-0.0961	0.0440	0.0440	2.1327	0.0342	Yes
MANAG SUPP -> INTER-PL	0.3067	0.2896	0.0686	0.0686	4.4677	0.0001	Yes
MANAG SUPP -> INTRA-PL	0.2070	0.1911	0.0785	0.0785	2.6363	0.0091	Yes
PRO CULT -> INTER-PL	0.1224	0.1039	0.0615	0.0615	1.9873	0.0483	Yes
PRO CULT -> INTRA-PL	0.2794	0.2676	0.0652	0.0652	4.2835	0.0001	Yes
SKB -> FRAG	0.5949	0.5841	0.0766	0.0766	7.7585	0.0001	Yes

5.26 Results of Mediating Test

As stated previously, the current study follows the procedures of (Baron & Kenny, 1986) and (Kelloway, 1995) for the mediating test. The enablers (i.e., MANAG SUPP, KS SUPP, and PRO CULT) were tested to identify their exact influence on INTRA-PL and INTER-PL via FRAG. To conduct the test, the research developed three models: Model 1 (model without the direct path from fragmentation to inter-and intra-project learning); Model 2 (model without the mediating constructs); and Model 3 (original model with direct path from fragmentation to inter- and intra-project learning). The following figures depict the three models. The purpose of the first model is to test the association between endogenous variable and the mediators, which should be significant (Baron & Kenny, 1986). There is a strong association between FRAG and MANAG SUPP, KS SUPP, and PRO CULT (Figure 5.15).

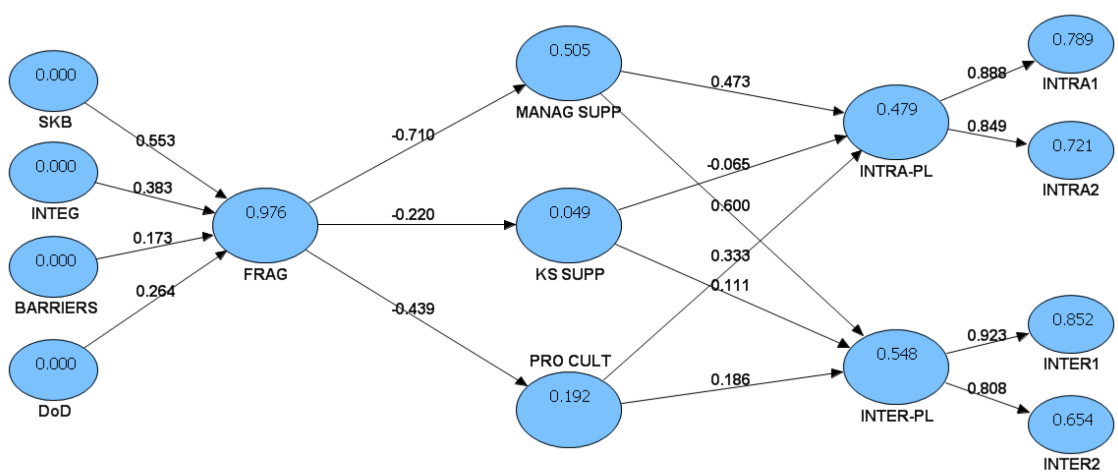


Figure 5.15: Model 1 (full model without direct relationship)

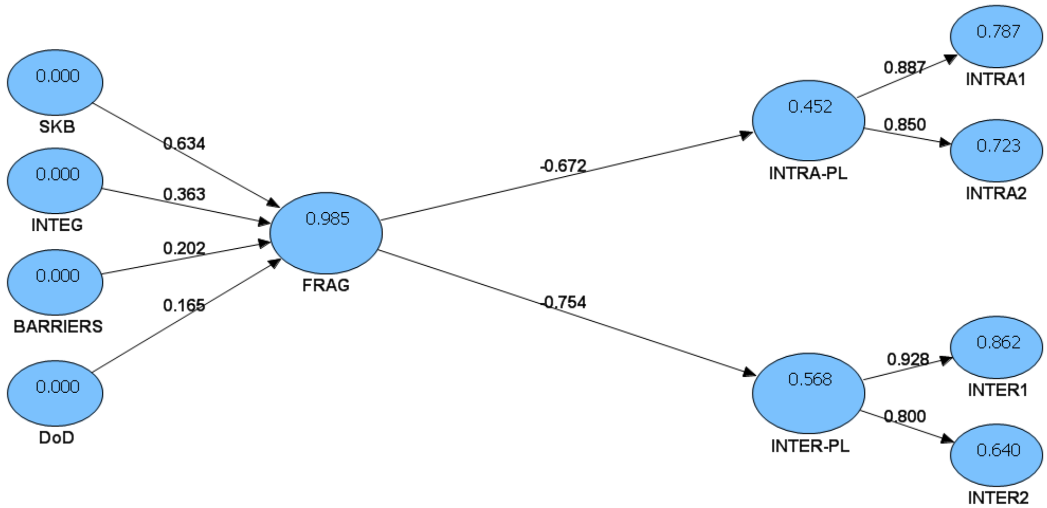


Figure 5.16: Model 2 (model without mediating constructs)

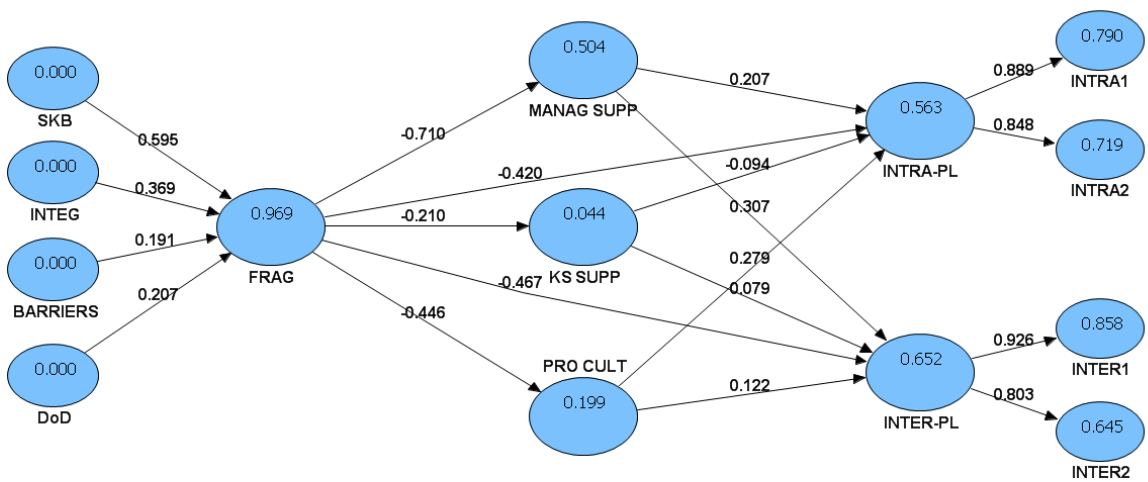


Figure 5.17: Model 3 (full model with direct relationship – original model)

To examine the mediating effect, the following conditions must be satisfied:

1) Effect of independent constructs on dependent constructs must be significant in Model 2.
2) Effect of independent constructs on mediating constructs must be significant in Model 3.
3) Effect of mediating constructs on dependent constructs must be significant in Model 3.
4) Effect of independent constructs on dependent constructs must be lower in Model 3 than in Model 2.

There is a perfect mediating effect if the direct relationship of independent constructs on dependent constructs is not significant in Model 3. If direct relationship is reduced, but still significance then there is a partial mediating effect. Table 5.37 shows the results of the mediating test of Models 2 and 3.

Table 5.37: Comparing Model 2 with Model 3 to examine the mediating effect

	Model 2 (without the mediating constructs)		**Model 3** (original model: direct relationship between dependent and independents)	
	Path coefficient	**T-Statistics**	**Path coefficient**	**T-Statistics**
FRAG ->KS SUPP	-	-	-0.2099	2.0418*
FRAG -> MANAG SUPP	-	-	-0.7101	21.7225**
FRAG -> PRO CULT	-	-	-0.4457	6.8732**
FRAG -> INTER-PL	-0.7536	29.8290**	-0.4672	7.1670**
FRAG -> INTRA-PL	-0.6725	16.0556**	-0.4199	5.3513**
KS SUPP -> INTER-PL	-	-	0.0789	1.6055
KS SUPP -> INTRA-PL	-	-	-0.0940	2.1327*
MANAG SUPP -> INTER-PL	-	-	0.3067	4.4677**
MANAG SUPP -> INTRA-PL	-	-	0.2070	2.6363*
PRO CULT -> INTER-PL	-	-	0.1224	1.9873*
PRO CULT -> INTRA-PL	-	-	0.2794	4.2835**

Note: Only second-order constructs are shown in this table.

* Significant at $p < 0.05$

** Significant at $p < 0.001$

According to Table 5.37, the effect of fragmentation (FRAG) on inter-project learning and intra-project learning (INTER-PL and INTRA-PL) in Model 2 is significant (-0.754, T = 29.83 and -0.673, T = 16.056, respectively).

In Model 3, effect of FRAG on mediating constructs – namely, KS SUPP, MANAG SUPP, and PRO CULT – is significant as well (-0.4672, T = 2.0418; -0.4199, T = 21.7225; and -0.2099, T = 6.8732).

In addition, in Model 3, the effect of mediator KS SUPP on INTER-PL is trivial and not significant (0.0789, T = 1.6055). KS SUPP has a small but significant effect on INTRA-PL (-0.0940, T = 2.1327). Effect of the second mediator MANAG SUPP on both INTER-PL and INTRA-PL is positive and significant, but slightly lower on INTRA-PL (0.3067, T = 4.4677 and 0.2070, T = 2.6363). Lastly, effect of the mediator PRO CULT on INTER-PL and INTRA-PL is significant (0.1224, T = 1.9873 and 0.2794, T = 4.2835).

Comparing the effect of independent construct FRAG on the dependent construct INTER-PL in Model 2 (-0.7536, T = 29.8290), we observed that the effect and significant level were reduced in Model 3 (-0.7101, and T= 7.1670). Moreover, the effect of FRAG on INTRA-PL in Model 2 (-0.6725, T = 16.0556) was reduced (-0.4457, T = 5.3513) in Model 3. We can notice that the effect of FRAG on both INTER-PL and INTRA-PL has reduced but remained significant in Model 3, compared with Model 2.

To summarize the previous results, the dependent constructs INTER-PL and INTRA-PL are partly mediated by two constructs (i.e., MANAG SUPP and PRO CULT). On the other hand, the effect of the mediator KS SUPP on INTER-PL is neither significant nor high. In addition, the influence of KS SUPP on INTRA-PL is negative but significant. This negative influence indicates that KS SUPP has small influence on INTRA-PL, so it cannot change the negative influence of FRAG.

5.27 Summary

The chapter presented the procedure of developing the measurement scale of four constructs, namely, fragmentation, intra-project learning, inter-project learning, and enablers. The procedure involved conceptualization, operationalization, content validity, measurement, and pilot study. The chapter elaborated on the method of analyses and data collection. Method of analyses involved a discussion on hierarchical measurement models and ways to analyze them using partial least squares-path modeling approach (PLS-PM). The chapter also elaborated on this approach and argued the appropriateness of using it for the current research.

Parallel analysis, principal factor analysis (PCA), and confirmatory factor analysis (CFA) were highlighted as well and used to develop the measurement scale. Data were collected from 36 big construction projects. Total collected valid questionnaires forms were 203, from professionals working in these projects.

Using SPSS, PCA was conducted to summarize variables and to identify the underlying structure of components. The components of fragmentation, intra-project learning, inter-project learning, and enablers were identified. CFA was conducted using PLS-PM approach to verify the results of PCA. PLS-PM approach was also used to analyze the whole model of project learning using SmartPLS software.

Different tests of model reliability, validity, and quality were conducted at two levels: measurement and structural models. Mediating test of the enablers was conducted to verify the role of three constructs in the model. The model of project learning was finalized accordingly.

The results confirmed the main hypothesis that fragmentation has a negative influence on project learning. Mediating test verified a partial mediating role of two factors, namely, Managerial Support and Project Culture, in enabling learning within fragmentation. Knowledge Sharing Support had a trivial effect on inter-project learning. Discussion of these finding will be presented in the next chapter.

CHAPTER 6: DISCUSSIONS

6.0 Introduction

The primary purpose of this chapter is to discuss the results of the quantitative study presented in the previous chapter. The chapter begins with an overview of main findings and results of both qualitative and qualitative studies. It discusses the full model of project learning, including the measurement models and structural model. The discussion then expands to include all items in the model. Lastly, the chapter argues the role of enablers as mediating factors.

6.1 Highlights of the Main Findings and Results

6.1.1 Main findings of the qualitative study

1. Project learning in local practice: Some interviewees viewed learning as a task of "people in the main office" at the end of the project. In fact, the practice of project review involves auditing activities. A committee composed of project director, project manager, coordinator, and so on is formed to check whether the contractor company has met its original plan of profit and project completion on time. The committee is expected to identify the reasons behind problems such as cost overrun, delay, and so on. Information developed at this stage will be used by the main contractor for better costing estimates and methods in the future.

However, when a problem occurs during the construction phase, reviews or lessons learned are not usually developed. In addition, construction projects are faced with setbacks such as inadequate resources, awareness, and objectives of learning.

2. Fragmentation: Some interviewees believed that fragmentation has an indirect influence on learning. Nevertheless, they believed that it may not influence knowledge sharing process among project team members who work in the same construction site. As stated by one interviewee, people are willing to share knowledge because they belong to the same project. All parties attached to the project are driven by the main goal of completing the project. Therefore, they will not hesitate to share the necessary knowledge to achieve this goal. Lack of competition among firms working within the same project may be one of the reasons that freely enable knowledge sharing.

On the other hand, builders viewed fragmentation as a real problem that hinders the performance of projects. Interviewees highlighted some factors that contribute to fragmentation, such as attitude of people, negative perception (e.g., "builders always cheat"), and low level of coordination (i.e., horizontally among team members and vertically between main contractor and subcontractors). Factors that may reduce the influence of fragmentation include good working relationship, attitudes of leader and individuals, and inter-sectoral collaboration. Lastly, the interviewees highlighted some factors that enable trust, collaboration, and integration, including participation and responsibility, contract, procedures, relationships, working environment, togetherness, top management role, and coordinator role.

3. Enablers of knowledge sharing and knowledge creation: Results of the qualitative study identified various variables such as: meetings (e.g., interfacing and technical meetings), working environment, spirit of project team, transparency, documentation (e.g., method statement), project leader's attitude, motivations, policy of companies, and knowledge type. The results also affirmed some factors identified from the literature, such as IT, boundary objects, a common main goal, and leaders' roles.

The factors, combined from the literature and findings of qualitative study, were used to develop the theoretical model (see Chapters 3 and 4). Quantitative study was employed to test and develop the model further to attain the final model of project learning. The quantitative study also involved a questionnaire survey to measure fragmentation, project learning, and enablers, and to determine the relationship among these. In addition, quantitative study was used to verify the findings of the qualitative study.

6.1.2 Main results of quantitative study

The quantitative study involved developing three hierarchical measurement models, namely, fragmentation, intra-project learning, and inter-project learning. The study also involved testing and developing the whole model of project learning. The results concentrated around two levels: structural and measurement models.

Analysis of the structural model was conducted to determine the extent of fragmentation's influence on the project learning process. The results affirmed that fragmentation has a negative significant influence on both intra- and inter-project learning. In addition, fragmentation has a significant influence on the mediating constructs: managerial support, knowledge sharing support, and project culture. Managerial support has positive significant relationships with both intra- and inter-project learning. Moreover, project culture has a positive significant relationship with intra- and inter-project learning. Knowledge sharing support has no effect on inter-project learning, but it has a small effect on intra-project learning.

Values of variance explained (R^2) of the endogenous constructs (dependents) were quite high. This demonstrates a good theoretical structural model. Other tests of the quality of model, such as path coefficient and model's goodness-of-fit, supported this finding. This confirms the importance of considering fragmentation of construction projects when addressing project learning.

To obtain a valid and reliable measurement scale, the study conducted content validity, pilot study, principal component analysis, and confirmatory factor analysis. Partial least squares-path modeling was conducted to test the whole model. In addition, the model's reliability, validity, and quality were attained. The analyses resulted in 43 variables measuring the main constructs (i.e., fragmentation, project learning, and enablers of learning). The final list of items of the whole model is shown in the following table.

Table 6.1: Variables of the full model of project learning

Constructs		Items
1. Fragmentation (FRAG)		
1.1	Spanning Knowledge Boundaries (SKB) (5 items)	Relationship, Insufficient information from previous stages, Insufficient information from other consultants, Access information easily, and Well managed information.
1.2	Integration (INTEG) (3 items)	Regular meetings, Focusing on project owner's needs, and Freedom for self organizing team.
1.3	Barriers (BARRIERS) (4 items)	Professionals' barriers, Organizational barriers, Language barriers, and Cultural barriers.
1.4	Decoupling of Diversity (DoD) (3 items)	Contact with other professionals, Discrepancies or clashes, and Understanding other professionals.
2. Intra-Project Learning (INTRA-PL)		
2.1	INTRA 1 (4 items)	Open discussion, Collaboration support, Face-to-face communication, and Asking others.
2.2	INTRA 2 (3 items)	Efficient problem solving, Implementing new technology or methods, and Job delegation.
3. Inter-Project Learning (INTER-PL)		
3.1	INTER 1 (6 items)	Lessons learned sessions, Visiting other projects, Networking, Communication with people from other projects, Debriefing meetings, and Brainstorming sessions.
3.2	INTER 2 (4 items)	Storage of project plans, Storage of important information, Review sessions, and Ad hoc meetings.
4. Enablers (SUPP)		
4.1	Managerial Support (MANAG SUPP) (4 items)	Enough time for learning, Enough resources for learning, Making decision about the way of learning, and Company's policy supports openness.
4.2	Knowledge Sharing Support (KS SUPP) (3 items)	Incentives for knowledge sharing, Relationship between companies to enable KS, and Friendship relation to facilitate knowledge sharing.
4.3	Project Culture (PRO CULT) (4 items)	Role of leader to support good relationship, Respect each others' views, Knowing each others' abilities, and Setting of site office.

The following sections discuss two levels of the whole model, namely, structural and measurement models. The first level involves the relationship among main constructs, as well as the interpretation of mediating effect of enablers on project learning. The second includes the relationship between manifest variables and their constructs, such as the relationship between indicators and integration that measures fragmentation.

6.2 Discussions on the Relationship among Constructs

This section discusses the results of the structural model (i.e., path analysis). The discussion involves two directions, namely, the relationship between first- and second-order constructs and the relationship among second-order constructs (i.e., fragmentation, project learning, and enablers). Figure 6.1 shows the final model of project learning and the influence of fragmentation as exogenous construct and enablers as mediating constructs. Indicators of all the constructs have been shown previously in Table 6.1. Values on the arrows indicate the strength and significant of the relationships (path coefficient and p-value), while values inside the constructs indicate the variance explained (R squared).

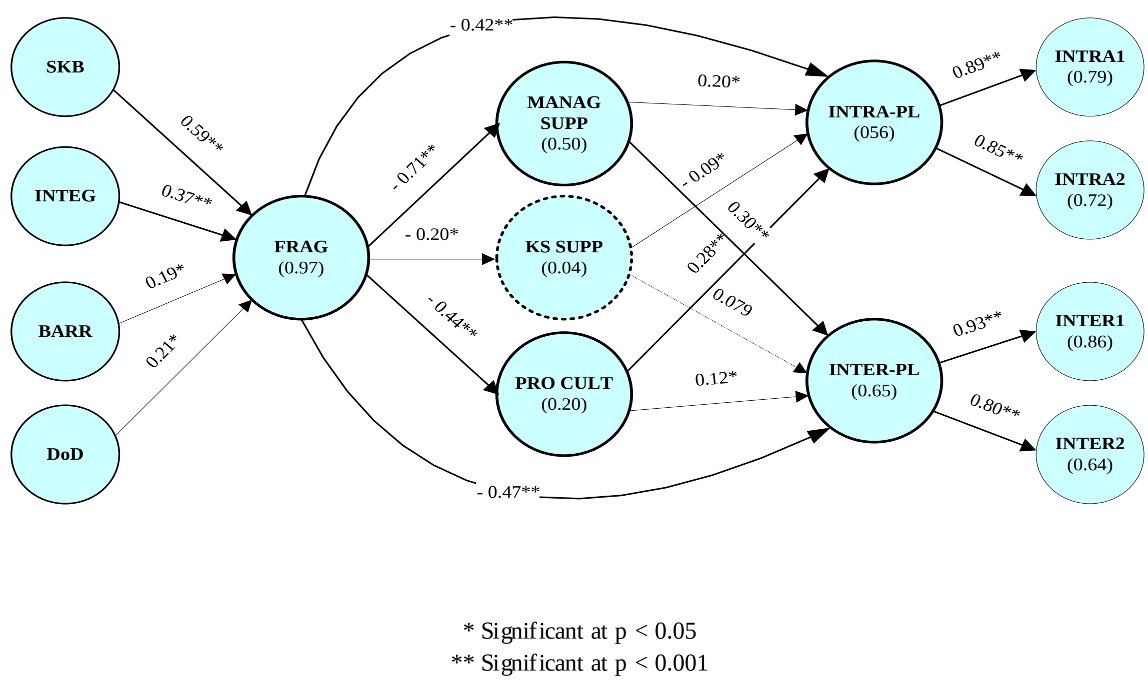


Figure 6.1: Structural relationships of the project learning model

6.2.1 Interpretation of the relation between first- and second-order constructs

The full model of project learning included three main constructs identified as hierarchical or second-order constructs, namely, fragmentation, intra-project learning, and inter-project learning. These constructs are measured by first-order latent constructs, either formatively or reflectively. The previous figure (6.1) shows the relationship between the first- and second-order models. All relationships are strong and significant.

There are four components that contribute to fragmentation: spanning knowledge across boundaries, integration (lack), decoupling of diversity (DoD), and barriers. Path coefficient and T-statistics indicate good and significant relationship between these components and fragmentation. Referring to Figure 6.1, it appears that spanning knowledge boundaries (SKB) has the most influence on fragmentation. The average weight of items measuring SKB, which will be discussed later on in Section 6.3.1, affirmed this finding. These items – which are well-managed information, long-term relationship, access information, sufficient information from other consultants, and sufficient information from previous stages – can explain fragmentation from a new perspective. In this regard, fragmented construction processes may indicate a problem related to information and knowledge, such as sufficiency of information from other consultants, difficulty to access information, and relationship among consultants.

The level of team integration (INTEG) significantly influences fragmentation. Three items that measure this level, which are autonomy of the team to organize work for better outcome, mutual focus on owner's requirements, and getting together (regular meetings). This construct has the second most influence on fragmentation after SKB.

Decoupling of diversity (DoD) has significant influence on fragmentation, but lower than SKB and INTEG. The construction project is described as an arena where different people from different professions are gathered to achieve one goal. Specialization per se is considered an advantage; however, decoupling or disintegration of different professionals is the issue. This level of decoupling can be measured by understanding information from people from other backgrounds, solving discrepancies or clashes between design and construction, and maintaining a level of contact with professionals from other backgrounds. Understanding information from people from other backgrounds scored the highest weight on fragmentation, while the other two scored low weights. From this perspective, fragmentation can be viewed as the level of understanding information among different professionals.

The last component that influences fragmentation is barriers (BARRIERS). This component includes various aspects, including professional, organizational, cultural, and language barriers. This component has the lowest influence on fragmentation compared with the other three components. In addition, three items under this component (i.e., organizational, cultural, and language barriers) have trivial influence on fragmentation. Meanwhile, professional barriers scored quite significant weight. Hence, fragmentation can be interpreted as a feature of professional barriers.

On the other hand, intra-project learning can determine two components: INTRA 1 and INTRA 2. Both components have a very strong and significant relationship with intra-project learning. While the first component can be related to the social or “soft” process of learning, the second can be related to more technical or complex ways of learning. The first component includes face-to-face interaction, open discussion, collaboration with new colleagues, and asking others. The second component includes items with a more complex level of learning, such as problem solving, implementation of a new technology and method, and job delegation. Both, social and technical constructs, have equal contribution to intra-project learning. Learning in construction projects, therefore, can be regarded as a socio-technical perspective.

Similarly, inter-project learning can be determined by two components: INTER 1 and INTER 2. The relationship between these with inter-project learning is also very strong and significant. The first component includes items that indicate the process of experience accumulation and knowledge articulation. These items include visiting other projects, contacting individuals from other projects, networking, de-briefing meetings, brainstorming sessions, and lessons-learned sessions. In the original theoretical framework, experience accumulation and knowledge articulation are separated components (Prencipe & Tell, 2001), but they are identified as one component in the current study. This is possibly attributed to the high association between the two.

The second component includes items related to knowledge articulation and knowledge codification, such as storage of important information, storage of project plans/audit, review sessions, and ad hoc meetings. Review sessions can reveal some aspects of knowledge articulation, but they include the aspect of knowledge codification as well. For example, during review sessions, the main activity is to identify causes of problems or issues, which will be followed by writing in the form of reports.

Therefore, inter-project learning can be viewed as two main processes. The first involves the process of experience accumulation to knowledge articulation, while the second involves the process of knowledge articulation to knowledge codification. This shows that inter-project learning is a continuous but not linear process. Thus, it is an intertwined activity of the three main processes mentioned above.

6.2.2 Influence of fragmentation on project learning

Previous studies (e.g. Barlow & Jashapara, 1998; Forgues et al., 2009; Gieskes & Broeke, 2000; Knauseder et al., 2007) indicated a negative influence of fragmentation on different learning activities. The results of the current study confirm the negative influence of team fragmentation on project learning processes. In the direct relationship model, without considering the influence of enablers (or mediating variables), the path coefficient between fragmentation and intra- and inter-project learning is -0.67 and -0.75, with high T-statistic values of 16.1 and 29.8, respectively (refer to Figure 5.16 in the previous chapter). This indicates a strong and significant association.

The variance of intra- and inter-project learning (R squared) explained by fragmentation is quite high as well. The variance explained for intra-project learning is (R^2 = 0.45), while the variance explained for inter-project learning is (R^2 = 0.57) (see Figure 5.16 in the previous chapter). In other words, fragmentation can explain approximately **20%** of the variance in intra-project learning. Similarly, fragmentation can also explain **32%** of the variance in inter-project learning. Both values are considered quite high, especially if we bear in mind that there is only one exogenous construct in the model, which is fragmentation. This clearly demonstrates the importance of considering fragmentation in the learning process of construction projects. The argument here is that fragmentation must be considered when the purpose is to obtain efficient team learning in construction projects.

6.2.3 Role of the enablers in the model

Two of the mediating constructs (managerial support and project culture) partially mediate the relationship between fragmentation and both intra- and inter-project learning. However, project culture has quite a low influence on inter-project learning. The third mediator (i.e., knowledge sharing support) has no strong mediating effect on the model, specifically on inter-project learning. This is possibly due to people's perception that knowledge can be shared freely with every individual in the project. In addition, people might be willing to share the necessary knowledge to achieve the objectives of the project.

These mediating variables can partially explain how learning occurs within a fragmented context. Some variables have considerable roles in enabling project learning. For example, allocations of time and resources, authority for choosing the preferred way of learning, and support for openness are some variables that have partial roles in this context. Other variables that facilitate the project learning process include supporting good relationships, respect for each other's views, awareness of each other's abilities, and the setting of the site office. Some of these variables were obtained from Sense's model (e.g. Sense, 2004, 2007b), which is based on the situated learning theory. For the current study, the theory implies that context is significant not only to attain learning, but also to enable learning within fragmentation. Social activities and communicative interaction among team members (Egbu, 2006; Sense, 2009) have a significant influence in this regard.

Other variables may possibly have a stronger influence on achieving project learning within fragmentation. Identifying such variables requires more in-depth investigation that focuses on this topic per se. However, procurement method, knowledge management, partnering, and project governance, may have a significant role in enabling project learning in this context. Efforts to manage and harvest knowledge in projects can help in reducing the fragmentation of organizational knowledge (Love et al., 2005).

6.3 Discussions on the Measurement Models

Measurement scales of fragmentation, intra-project learning, and inter-project learning may advance the way of measuring these notions as second-order latent constructs. The following discusses each main construct in the model and their manifest variables (i.e., items).

6.3.1 Indicators of fragmentation

Table 6.2 shows the average weight of all first-order constructs that indicate fragmentation. Average weight of each construct shows the contribution of first-order constructs to fragmentation. The results infer that spanning knowledge boundaries (SKB) and lack of integration (INTEG) are the constructs that contribute the most to fragmentation. On the other hand, barriers (BARRIERS) have the lowest influence on fragmentation. Only one item under this construct contributes to fragmentation: professional barrier. The rest have trivial influence, as they scored weights less than 0.1 (Chin, 1998b). However, formative items, even with very small weights, should not be eliminated from the analysis because they contribute to the measurement (Chin, 2010). The table also shows the ranking of each item according to weight. For example, "*understanding information from people from other background*" under decoupling of diversity (DoD) is the highest contributor to fragmentation. Meanwhile, "*language barrier*" under BARR is the lowest. The following discusses the indicators of fragmentation according to their ranking.

Table 6.2: Average weight and ranking of first-order constructs contributing to fragmentation

Variables	Construct	Label	Ranking	Weight
Frag27	Decoupling of Diversity (DoD)	Understanding information from people from other background	1	-0.282
Frag26		Solving discrepancies – clashes	13	0.026
Frag24		Contact with other professionals	14	-0.019
Average weight				**0.109**
Frag5	Spanning Knowledge across boundaries (SKB)	Well managed information	2	0.273
Frag14		Long term relationship	3	0.210
Frag4		Access information easily	6	0.134
Frag29		Insufficient information from other consultants	7	0.120
Frag28		Insufficient information from previous stages	12	0.034
Average weight				**0.154**
Frag18	Integration (INTEG)	Freedom for self-organizing team/work	4	0.179
Frag17		Focus on project owner's requirements	5	0.174
Frag12		Irregular meetings	9	0.105
Average weight				**0.153**
Frag19	Barriers (BARRIERS)	Professional barrier	8	0.108
Frag20		Organizational barrier	10	0.075
Frag22		Barriers between different ethnic groups	11	0.062
Frag21		Language barrier	15	-0.002
Average weight				**0.062**

Note: The average weight of each construct was calculated without considering the effect of the negative sign, which is a result of negative wording in the questionnaire.

The first item in the ranking intends to measure the degree of "*understanding information from people from other backgrounds*." This item contributed the most to fragmentation. The construction project is an arena of diverse specializations and professions. Inadequate understanding of information among professionals indicates team fragmentation. Professionals are supposed to speak the same "technical language." However, it appears that the project team requires more standardized information. Mutual understanding of project knowledge and information among team members may influence learning.

The second item that indicates fragmentation is "*well managed information*." In fact, well-managed and organized information influences its usage by different team members across the project life cycle. This allows for easier sharing of information during the construction stage and other stages of the project. Another item related to this item is "*ease of information access*." This item ranks sixth and indicates the availability and accessibility of information when needed. Ease of information access indicates the utilization of certain tools (e.g., IT) in the project, which facilitate information sharing across project boundaries.

The indicator "*long-term relationship*" was originally under the coordination construct in the theoretical framework (Ali et al., 2009). After conducting principal component analysis, this item was linked with other items to the spanning knowledge boundaries (SKB) construct. Long-term relationship works as an enabler of better knowledge sharing across project boundaries. However, one may ask, "how is this item related to fragmentation?" To understand its role in fragmentation, we must think about it as one of the items that measure spanning knowledge across boundaries (Ratcheva, 2009). Mitigating the impact of fragmentation can be attained by efficient information and knowledge sharing across boundaries. Good relationship among the team is one of the ways that break different boundaries in the project and enable knowledge sharing.

“*Freedom for self-organizing team/work*” indicates the degree to which team members have the autonomy to overcome barriers that contribute to fragmentation. Inadequacy of self-organizing team can increase the negative influence of fragmentation. Ayas (1996) indicated that the project team is one of the best ways to integrate across boundaries; with a self-managing team, effective performance and success can be achieved. The ability of team members to enjoy some degree of autonomy may influence their learning as well (Sense & Antoni, 2003).

The fifth indicator of fragmentation is “*inadequate focus on the owner’s (sponsor) needs.*” This indicator implies a low level of collaboration and integration within the team (Baiden et al., 2006). In addition, inadequate collaboration within the team can influence the performance of the project in general, and it is believed to increase fragmentation.

“*Insufficient information from other consultants,*” which is under SKB, indicates limited sharing of information and explicit knowledge. This is related to a negative lateral relationship among team members or shortcoming in the current practice in construction. Insufficient information from other members (e.g., consultants) may be related to the nature of the construction project, where there is always a degree of uncertainty when conducting the work. In such cases, consultants may not be able to provide comprehensive information about some activities/works.

Items that measure fragmentation but with low weight (less than 0.1) include language barriers, organizational barriers, cultural barriers, contact with other professionals, solving discrepancies or clashes, and insufficient information from previous stages. Barriers, excluding professional barriers, have a small effect on fragmentation. People in construction projects believe that cultural or organizational related barriers do not influence their relationship. On the other hand, contact with other professionals also has a small influence on fragmentation. This is due to ease of usage and advances of communication tools in projects. Solving discrepancies or clashes between design and construction may not indicate the latent dimension of fragmentation as defined in the current study. Discrepancies are common in most projects, and solving them is considered normal practice in construction projects. However, the efficiency of solving discrepancies may indicate high level of communication and sharing information among team members. Lastly, insufficient information from previous stages has low influence on fragmentation, possibly because builders believe they have enough information from previous stages or they can request for it when needed.

6.3.2 Dimensions of intra-project learning

The measurement of intra-project learning (INTRA-PL) includes seven reflective items within the full model. This construct consists of two dimensions or first-order constructs, namely INTRA 1 and INTRA 2. The first involves items that can be considered social or simple processes of learning within projects. These include open discussion, collaboration with new colleagues, face-to-face communication, and asking others. Meanwhile, INTRA 2 involves items that are technical or require procedural process of learning; thus, it can be called complex process of learning. Items measuring this construct include problem solving, implementation of new technology or methods, and job delegation.

The first item indicates the social aspect of learning is "*open discussion*," which implies a degree of transparent and frank discussion on problems and/or issues related to the project (Knauseder et al., 2007). Open discussion help in identifying the causes of problems and their solutions efficiently. "*Collaboration with new colleagues*" is considered one of the items that support the development of better relationships and cooperation. According to Knauseder et al. (2007), appropriate project preparation and cooperation among individuals enable experience exchange and expand knowledge base. "*Face-to-face communication*" is an important aspect of knowledge creation. This item, along with others, forms the socialization mode of the knowledge creation process in Nonaka's model. Moreover, physical closeness is the first item in (Roth et al., 2000) for achieving knowledge creation. Face-to-face interaction enables direct sharing of experience and immediate feedback. Among other items that measure knowledge creation, face-to-face communication appears to be the most frequent variable used in this context. The last item under the first component of intra-project learning is "*asking other professionals*." Although this item appears simple, but it can be a significant approach of learning. This is because it involves communication, experience sharing, and feedback. In addition, it indicates good relationship with those who have the experience (mentor relationship).

The first item under the technical aspect of learning is "*efficient problem solving*." One of the main processes of organizational learning is detecting and correcting errors (Argyris & Schön, 1978). Efficient problem solving encompasses identifying problem causes and their solutions (Bourgeon, 2007; Kotnour, 1999; Kotnour & Hjelm, 2002). On the other hand, Ibert (2004) referred to this process as the "task of problem solving," which he considers one of the main processes in project learning. Furthermore, Fong (2003) considered this task as one of the processes of collective (self-directed) learning, which is one of the components of knowledge creation within the construction team.

The second item is "*implementing new technology or method*" during construction. Again, collective learning can be attained by offering people opportunities to absorb new technology (Fong, 2003). This item was part of one component in (Knauseder et al., 2007), which was called experimenting. Experimenting is an important process in the learning cycle in projects (Kolb, 1984; Kotnour, 1999). Among other items in Knauseder et al.'s (2007) model, this item appears to be the only one practiced in local construction projects. "*Job delegation*" is the project leader or manager's act of authorizing team members to perform a certain task. In addition, job delegation is one aspect of project team empowerment (Newcombe, 1996). Team members work – and possibly learn – better when given the trust to perform a certain duty. Furthermore, team members may learn when exposed to different tasks and duties. Lastly, delegating work enables individuals to involved in certain tasks such as decision-making and coordination, which help in establishing knowledge networks and gaining new knowledge (Teerajetgul & Charoenngam, 2006).

6.3.3 Dimensions of inter-project learning

Inter-project learning or cross-project learning can be measured by two main components in the context of the current study. The first component (INTER1) contains different items, including networking, experience accumulation, and knowledge articulation. Meanwhile, the second component (INTER2) is related mainly to knowledge codification. Both components contain items from the two models proposed by (Prencipe & Tell, 2001) and (Knauseder et al., 2007).

The first item that measures the first component (INTER1) is "*visiting other projects during the current project*." This item indicates direct sharing of knowledge from/to other projects (Disterer, 2002). The frequency of visiting other projects may create opportunities for direct experience sharing across projects. Knowledge accumulation in this context can occur not only within a project but also from other people across projects. "*Communication with people from other projects*" implies the level of interaction and networking among people in different projects. In this item, degree of physical contact is lower than the first item. However, item can be more practical than the first item, as visiting other projects physically implies time constraints and location proximity. The third item, which is also an aspect of networking, is "*ease of finding people in current project or other projects to answer enquiries*." Good relationship among team members is believed to contribute to this item. Apparent advantages of networking include bridging boundaries and enhancing learning (Knauseder et al., 2007).

Several mechanisms are encountered in knowledge accumulation and articulation, including "*de-briefing meetings,*" "*brainstorming sessions,*" and "*lessons-learned sessions*." These mechanisms are practiced in local construction projects, or at least people believe that they have a role in this process. In fact, these activities can work as a preliminary process to knowledge codification, which is an integral part of inter-project learning processes.

Knowledge articulation and codification, which represent the second component (INTER2), consist of the first item: "*review session*." In fact, review session activities involve certain aspects of both brainstorming and writing up or codifying knowledge.

Similarly, "*ad hoc meetings*" involve some aspects of both knowledge articulation and codification. Project team members in such meetings may highlight certain problems (or instant issues), where meeting minutes or any other forms of knowledge codification will take part in this process. The last two items of knowledge codification mechanisms are "*storage of project plans/audit*" and "*storage of important information about the project*." Important information includes project milestones, correspondents, case writing, reports on certain problems during construction, and others. To be more precise, these items imply information codification rather than knowledge codification. Explicit knowledge codification is a rather more complex process than information codification. However, these items are able to hold sufficient information that can be treated as explicit knowledge. Tacit knowledge is rather more difficult to codify, specifically in a construction project, that is described as complex and multi-disciplinary arena.

6.3.4 Measurement of enablers of project learning

Enablers of project learning within fragmentation are knowledge sharing support (KS SUPP), managerial support (MANAG SUPP), and project culture (PRO CULT). The following paragraphs elaborate each item under these constructs.

1. Knowledge sharing support (KS SUPP): The theoretical framework of the current study assumes that some items can facilitate knowledge sharing within fragmented projects. There are three items under this component: "*incentives for knowledge sharing*," "*relationship between companies to enable experience sharing*," and "*friendship relation to facilitate knowledge sharing*." Incentives for knowledge sharing include monetary and non-monetary incentives. Mutual collaboration among companies includes joint venture and alliance, for example. Sharing experience with friends only indicates the influence of relationships on learning.

Surprisingly, the effect of these items on project learning within fragmentation was trivial. Individuals possibly view knowledge as one that cannot be traded with money or other incentives. Knowledge may be shared freely as long as it contributes to the betterment of the project. In addition, friendship and other close relationships appear to have unessential roles in this activity. A possible reason is that individuals are driven by the main goal of completing the project, and they will share the necessary knowledge to achieve this goal.

2. Managerial support (MANAG SUPP): This construct consists of four items, most of which are derived from Sense's model of project learning. The first and second items under this component are "*enough time for learning*" and "*appropriate resources for learning*." The project team shall be given sufficient time to discuss and share their experiences in line with their daily activities on the site. Appropriate resources include facilities for efficient meetings, communication tools, and others. According to Sense (2007b), learning requires establishing time and a learning space for conversation and reflection among project team members and the intervention of a "project sponsor" in the learning space. "Organizational action" that offers learning resources (i.e., time, money, and training programs) is an essential component in project team learning (Kotnour & Hjelm, 2002). The third item under this component is "*making decision about the way of learning*." This item is basically about individuals' authority to formulate decisions on the way they create and share knowledge. It involves two aspects: individual authority leads to better understanding of learning and project sponsor influence on this activity, which influence individuals action to explore issues more deeply and more freely (Sense, 2008;

Sense & Antoni, 2003). Within the context of the current study, team members appear to prefer less interference about their way of learning. The last item, "*organizational support of openness,*" includes organizational support for accepting alternative solutions and methods, promoting a flexible way of working, and considering new ideas (Knauseder et al., 2007).

Managerial support in the current study has partial mediating but significant influence on both intra-project and inter-project learning. Items under this component, as discussed in the previous paragraphs, are essential to support learning in projects in general. The current study found that these items partially support learning within a fragmented context. However, one may ask, "Why do these items support learning in this context?" It appears that these items have a strong influence that they could overcome the negative influence of fragmentation.

3. Project culture (PRO CULT): The first item to be discussed under this component is the "*leader's role to encourage good relationships.*" Supporting good relationship in the project team is essential not only for achieving the project goal, but also for better experience sharing and openness. Regardless of team diversity, good relationship can thaw boundaries between individuals. The leader has to serve as a role model and show a good example of how to deal with others. In addition, the leader should attempt to resolve conflicts and reduce divergence among team members. He or she may encourage opportunities for team cohesiveness and support off-site activities. The second item is "*respecting each other's views,*" which is part of Kotnour and Hjelm (2002) study of project culture in supporting team learning. In fact, it is a way of evaluating each other's experiences, which can overcome boundaries among professionals (Fong, 2003).

Moreover, equitable team relationship and respect for all are important elements for achieving an integrated team (Baiden et al., 2006). The third item, "*knowing each other's knowledge and experience*," is also a boundary object and is essential for knowledge sharing and learning. According to Sense (2004), this item is the first step in building "learning relationships" among individuals in projects. In addition, this item also entails better knowledge identification and acquisition. The last item, "*setting of site office or workplace*," is considered part of learning environment support (Sense, 2007b). The workplace setting includes the appropriate layout and provision of facilities, may create opportunities for face-to-face interaction, communication, discussion, and reflection. A common site office allows for situating team members in a single place, which facilitate their integration (Baiden et al., 2006).

According to Kotnour and Hjelm (2002), project culture is one of the elements that explain project team learning. For the current study, project culture has a significant relationship with both intra- and inter-project learning. Thus, items under this component mainly support learning processes within projects. Support across project learning requires the inclusion of variables that mainly facilitate knowledge codification and transfer.

6.4 Summary

The chapter commenced with an overview of the main findings of both qualitative and quantitative studies. However, the primary purpose of this chapter was to discuss the results of the full model of project learning. The discussion was divided into two main parts: structural and measurement models.

The first involved interpreting the relationship between the four main constructs, namely: fragmentation, intra-project learning, inter-project learning, and enablers of learning. The argument is that fragmentation, as a distinguished characteristic of construction, has a significant influence on the project learning process and is important to consider if the purpose is to attain learning. The role of enablers as intervening factors was discussed as well. The discussion elaborated on the role of managerial support, project culture, and knowledge sharing support. The low influence of knowledge sharing support was interpreted. The discussion likewise involved the relationship between the four main constructs and their sub-constructs (i.e., first and second-order constructs).

The second part focused on interpreting the relationship between the constructs and their variables (i.e., measurement models). The discussion elaborated on each item and its role in determining the four constructs, namely, fragmentation, intra-project learning, inter-project, and enablers.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.0 Summary of Objectives and Main Findings

The first objective of the study was to identify the features of project learning from literature. Project team action to learn is one of the features of project learning. Project learning includes some aspects of organizational learning, such as detecting and correcting errors. Moreover, project learning can be determined by knowledge being created and shared within and across projects. Projects encompass situated and unintentional features of learning; thus, learning is assumed to occur in any project. In this regard, three approaches of learning in projects can be observed: knowledge in action, integrating different entities, and project as a challenging task. Projects are temporary and devoid of memory; therefore, it is assumed that projects per se cannot learn. Lastly, project characteristics may have a significant influence on shaping learning processes.

The second objective was to identify the factors that facilitate learning processes in construction project considering fragmentation. The qualitative study was used to explore some factors (called enablers) of project learning. These factors were purified and validated in the quantitative study. Three main construct comprise the enablers are knowledge sharing support, management support, and project culture, were identified.

The last objective was to develop the project learning model that considers fragmentation as a distinguished characteristic of construction. The model was first developed based on related theories and on the qualitative study. It was assumed that fragmentation has a negative and significant relationship with intra- and inter-project learning. In addition, it was assumed that project learning requires enablers that attain learning within this context.

The quantitative study used principal component analysis (PCA) and partial least squares-path modeling approach (PLS-PM) for further testing of the theoretical model. The purpose of the quantitative study was threefold: to develop the measurement models and ascertain their reliability and validity; to examine the interdependence relationship among constructs (i.e., path analysis and hypotheses testing of the main constructs); and to examine the mediating effect of enablers. The empirical investigation has determined the relationship among all constructs. In addition, several tests were conducted to attain validity, reliability, and quality of the full model.

Two main enablers of project learning have exhibited partial mediating effect on the relationship between project learning and fragmentation, namely, Managerial Support and Project Culture. Meanwhile, the third enabler (i.e., Knowledge Sharing Support) had no significant effect on both intra- and inter-project learning (refer to Figure 6.1 in the previous chapter for the full model of project learning).

7.1 Contributions of the Study

The current study attempted to contribute to the theory of project learning in four areas. First, it identified the aspects of project learning from the literature. This facilitated understanding what project learning is and how it differs from similar concepts such as project-based learning. In addition, the study provided a framework of project learning comprises the indicators of this latent construct. Quantifying such construct required rigorous process and various analyses.

Second, the project learning model that encompasses intra-project and inter-project learning were identified as hierarchical measurement models. Intra-project learning was determined by two constructs: "social" and "technical" or dimensions of learning. For example, face-to-face interaction is considered as a soft dimension, while the problem-solving process was identified under the procedural dimension. On the other hand, two aspects of inter-project learning model were identified as well. While the first aspect involves dimensions of experience accumulation and knowledge articulation, the second includes dimensions of knowledge codification. Developing hierarchical measurement models using PLS-PM retains full and concrete definition of such abstract notions. Using this method can establish advantages in the construction field such as better understanding of project learning process.

Third, the study advanced the theory of project learning by considering the effect of fragmentation of construction project. It provides an empirical evidence on the extent of fragmentation's influence on project learning. In addition, the study was able to explain how learning can be attained within this milieu. This was achieved by identifying the factors that contribute to overcoming the negative influence of fragmentation on project learning. The influence of these enablers was deemed to be partial between fragmentation and project learning.

Finally, the current study advanced the fragmentation measurement scale by indicating this concept as a multi-faceted second-order construct (Type II formative hierarchical model). This construct was measured by formative manifest variables, while the first-order constructs were measured by reflective manifest variables. The study recognized the latent dimensions of fragmentation, which include more than the separation between design-and-build process or individuals working in silos. A fragmented project team implies the following new aspects: level of spanning of knowledge boundaries, level of team integration, decoupling of diversity or specialization, and barriers. Determining the concepts of fragmentation and project learning as hierarchical measurement models using PLS-PM approach has, to the best of the researcher's knowledge, not used previously in construction studies.

7.2 Implications of the Study

Results of the current study have theoretical as well as practical implications. First, the project learning model may serve as a base for other researchers to create a comprehensive framework of the notion in construction. In addition, researchers may utilize the measurement models (specifically the results of CFA) to conduct other investigations on fragmentation, project learning, or the enablers of project learning. Furthermore, researchers may use the same method to develop and measure other latent concepts in the field.

Implications for practitioners include the following. Practitioners can use the result of the study to assess the project learning situation in the industry and advance the practice of project learning by defining what is lacking. In addition, project managers and other stakeholders (of construction project and project-based organization) can leverage the results of this study to understand learning and recognize its challenges. The study shows the process of learning within and across projects, which people in the industry can adopt to gain the benefits of learning. Moreover, practitioners can be more cautious about the drawback of learning (i.e. variables of fragmentation) so as to tackle them more effectively. Lastly, practitioners may focus on the enablers proposed by the current study to stimulate learning within and across projects.

7.3 Directions for Future Research and Recommendations

The exploratory nature of the current study and purposive sampling of the quantitative study may influence generalization of the results to the population. The study focused on mega-size building projects only (i.e., projects undertaken by G7 companies). Further investigation is required targeting a random sample of construction projects, including different types of projects such as infrastructure projects. In addition, a cross-sectoral investigation to compare the model between construction and non-construction projects would be interesting. This will allow for generalization of the results and testing of the model in different contexts.

The study was limited to investigating the influence of one independent factor: fragmentation. Although this allowed for comprehensive investigation, considering other characteristics of construction projects may lead to a profound model of project learning. Other limitations of the current study, which can be covered in future studies, include investigating the role of control variables (e.g., procurement method, team composition, project structure, and so on) on fragmentation and project learning. Future studies may include also investigating the influence of fragmentation and project learning on other variables such as performance or innovation in construction projects.

To conclude, the current research is an attempt to attain efficient learning in construction projects. Construction as an arena of various disciplines and professions, can offer many learning opportunities for better development and efficiencies. However, fragmentation can be one of the major drawbacks of learning and its benefits. Understanding fragmentation's influences on learning and how learning can be stimulated within this context is useful. Awareness of project sponsors and top management of these issues is important, while their support of learning activities would benefit team development and project performance. Finally, overcoming the influence of fragmentation to achieve learning is required for competitive, knowledge-based, and innovative construction industry.

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APPENDICES

APPENDIX A: List of Publications

Alashwal, A. M., Abdul Rahman, H., Abdullah, A., and Abdul Samad, Z. (2009). Project Learning and Knowledge Management in Construction: Literature Review. Paper presented in the 3rd APGS, April, Kuala Lumpur.

Abdul Rahman, H., Alashwal, A. M., Jamaludin, Z. (2010). Project Learning Practice of Quantity Surveying Firms. Proceeding of KMICe, Kuala Terengganu, Malaysia.

Alashwal, A. M. and Abdul Rahman, H. (2010). Project Learning and Fragmentation in Construction Organizations. Proceeding of the 2nd International Conference on Construction In Developing Countries, 3-5 August, Cairo, Egypt.

Abdul Rahman, H., Alashwal, A.M., & Jamaludin, Z.H. (2011). "Implementation and Methods of Project Learning in Quantity Surveying Firms: Barriers, Enablers and Success Factors". *American Journal of Economics and Business Administration* 3 (3): 430-438

Alashwal, A. M., Abdul Rahman, H., and Beksin, A. (2011). Knowledge Sharing in a Fragmented Construction Industry: On the Hindsight. *Scientific Research and Essays,* Vol. 6 (7), pp. 1530-1536.

Alashwal, A. M., Abdul Rahman, H. & Wang, C. (2011). How fragmented is the construction industry? A theoretical outlook. Proceeding of the 2nd International Conference of Project and Facilities Management, University of Malaya, Malaysia. 18-19 May, pp. 188-193

APPENDIX B: Content Validity of the Questionnaire

Content validation of the instrumental questionnaire survey

On:

Developing a Project Learning Model Considering Fragmentation in Construction

By:

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FACULTY OF BUILT ENVIRONMENT
UNIVERSITY OF MALAYA
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Dear Sir/Madam,

The aim of this research is to investigate the effect of fragmentation on project learning practice. It is assumed that fragmentation has a negative impact on project learning. This study attempts to test this premise using a questionnaire survey. A part from developing a strong questionnaire survey is to conduct a content validity. In content validity, we test the relevancy and importance of questions asked before sending the questionnaire for data collection. This questionnaire consists of four (4) sections as the following (divided according to the main constructs of this study): 1) factors that measure fragmentation of project team, 2) factors that measure learning within projects, 3) factors that measure learning across project, and 4) the enablers of project learning. Your feedback is essential to establish a valid instrument, which will contribute to the development of a good quality questionnaire survey.

Thank you very much for your feedback and cooperation.

Yours,

Ali Mohammed Alashwal

Ph.D. candidate

University of Malaya

Demographic data

Please fill in the blank or mark (√) on the appropriate column.				
Name:	…………………………………			
Gender:	☐ Male	☐ Female		
Age (year):	☐ 25-35	☐ 36-40	☐ 41-50	☐ 50 or above
Number of years of experience:	………………… (year)			
Affiliation: (where do you work?)	………………………………			

1: Fragmentation of Project Team

Fragmentation of project team happens due to some reasons: separation of design activities from construction activities, lack of integration, coordination, boundaries between project team and adversarial relationships. A project team will be described as a fragmented if all or most of these conditions appear in the project environment.

Kindly indicate your opinion about whether the following questions indicate fragmentation. You can also write down other items that you think they are relevant to fragmentation at the end of the questions.

Please rate the relevancy and importance of each of the following questions to the definition of the construct given above by using the following scale:

1 = not R / I (Not Relevant nor Important) **2 = R** (Relevant) **3 = I** (Important) **4 = R & I** (Relevant and Important)

No.	QUESTION	not R / I	R	I	R & I
1	In this project, it is difficult to communicate directly with other team members especially with those come from other companies	1	2	3	4
2	I have long-term business relationship with most of the team members	1	2	3	4
3	My relationship with other team members can be described as a 'good' relationship	1	2	3	4
4	The coordinator of this project plays important role to bring different members together	1	2	3	4
5	I often meet other team members (for example, the architect) to discuss or coordinate work	1	2	3	4
6	In this project information technology (IT) facilitates coordinating my work with others	1	2	3	4
7	The way I am working in this project is to have a common goal and focus with other team members to achieve it	1	2	3	4
8	I with other members will form single team with spirit of group identity	1	2	3	4
9	I with other members will form single team with no organizational boundaries	1	2	3	4
10	Project's outcomes and goals will consider the whole project team rather than individuals working in this project	1	2	3	4
11	Information related to project (for example cost) are accessed easily	1	2	3	4
12	Information related to project (for example cost) are managed appropriately	1	2	3	4
13	Me with other team members form a single team because we work in one common office	1	2	3	4
14	All team members in this project are treated as having equal and significant professional capability	1	2	3	4
15	Problems are identified and solved collectively (no blame culture for individuals)	1	2	3	4
16	I trust other team members working in this project though they come from different companies	1	2	3	4

17	I, and other team members, know what is the need of the owner of the project	1	2	3	4
18	In this project, I and other team members have the freedom to organize our self for better outcomes	1	2	3	4
19	Different team members (from different backgrounds) can participate in different tasks to get a collective decision-making	1	2	3	4
20	Different team members can participate in different tasks to increase trust and reliance	1	2	3	4
21	In this project, I feel there are barriers between me and other professionals who come from other companies	1	2	3	4
22	There are no barriers between me and the upper management	1	2	3	4
23	There are no cultural barriers between me and other team members (especially those from different ethnic groups)	1	2	3	4
24	There is no language barrier between me and other team members (especially those from different ethnic groups)	1	2	3	4
25	Procurement Method (categorical question): Traditional, D&B, Turnkey, or BOT.	1	2	3	4
Do you think that there are other items can be used to indicate fragmentation according to the definition? Please specify the items below and rate them accordingly.					

2: Learning within Construction Project

Learning within project is defined as project team actions to create and share knowledge. There are some factors that can help in supporting learning within project include: structuring project environment for learning, leaders supports, good relationship between individuals etc. Similar to the previous section, you are required kindly to indicate whether the questions are relevant and important to measure learning within construction projects.

Please rate the relevancy and importance of each of the following questions to the definition of the construct given above by using the following scale:

1 = not R / I (Not Relevant nor Important) **2 = R** (Relevant) **3 = I** (Important) **4 = R & I** (Relevant and Important)

No.	QUESTION	not R / I	R	I	R & I
1	I often have informal dialogue with other team members (example a discussion over coffee break)	1	2	3	4
2	I often contact other team members if there is a new idea to discuss	1	2	3	4
3	From time to time, I attend meetings to discuss new ways of doing things	1	2	3	4
4	I can describe my relationship with other team members to be informal more than formal	1	2	3	4
5	Project leader always considers any new idea I propose for the betterment of the project	1	2	3	4
6	Others team members can share their experience with me so I can develop new ideas	1	2	3	4

7	I trust others in the team so I can share my experience with them without hesitation	1	2	3	4
8	All team member have the same technical language so our communication is very easy	1	2	3	4
9	I communicate easily with other team members because we can speak the same language (e.g. BM or English)	1	2	3	4
10	In this project, sharing experience is easy because team members have good relationship (e.g. friendship)	1	2	3	4
11	In this project, I with other team members use (IT) to facilitate our experience sharing	1	2	3	4
12	I and other team members share what we have learned from previous projects	1	2	3	4
13	The leader of this project encourages us to work as one team	1	2	3	4
14	Communication with top management is easy in this project	1	2	3	4
15	I have little experience in this type of projects	1	2	3	4
16	I have met few problems that we face in this project before	1	2	3	4
17	In this project, other team members have different values and experience than mine	1	2	3	4
18	I often collaborate with new colleagues	1	2	3	4
19	In this project, I can learn from other occupational /professional groups	1	2	3	4
20	Me and other team member can tell about mistakes we do freely	1	2	3	4
21	I get much feedback in this project	1	2	3	4
22	In this project, I can use many new technical solutions	1	2	3	4
23	I constantly seek new ideas and use many new material	1	2	3	4
24	I have changed my way of working in this project	1	2	3	4
25	I, with other colleagues, can change the basic way of doing work if a better way found	1	2	3	4
26	No much routine work in this project compared with the routine in the company	1	2	3	4
27	In this project I feel that my knowledge has gotten polished	1	2	3	4
28	I learn more by building relationship with other professionals or skilled individuals	1	2	3	4
29	I feel that this project is a new challenging task for me	1	2	3	4
30	I, with my colleagues, know the objectives and goals in this project	1	2	3	4
31	I often have an open discuss with other team members about problems solution or new ideas	1	2	3	4
32	I always tell persons I see doing wrong or using insufficient method	1	2	3	4

33	When a problem arises, we will report to upper management	1	2	3	4
34	We will develop a repair plan of troubleshooting when problem arises	1	2	3	4
35	In this project, there are some experts who do coaching for other team members	1	2	3	4
36	I learn from other professionals in the project although they come from different disciplines or have different background	1	2	3	4
Do you think that there are other items can be used to indicate learning within projects according to the definition? Please specify the items below and rate them accordingly.					

3: Learning across Construction Project

Learning across project can be attained by project team process of experience accumulation, knowledge articulation and knowledge codification. Basically, it involves transferring learning gained from one project to another directly or via a company first then to other projects. Please state whether you think that the following questions represent construction team learning across projects.

Please rate the relevancy and importance of each of the following questions to the definition of the construct given above by using the following scale:

1 = not R / I (Not Relevant nor Important) **2 = R** (Relevant) **3 = I** (Important) **4 = R & I** (Relevant and Important)

No.	QUESTION	not R / I	R	I	R & I
1	We solve problems or discuss ideas in this project by having group thinking session	1	2	3	4
2	I share my experience with other team members directly (person-to-person communication)	1	2	3	4
3	Usually I see other team member off the project (informal gathering)	1	2	3	4
4	I take some ideas or use some methods from other projects	1	2	3	4
5	I can attend meetings with people in other projects	1	2	3	4
6	I consider that it is easy to transfer and implement some ideas in other projects to this project	1	2	3	4
8	I discuss some problems with colleagues who work in other projects	1	2	3	4
9	New ideas have been discussed in this project can be transferred to our head office	1	2	3	4
10	The head office (or company) concern about project team to get new knowledge from projects	1	2	3	4
11	I will be able to transfer what I have learned in this project to other projects easily	1	2	3	4
12	Usually we conduct brainstorming sessions in this project	1	2	3	4
13	We conduct meetings to review important issues and identify the causes of some problems	1	2	3	4

15	I often use documents from previous projects (e.g. lessons learned) to get new knowledge that can be implemented in this project	1	2	3	4
16	Normally, project review (for example project audit, postmortem etc.) will take place at the end of this project	1	2	3	4
17	Important information about the project (e.g. milestones, deadlines…etc.) will be recorded clearly	1	2	3	4
18	Minutes of meetings will be kept for future usage	1	2	3	4
19	This project has a data base to record lessons learned which can be used in future projects	1	2	3	4
20	This project has a compiled record of 'project history'	1	2	3	4
Do you think that there are other items can be used to indicate learning across projects according to the definition? Please specify the items below and rate them accordingly.					

4: Enablers of Project Learning within Fragmentation

These enablers represent the factors that may help in achieving learning within and across project regardless of fragmentation. The enablers can be divided into: structuring project environment for learning, networking, supporting relationships, knowledge type, etc. Kindly check the relevant and important factors similar to the previous section.

Please rate the relevancy and importance of each of the following questions to the definition of the construct given above by using the following scale:

1 = not R / I (Not Relevant nor Important) **2 = R** (Relevant) **3 = I** (Important) **4 = R & I** (Relevant and Important)

No.	QUESTION	not R / I	R	I	R & I
1	I need to attend more meetings in this project to share experience and exchange knowledge with others	1	2	3	4
2	In this project, I need to see more people formally or informally to exchange ideas and discuss important issue	1	2	3	4
3	We need to conduct brain-storming and decision making sessions for experience sharing and exchange of ideas	1	2	3	4
4	Attitude of the project's leader influence the way I am sharing my experience with other people in the team	1	2	3	4
5	I think it is necessary to record important issues or problems for this project	1	2	3	4
6	There is a need for everybody to feel the spirit of project team in this project	1	2	3	4
7	Some form of recorded knowledge as 'Method Statement' is important for experience sharing between different team members	1	2	3	4
8	Project leader has to play important role to encourage us to build up good relationship with other team members	1	2	3	4

9	I am always encouraged to trust others	1	2	3	4
10	I am willing to share my experience if I get appropriate incentive (monetary incentive for example)	1	2	3	4
11	I will share my experience only with the people I know (for example my buddies)	1	2	3	4
12	I will share only part of my experience because some of what I know is considered 'trade secrete'	1	2	3	4
13	I will share my experience with others because the policy of my company required that	1	2	3	4
14	I get words of thanks when I share my experience with others	1	2	3	4
15	I have to share my experience with others because that is mentioned in the contract	1	2	3	4
16	Project owner can ask me to share my experience with other team members	1	2	3	4
17	I believe it is important to know each other abilities so there will be better sharing of experience	1	2	3	4
18	My way of learning is innovative: I like to think of different ways of doing things and like to challenge the current paradigm in work	1	2	3	4
19	My way of learning is adaptive: I like to look at how things are being done and I found changing the existing paradigm very difficult	1	2	3	4
20	I believe that this project needs more infrastructure that supports recording and using important knowledge	1	2	3	4
21	I believe we need better support for dialogue, conversations and discussion in this project	1	2	3	4
22	It is important to set learning as one of the project's goals	1	2	3	4
23	Time and resources for learning are not adequate in this project	1	2	3	4
24	I think that our leaders need to be more open for new ideas from any body	1	2	3	4
25	I think that our leaders need to behave in boundary-less fashion	1	2	3	4
26	Our leader should show role model in open communication, honesty and show how to trust others	1	2	3	4
27	I believe that project leader shall highlight the importance of learning from the project	1	2	3	4
28	I think our leaders should give us more room for discussion and problem solving by ourselves	1	2	3	4
29	It is important to engage us in making decisions related to the way of how we should learn in this project	1	2	3	4
Do you think that there are other items can be used to support project learning within fragmented construction? Please specify the items below and rate them accordingly.					

This is the end of this survey, thank you very much for your response

APPENDIX C: The Questionnaire Survey Instrument

Code (for researcher only)	

Faculty of Built Environment, University of Malaya,

50603, Kuala Lumpur, Malaysia

DEVELOPING A PROJECT LEARNING MODEL CONSIDERING FRAGMENTATION IN CONSTRUCTION

Questionnaire Survey - 1

---------------------------**Part of requirements to fulfill Ph.D. study**------------------------

The aim of this survey is to examine the impact of team fragmentation on learning practice in construction projects in Malaysia. In addition, this survey attempts to find out the factors that may help in reducing this impact.

Fragmentation of project team involves: diversity of skilled team; the separation between design and build process; lack of integration, coordination and collaboration; and lastly the adversarial relationship between project team members.

Project Learning Practice is the action that project team do to create and share knowledge within and between projects. It is believed that fragmentation has a negative influence on project learning practice.

Project Team here means any professional works in the project site including the design team or consultants and the construction team as well as project engineer, coordinator or project manager.

Your positive respond to this survey is very much appreciated and, hopefully, will help in the betterment of construction industry in Malaysia. You are required to fill up the following questions and give your opinion. Your answer will be confidential and the questionnaire will not ask you to write down your name, which will guarantee the anonymity of the respondents. The results of this survey will be used for the purposes of the academic research only. Filling up this survey will take about **15 minutes** of your valuable time. We really appreciate your effort and support to accomplish this research. We are willing to share part of the results of this survey upon your request.

Yours,

Ali Mohammed Alashwal

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"This survey will be used for the purpose of research only and the participants' identity or views will be treated in strictest confidence"

SECTION 1: Personal Information

(Please state or tick the appropriate answer):

1. What is your age?	**2. What is your highest education?**	**3. How many years of experience do you have in construction?**
1) Less than 30 ☐ 2) Between 30-39 ☐ 3) Between 40-49 ☐ 4) Between 50-59 ☐ 5) More than 60 ☐	1) High School ☐ 2) Bachelor Degree ☐ 3) Master Degree ☐ 4) PhD ☐ 5) Other	1- Less than 5 years ☐ 2- Between 6-10 years ☐ 3- Between 11-15 years ☐ 4- Between 16-20 years ☐ 5- Between 21-25 years ☐ 6- More than 25 years ☐
4. What is your gender?	**5. What is your position in this project or the organization?**	**7. Your background:**
1) Male ☐ 2) Female ☐ **6. Size of your company:** 1) Small (*G1-G3*) ☐ 2) Medium (*G4-G6*) ☐ 3) Big (*G7*) ☐	1) Project Manager ☐ 2) Manager Assistant ☐ 3) Project Consultant ☐ 4) Project Engineer ☐ 5) Resident Engineer ☐ 6) Resident Architect ☐ 7) Other:	1) Civil Engineering ☐ 2) Architecture ☐ 3) QS ☐ 4) Mechanical Engineering ☐ 5) Other (pls specify).............
8. Working mode in this project:	**9. Are you a member in BEM, PAM or other associations…?**	**10. Do you have experience in Post Project Review or Audit?**
1) Temporary contract ☐ 2) Permanently join a company ☐	Yes ☐ No ☐	Yes ☐ No ☐ If yes, how many years? ………...

SECTION 2: Practice of Project Team in this Project

This section attempts to perceive your opinion about fragmentation. Team fragmentation involves some aspects as lack of collaboration, separation between design and construction process, adversarial relationships, and diversity of project team. Kindly use the scale below, and write the appropriate number (from 1 to 5) on the blank by each statement. Number **1** indicates that you totally disagree with the statement, **2** you disagree, **3** neutral or don't know, **4** you agree and **5** you totally agree.

Totally Disagree	Disagree	Neutral	Agree	Totally Agree
1	2	3	4	5

1	In this project, I and other team members have the same objective (no individual objectives)	
2	I form a single team with other members although they come from different companies	
3	Project's outcomes and benefits will consider the whole project team rather than individuals	
4	I can easily access to information related to construction cost and schedule of this project	

5	Information related to this project are well managed	
6	I work with all team members in one common site office	
7	Me and other team members have fair chance to contribute in making decisions about the work	
8	In this project all team members are treated as having equal professional capability	
9	There is no blame for an individual if any problem happens (group will take responsibility)	
10	Problems will be solved by the whole project team rather than individuals	
11	In this project, I can directly call other team members (e.g. consultants or project engineers)	
12	I have regular meetings with other team members (e.g. consultants or project engineers)	
13	Information Technology (IT) facilitates coordinating works between me and other members	
14	I have long-term relationship with most of the project team members	
15	The coordinator of this project plays important role to bring different people together	
16	I trust other team members work in this project though they come from different companies	
17	We focus mainly on the requirements of the owner/client of this project	
18	We have the freedom to organize ourselves / our work for better outcomes	
19	I feel there are barriers between me and other professionals who have different background	
20	I feel there is a barriers between me and other team members come from other companies	
21	There is a language barrier between me and other team members (especially those from different ethnic groups)	
22	There are cultural barriers between me and other team members (especially those from different ethnic groups)	
23	My contact with members who come from different background or discipline is limited	
24	I often participate with other members, from different backgrounds, in solving problems (e.g. to solve a problem related to the design)	
25	Clashes between design and construction (omissions / errors of design) are difficult to resolve in this project	
26	It is difficult for me to understand some information from people from other backgrounds	
27	I need to get sufficient information from previous phases of this project	
28	I need to get sufficient information from other project consultants or professionals	
29	My relationship with most of project team is good (including contractor's team and other consultants)	

SECTION 3: Learning within Projects

This section aims to get your opinion about factors that promote learning of team within the project. Project learning involves project team sharing and creating of experience and knowledge in construction projects. Kindly write down the appropriate number from **1** to **5** in the blank.

Totally Disagree 1	Disagree 2	Neutral 3	Agree 4	Totally Agree 5

1	I trust other team members so I can share my experience with them freely	
2	I often have informal dialogue with other team members (e.g. a discussion over coffee break)	
3	I communicate with experts in-person (face-to-face) to get some experience or information	
4	I often contact external consultant if there is a new idea or problem to discuss	
5	I am able to contact all people in this project directly	
6	Information Communication Tools (ICT) facilitates my communication with other members (e.g. video conferencing etc.)	
7	I get very much experience from the frequent meetings I attend	
8	Normally I attend group discussions about certain issues or problems related to this project	
9	I do not hesitate to ask questions about issues related to the project	
10	I can inform about mistakes I do freely	
11	I can have an open (frank) discussion about issues or problems related to this project	
12	I can tell people who do wrong or use insufficient method	
13	I, and other members, always try to find alternative ways of doing things	
14	Solving problems in this project is efficient (e.g. resolving design clashes/omissions)	
15	In this project, we have to identify the causes of problems happen in the site	
16	When problem happen we will report to upper management	
17	In this project, I have implemented new technology / technique	
18	I learn new things when project leader delegate some of his work to me	
19	I am encouraged to collaborate with new colleagues	
20	It is always appreciated when we collaborate with people from other companies	
21	In this project, interaction with other team members has polished my experience	
22	I always follow the common routines/standards of doing work in this project	
23	I feel that this project is a challenging task for me	
24	I am committed to the main objective of this project	
25	We need to learn from mistake and not to be punished for trying new things	
26	We deserve to have second chance if we made mistakes	

SECTION 4: Learning across Projects

This section aims to perceive your opinion about factors that promote the practice of project learning across construction projects. Similar to the previous sections, you are requested to state your response number by writing down the appropriate number (1 to 5).

Totally Disagree 1	Disagree 2	Neutral 3	Agree 4	Totally Agree 5

1	In this project, mostly we communicate face-to-face other than other ways (e.g. telephone, email etc.)	
2	I see team members off-the-project for informal gathering or activities	
3	It is easy to find people in this project or other project to answer my inquiries	
4	I use some ideas/techniques/documents from other projects and implement it in this project	
5	I contact people from other projects to discuss about certain issues related to this project	
6	We conduct special meetings to obtain some useful information or knowledge about the project	
7	I attend brainstorming sessions with colleagues to discuss certain problems	
8	We conduct investigation to review some problems and identify their causes	
9	Other than the regular meetings, I attend meetings when something urgent need to be discussed	
10	I attend meetings/activities to develop lessons that can be learned from this project	
11	Project plans are recorded clearly so can be kept for future usage	
12	Important information as project milestones are recorded clearly	
13	Meeting minutes in this project will be kept for future usage	
14	This project has a compiled record of 'project history'	
15	This project need an appropriate database to record important information and lessons learned for future projects	
16	I visited other projects during this project	
17	I often contact the main office of my company to discuss about issue related to this project	

SECTION 5: Supporting Project Learning

This section attempts to get your opinion about some items that can help in promoting project learning practice within fragmentation of construction. Similar to the previous section, you are required to state your response number by writing down the appropriate number (1 to 5).

Totally Disagree 1	Disagree 2	Neutral 3	Agree 4	Totally Agree 5

1	I need to attend more meetings with different members for experience and knowledge sharing	
2	There is a need for everybody to feel the spirit of the project team	
3	Being open to everybody in the project is one of my company's policies	
4	Project owner/client has important role to play in getting different project team together	
5	I am willing to share my experience if I get appropriate incentive (e.g. monetary incentive)	
6	I share more experience with people that my company has long-term relationship with their companies	
7	I share my experience with my friends only	

8	I share my experience with other members if there are benefits for all of us and for the project	
9	Drawings and specification of this project play important role to facilitate ideas and experience sharing	
10	Construction contract can play important role to oblige experience sharing between project team	
11	I need to be trusted by other team members especially those from other companies	
12	I need to feel that my experience is valuable for other team members	
13	ICT tools (as video conferencing etc.) will be useful for better communication with other project team (e.g. the designer)	
14	I believe it is important to set learning as one of the project's goals	
15	This project needs more support from project leader for dialogue, conversations and open discussions with everybody	
16	Our leader should show role model in open communication, honesty and show how to trust others	
17	The attitude of project leader can influence my relationship with people from other companies	
18	Project manager/leader has to encourage us to build up good relationship with every team members	
19	We need to be committed to respect each other's views	
20	I think it is important to know each other's experience and abilities so we can share knowledge better	
21	My way of learning is to think of different ways of doing things (challenge the current standards of work)	
22	My way of learning is to look at how things are being done (cannot change the existing standards/paradigms)	
23	The setting of site office allow for better communication with everybody	
24	I have enough time to discuss and share experience with other team members	
25	This project has the appropriate resources for learning	
26	I understand my role in sharing experience and learning in this project	
27	I like to make decisions about the way I can learn from this project	

This is the end of this survey. Thank you very much for your kind response ☺

Code (for researcher only)	

UNIVERSITY OF MALAYA
The Leader in Research & Innovation

Faculty of Built Environment, University of Malaya,

50603, Kuala Lumpur, Malaysia

DEVELOPING A PROJECT LEARNING MODEL CONSIDERING FRAGMENTATION

Questionnaire Survey – 2

----------------------------Part of requirements to fulfill Ph.D. study-----------------------

The aim of this survey is to identify the practice of project learning within project team in the Malaysian construction projects. In addition, the survey attempts to identify the influence of some characteristics of construction on learning and project performance. **This part of questionnaire shall be filled in by project manager or any person who has sufficient information about the whole project.** Please note that this survey will be used for the purpose of research only and the participants' identity or response will be treated as confidential information.

Appreciate your time and efforts.

Thank you very much,

Yours,

Ali Mohammed Alashwal

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University of Malaya
H/P: 017-7144079
E-mail: alialashwal@gmail.com

GENERAL INFORMATION ABOUT THE PROJECT

(Please state or tick the appropriate answer):

1. Name of this project:	**2. Location:**	**3. Date of award of project:**
………………………….	………………………….	/ / /
4. Owner of project:	**5. Name of the main contractor:**	**6. Grade of the main contractor:**
………………………….	………………………….	G1 G2 G3 G4 G5 G6 G7

7. Category of the project:	**8. Procurement method used:**	**9. Completion percentage:**
1- Government ☐ 2- Private ☐ 3- Mixed ☐	1- Traditional / Conventional ☐ 2- Design-and-Build ☐ 3- Turnkey ☐ 4- Built, operate, & transfer (BOT) ☐ 5- Other ………………. ☐	1- Less than 20 % ☐ 2- Between 21 to 40 % ☐ 3- Between 41 to 60 % ☐ 4- Between 61 to 80 % ☐ 5- More than 80 % ☐
10. Type of the project* **(*note*):**	**11. Value of the project (RM):**	**12. No. of sub-con. & consultant firms work in this project:**
1- Residential ☐ 2- Non Residential ☐ 3- Social Amenities ☐ 4- Mix Development ☐ 5- Infrastructure ☐ 6- Other ……………….	1- Less than 10 million ☐ 2- Between 10 - 50 million ☐ 3- Between 50 - 100 million ☐ 4- Between 100 - 300 million ☐ 5- Between 300 - 500 million ☐ 6- Between 500 - 1,000 million ☐ 7- More than 1,000 million ☐	1- Less than 5 firms ☐ 2- Between 5 to 14 ☐ 3- Between 15 to 24 ☐ 4- Between 25 to 34 ☐ 5- Between 35 to 44 ☐ 6- More than 45 firms ☐

13. How do you describe the discrepancy between design and construction (clashes or errors of design)?	**14. How do you describe the S-curve of this project, so far**
1) No clashes or discrepancies in this project so far ☐	1) Less than 6% of the plan ☐
2) Clashes / discrepancies are less than 2% ☐	2) Less than 1-5 % of the plan ☐
3) Clashes / discrepancies represent 2 to 5% ☐	3) According to the plan ☐
4) Clashes / discrepancies represent 6 to 10% ☐	4) More than 1-5% of the plan ☐
5) Clashes / discrepancies represent more than 10% ☐	5) More than 6% of the plan ☐

15. Approximately, how many professionals work in this project (including managers assistant, project consultants, project engineers, resident architect, coordinators, mechanical engineers etc.)?………………..

***Residential:** Quarters, terrace house, semi-detached house, bungalow, flat, condominium, apartment, townhouse and dormitory. **Non-Residential:**, Administration, commercial, manufacturing, safety, and agriculture buildings. **Social Amenities:** Hospital, clinic, medical laboratory, medical treatment center, higher learning institution, school, education and training center, youth center, sport centers, welfare center, rehabilitation center and protection center, religious house, community center, public hall and multipurpose hall, etc. **Mix Development:** Construction project with more than one category. **Infrastructure:** Airport, railway or train station, bus station, taxi station, harbor, jetty, road, highway, railway track, rail, traffic light, bridge and tunnel, etc.

Thank you very much for your response

APPENDIX D: Missing Data Analysis

Missing Data Analysis

	N	Mean	Std. Deviation	**Missing**		No. of Extremes[b]	
				Count	**Percent**	Low	High
PROmethod	203	1.65	.779	0	.0	0	5
TIME	198	2.5000	1.08871	5	2.5	0	0
COST	197	3.1777	.79790	6	3.0	4	0
SATSF	200	2.7650	.48055	3	1.5	0	0
CLASHES	201	2.7861	.73417	2	1.0	0	8
Scurve	197	2.8477	1.02875	6	3.0	.	.
AGE	203	2.46	1.001	0	.0	0	1
EDU	202	2.44	.874	1	.5	0	13
EXp.Const	203	2.91	1.399	0	.0	0	0
GEN	203	1.11	.318	0	.0	.	.
Position	200	4.32	1.989	3	1.5	0	0
SizeCom	193	2.64	.606	10	4.9	0	0
Backg	199	2.26	1.327	4	2.0	0	0
WorkingMOD	189	1.72	.448	14	6.9	0	0
MbrAssoc	198	1.44	.498	5	2.5	0	0
Exp.PL	201	1.64	.481	2	1.0	0	0
Frag1	202	1.6782	.64678	1	.5	0	1
Frag2	203	2.0887	.83962	0	.0	.	.
Frag3	203	1.7537	.69540	0	.0	0	5
Frag4	202	2.0000	.90877	1	.5	0	14
Frag5	202	2.0644	.82908	1	.5	.	.
Frag6	202	1.8366	.91860	1	.5	0	12
Frag7	203	2.0690	.77407	0	.0	.	.
Frag8	203	2.0345	.82281	0	.0	0	8
Frag9	203	2.1823	.94465	0	.0	0	4
Frag10	202	1.9257	.79139	1	.5	0	10
Frag11	203	1.8374	.80110	0	.0	0	7
Frag12	203	1.8621	.72487	0	.0	0	5
Frag13	203	2.0739	.80804	0	.0	0	1
Frag14	203	2.1921	.90518	0	.0	0	2
Frag15	203	1.8473	.72531	0	.0	0	3
Frag16	203	2.0739	.69614	0	.0	.	.
Frag17	202	1.8713	.69344	1	.5	0	2
Frag18	203	1.9852	.77382	0	.0	0	5
Frag19	203	2.7882	1.11224	0	.0	0	0
Frag20	203	2.7143	1.02307	0	.0	0	7

Frag21	203	2.2414	.99795	0	.0	0	3
Frag22	203	2.1872	.95151	0	.0	0	3
Frag23	203	2.7783	1.19202	0	.0	0	0
Frag24	203	2.0739	.71716	0	.0	.	.
Frag25	203	3.1232	1.14736	0	.0	0	0
Frag26	203	3.3448	1.11662	0	.0	0	0
Frag27	203	2.1576	.96204	0	.0	0	0
Frag28	203	2.3005	1.01638	0	.0	0	6
Frag29	203	1.7389	.63387	0	.0	0	0
IntraPL1	202	4.1485	.62908	1	.5	1	0
IntraPL2	203	4.1281	.66254	0	.0	3	0
IntraPL3	203	4.1478	.64319	0	.0	3	0
IntraPL4	203	3.8177	.96538	0	.0	5	0
IntraPL5	203	4.0739	.75088	0	.0	5	0
IntraPL6	203	3.8030	.90684	0	.0	2	0
IntraPL7	203	3.9951	.76752	0	.0	8	0
IntraPL8	203	4.0887	.68363	0	.0	2	0
IntraPL9	203	4.2020	.66272	0	.0	2	0
IntraPL10	203	3.9064	.73532	0	.0	0	0
IntraPL11	203	4.0443	.69154	0	.0	.	.
IntraPL12	202	3.9653	.78149	1	.5	.	.
IntraPL13	203	4.1576	.65610	0	.0	0	0
IntraPL14	203	4.0000	.78979	0	.0	7	0
IntraPL15	203	4.0985	.67498	0	.0	3	0
IntraPL16	203	3.9803	.75098	0	.0	.	.
IntraPL17	203	3.8128	.89245	0	.0	1	0
IntraPL18	203	4.0837	.71607	0	.0	4	0
IntraPL19	203	4.0690	.66390	0	.0	.	.
IntraPL20	203	4.0591	.72197	0	.0	3	0
IntraPL21	203	4.1330	.62699	0	.0	2	0
IntraPL22	203	1.9557	.73323	0	.0	0	5
IntraPL23	203	4.1133	.71889	0	.0	4	0
IntraPL24	203	4.2709	.61378	0	.0	0	0
IntraPL25	203	4.1576	.77382	0	.0	4	0
IntraPL26	202	3.9752	.76904	1	.5	.	.
InterPL1	203	4.0640	.79031	0	.0	10	0
InterPL2	203	3.7635	.92450	0	.0	3	0
InterPL3	203	3.9754	.74753	0	.0	.	.
InterPL4	203	4.0443	.68434	0	.0	.	.
InterPL5	203	3.6601	.95323	0	.0	5	0
InterPL6	203	3.9852	.78019	0	.0	9	0
InterPL7	203	3.9507	.87174	0	.0	12	0

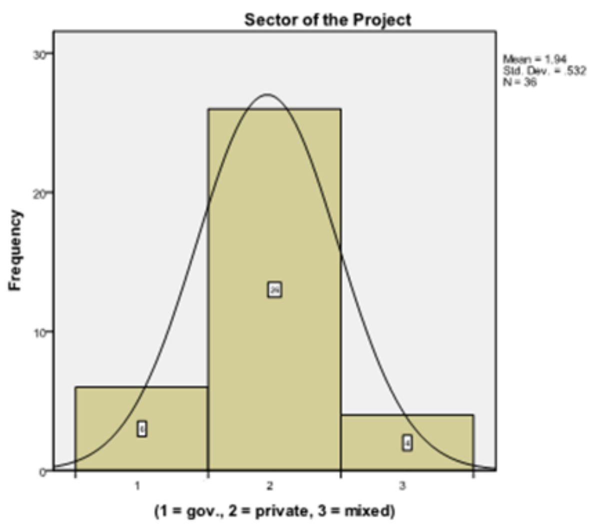
InterPL8	203	3.9951	.77394	0	.0	4	0
InterPL9	203	4.1084	.70926	0	.0	4	0
InterPL10	203	3.9754	.80493	0	.0	.	.
InterPL11	203	4.1034	.77341	0	.0	6	0
InterPL12	203	4.1626	.73672	0	.0	4	0
InterPL13	203	4.1675	.72544	0	.0	4	0
InterPL14	203	4.0000	.79603	0	.0	5	0
InterPL15	203	1.9458	.82775	0	.0	0	8
InterPL16	202	3.6634	1.11772	1	.5	11	0
InterPL17	203	3.8374	.99910	0	.0	0	0
SupPL1	200	4.0350	.83502	3	1.5	12	0
SupPL2	200	4.2400	.65155	3	1.5	2	0
SupPL3	200	4.0500	.77492	3	1.5	3	0
SupPL4	203	4.1872	.72058	0	.0	7	0
SupPL5	203	3.0099	1.21863	0	.0	0	0
SupPL6	203	3.3645	1.03174	0	.0	12	0
SupPL7	203	2.7241	1.22384	0	.0	0	0
SupPL8	203	3.9704	.90056	0	.0	15	0
SupPL9	203	4.2562	.67001	0	.0	3	0
SupPL10	203	4.1773	.72308	0	.0	3	0
SupPL11	203	4.0788	.76021	0	.0	7	0
SupPL12	203	3.9803	.78324	0	.0	.	.
SupPL13	203	3.9704	.80783	0	.0	0	0
SupPL14	203	4.0887	.70502	0	.0	3	0
SupPL15	203	4.0936	.80599	0	.0	8	0
SupPL16	203	4.2611	.66438	0	.0	3	0
SupPL17	203	4.1379	.70408	0	.0	3	0
SupPL18	203	4.2463	.62014	0	.0	2	0
SupPL19	203	4.2808	.65625	0	.0	1	0
SupPL20	203	4.2315	.59751	0	.0	0	0
SupPL21	203	4.0640	.67548	0	.0	.	.
SupPL22	203	3.8227	.95341	0	.0	0	0
SupPL23	203	4.0985	.73130	0	.0	4	0
SupPL24	203	3.8768	.86723	0	.0	2	0
SupPL25	203	3.9310	.84734	0	.0	0	0
SupPL26	203	4.1330	.62699	0	.0	1	0
SupPL27	201	4.0050	.79055	2	1.0	0	0

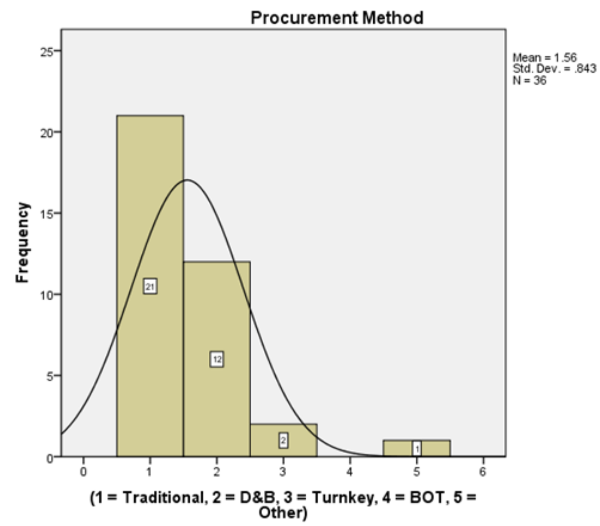
a. . indicates that the inter-quartile range (IQR) is zero.

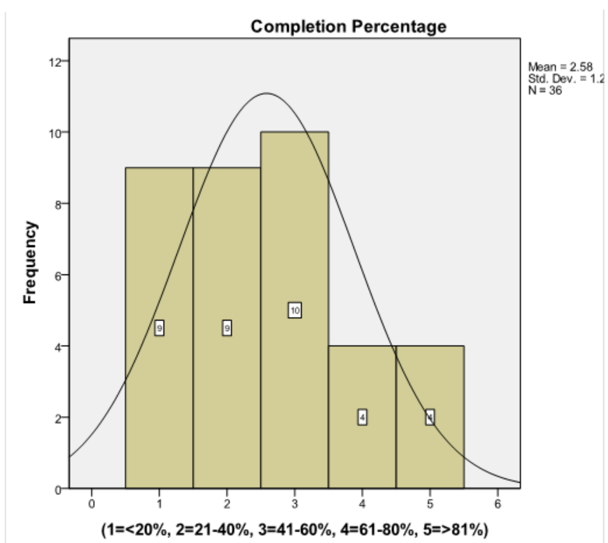
b. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

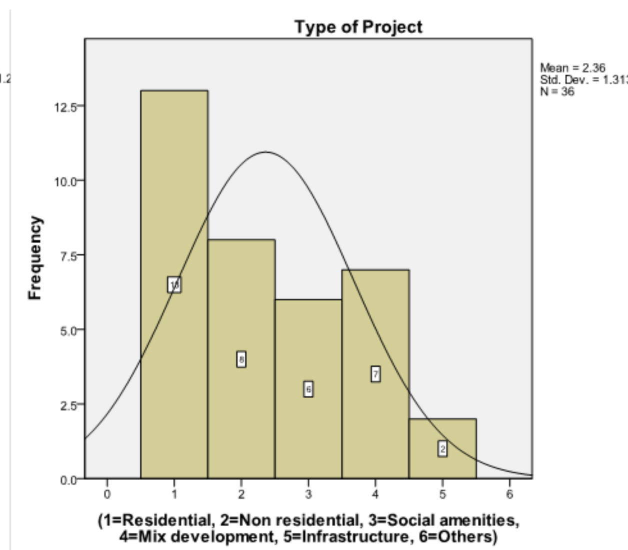
APPENDIX E: Distributions

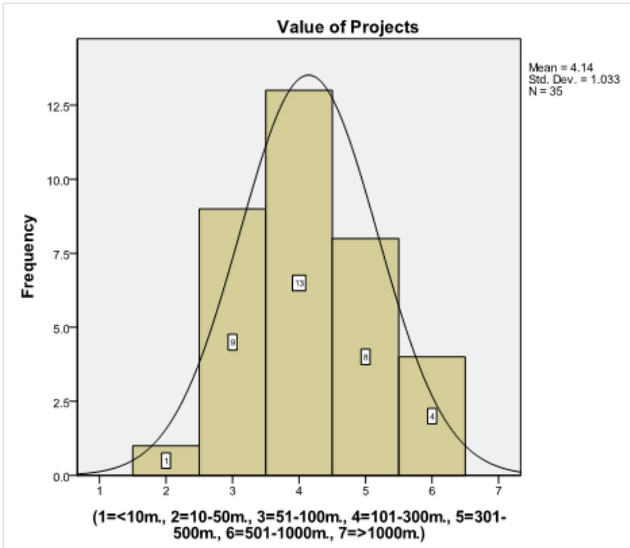
1. Distribution of the Selected Projects:

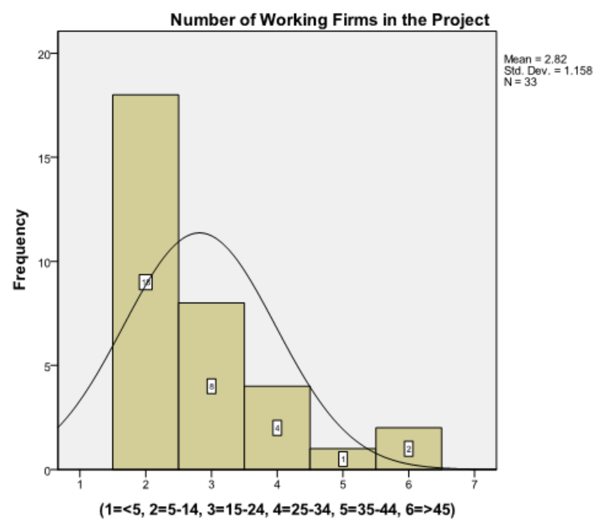


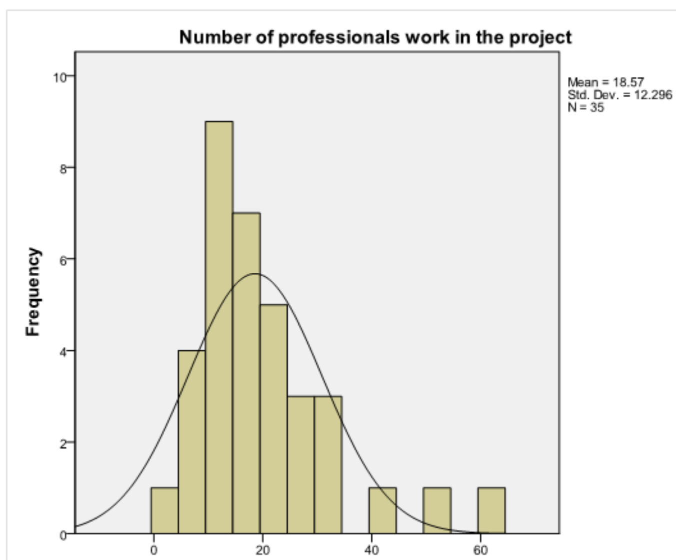




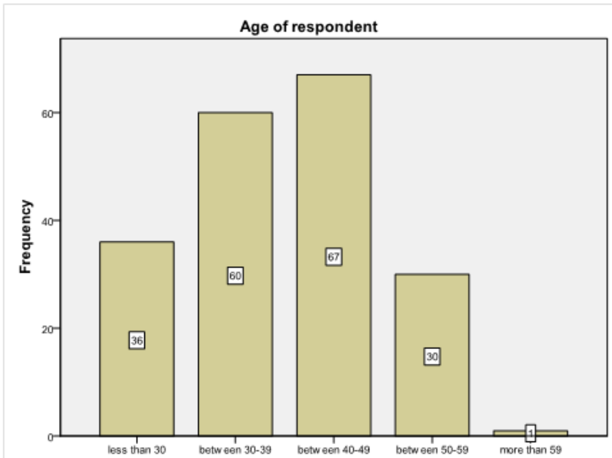


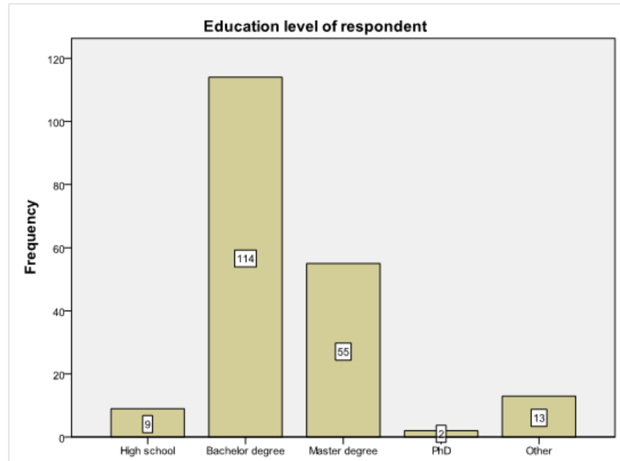

Value of Projects
Mean = 4.14
Std. Dev. = 1.033
N = 35
Frequency
(1=<10m., 2=10-50m., 3=51-100m., 4=101-300m., 5=301-500m., 6=501-1000m., 7=>1000m.)

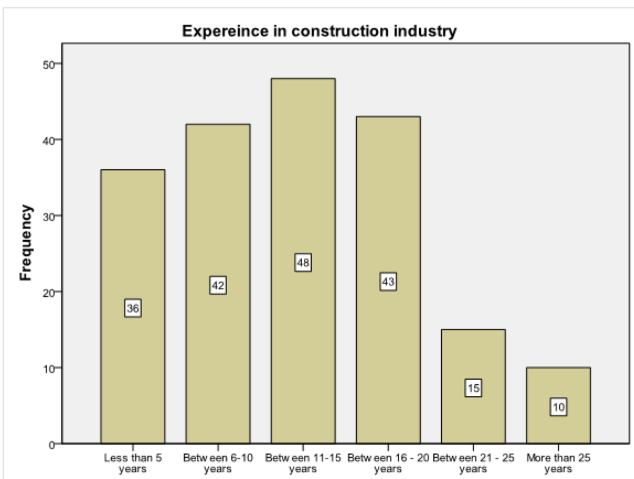

Number of Working Firms in the Project
Mean = 2.82
Std. Dev. = 1.158
N = 33
Frequency
(1=<5, 2=5-14, 3=15-24, 4=25-34, 5=35-44, 6=>45)

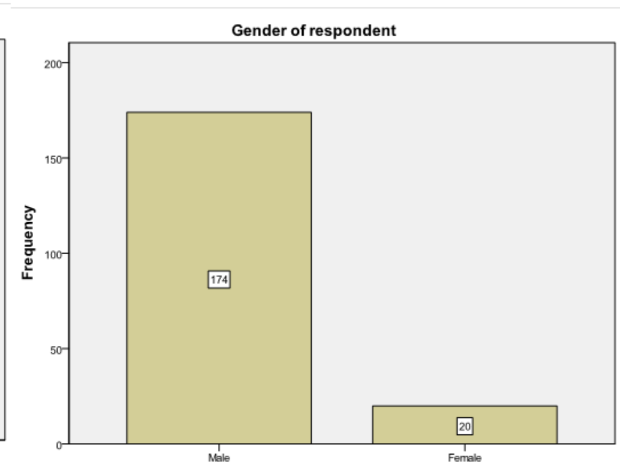

Number of professionals work in the project
Mean = 18.57
Std. Dev. = 12.296
N = 35
Frequency

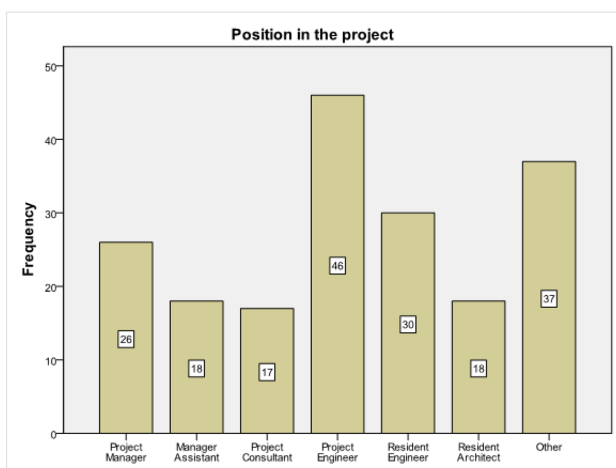
2. Distribution of the Respondents

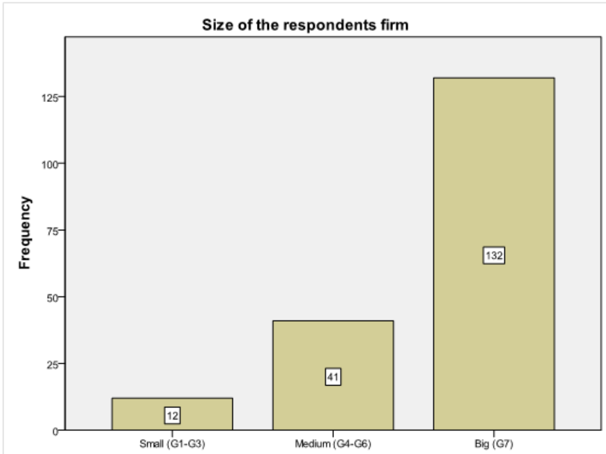


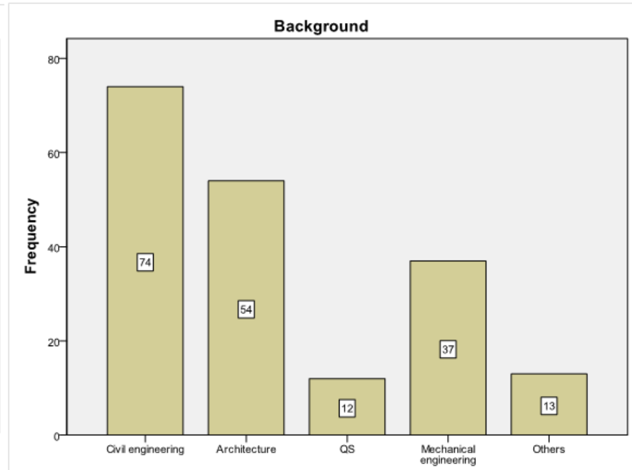


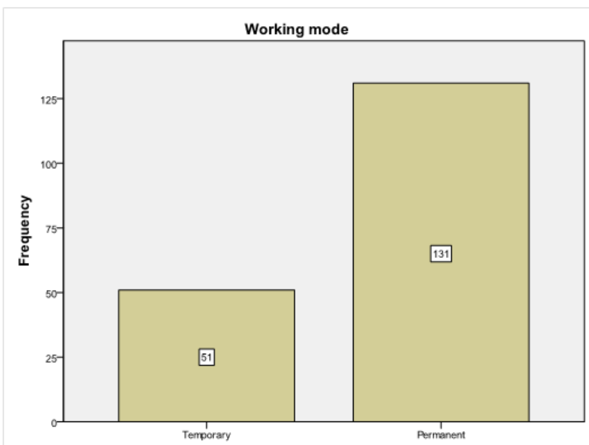


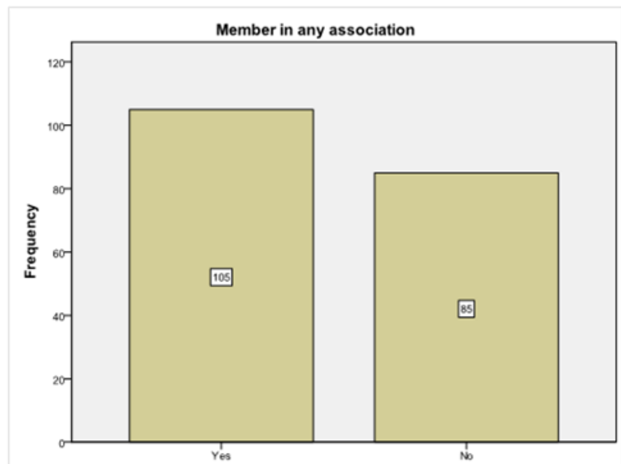


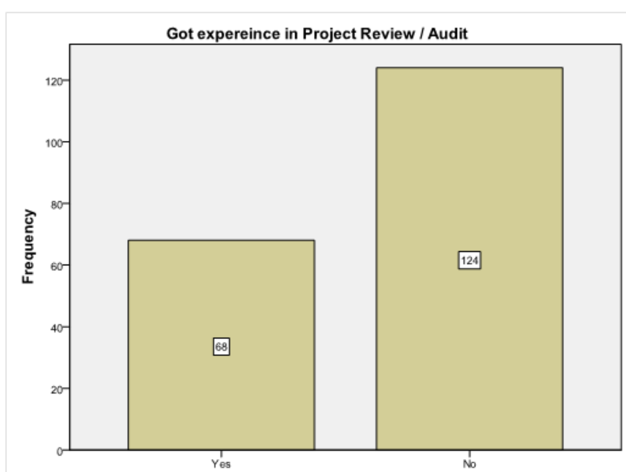



Size of the respondents firm
Frequency
0
25
50
75
100
125
12
41
132
Small (G1-G3)
Medium (G4-G6)
Big (G7)


Background
Frequency
0
20
40
60
80
74
54
12
37
13
Civil engineering
Architecture
QS
Mechanical engineering
Others


Working mode
Frequency
0
25
50
75
100
125
51
131
Temporary
Permanent


Member in any association
Frequency
0
20
40
60
80
100
120
105
85
Yes
No


Got expereince in Project Review / Audit
Frequency
0
20
40
60
80
100
120
68
124
Yes
No

APPENDIX F: Parallel Analysis

1. O'Connor's Syntax of Parallel Specification:

```
* Enter the name/location of the data file for analyses after
"FILE =";
  If you specify "FILE = *", then the program will read the
current,
  active SPSS data file;  You can alternatively enter the
name/location
  of a previously saved SPSS systemfile instead of "*";
  you can use the "/ VAR =" subcommand after "/ missing=omit"
  subcommand to select variables for the analyses.
GET raw / FILE = * / missing=omit / VAR = InterPL1 to InterPL17.

* Enter the desired number of parallel data sets here.
compute ndatsets = 100.

* Enter the desired percentile here.
compute percent  = 95.

* Enter either
  1 for principal components analysis, or
  2 for principal axis/common factor analysis.
compute kind = 1 .

* Enter either
  1 for normally distributed random data generation parallel
analysis, or
  2 for permutations of the raw data set.
compute randtype = 1.

****************** End of user specifications. ******************
```

2. Steps of conducting the analysis using SPSS:

1. Copy O'Connor's syntax to a new syntax in the data set.
2. Determine five criteria in the syntax, indicating the name of variables, number of data set (default number is 100), percentile (e.g., 95%), type of analysis (either principal component analysis or common factor analysis), and distribution of data (either normal distribution or permutations).
3. Run the syntax to obtain the output.

3. Specifications and output of the parallel analysis (example: Inter-project learning):

Specifications used to run the analysis of Inter-project are as the following:

- Variables' name (VAR = InterPL1 to InterPL17);
- Number of parallel data sets (ndatsets = 100);
- Percentile = 95;
- Extraction method = 1 (principal component analysis); and
- Distribution = 1 (normally distributed random data generation parallel analysis).

The output after running the syntax in SPSS is as the following:

```
Run MATRIX procedure:

PARALLEL ANALYSIS:

Principal Components & Random Normal Data Generation

Specifications for this Run:
Ncases    194
Nvars      17
Ndatsets  100
Percent    95

Raw Data Eigenvalues, & Mean & Percentile Random Data Eigenvalues
         Root     Raw Data        Means     Prcntyle
     1.000000     6.300243     1.555957     1.677537
     2.000000     1.518506     1.434151     1.507118
     3.000000     1.077819     1.350673     1.422956
     4.000000      .998899     1.274972     1.333581
     5.000000      .960785     1.202919     1.250889
     6.000000      .877134     1.142763     1.187820
     7.000000      .770399     1.084683     1.131202
     8.000000      .754337     1.027545     1.078670
     9.000000      .597052      .973868     1.019504
    10.000000      .559997      .920296      .964363
    11.000000      .502459      .870491      .921875
    12.000000      .488702      .821410      .867371
    13.000000      .414017      .771379      .811238
    14.000000      .352392      .725616      .766163
    15.000000      .309958      .671966      .715757
    16.000000      .288515      .621360      .665913
    17.000000      .228788      .549951      .607321

------ END MATRIX -----
```

Sequence Plot

Notes

Output Created		26-Sep-2011 10:57:20
Comments		
Input	File Label	File created by MATRIX
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	17
	Date	<none>
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	All the cases or all the specified cases are used to define the sequence.
Syntax		TSPLOT VARIABLES= rawdata means percntyl /ID= root /NOLOG.
Resources	Processor Time	00 00:00:00.593
	Elapsed Time	00 00:00:00.562
Use	From	First observation
	To	Last observation
Time Series Settings (TSET)	Amount of Output	PRINT = DEFAULT
	Saving New Variables	NEWVAR = CURRENT
	Maximum Number of Lags in Autocorrelation or Partial Autocorrelation Plots	MXAUTO = 16
	Maximum Number of Lags Per Cross-Correlation Plots	MXCROSS = 7
	Maximum Number of New Variables Generated Per Procedure	MXNEWVAR = 60
	Maximum Number of New Cases Per Procedure	MXPREDICT = 1000
	Treatment of User-Missing Values	MISSING = EXCLUDE
	Confidence Interval Percentage Value	CIN = 95
	Tolerance for Entering Variables in Regression Equations	TOLER = .0001
	Maximum Iterative Parameter Change	CNVERGE = .001
	Method of Calculating Std. Errors for Autocorrelations	ACFSE = IND
	Length of Seasonal Period	Unspecified
	Variable Whose Values Label Observations in Plots	Unspecified
	Equations Include	CONSTANT

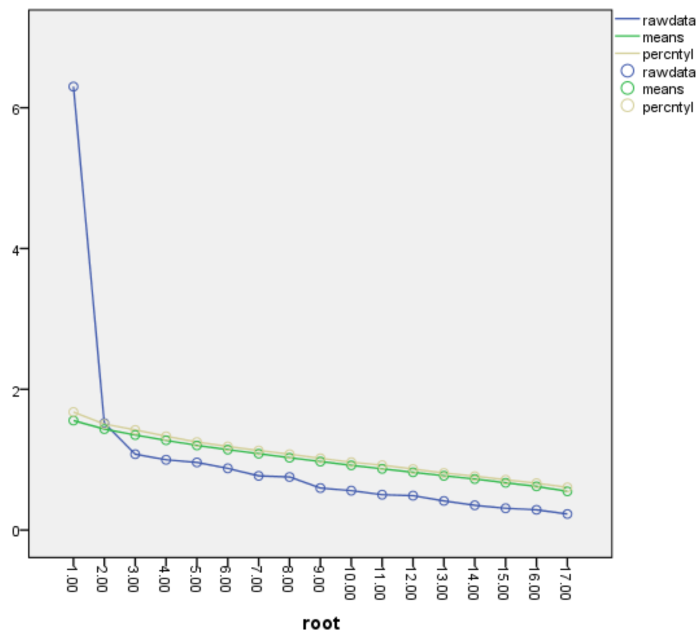
Model Description

Model Name		MOD_8
Series or Sequence	1	rawdata
	2	means
	3	percntyl
Transformation		None
Non-Seasonal Differencing		0
Seasonal Differencing		0
Length of Seasonal Period		No periodicity
Horizontal Axis Labels		root
Intervention Onsets		None
For Each Observation		Values not joined

Applying the model specifications from MOD_8

Case Processing Summary

		rawdata	means	percntyl
Series or Sequence Length		17	17	17
Number of Missing Values in the Plot	User-Missing	0	0	0
	System-Missing	0	0	0



[Tsplot of inter-project learning construct]

APPENDIX G: Cross-loading test of the whole model

Note: *scratched variables have been eliminated from the full model as they share more loadings with other construct than their own construct.*

	BARR	DoD	INTEG	INTER1	INTER2	INTRA1	INTRA2	KS SUPP	MANAG SUPP	PRO CULT	SKB
Frag12	0.052089	0.188633	0.624428	-0.282202	-0.251897	-0.240546	-0.296732	-0.161832	-0.273077	-0.208176	0.229443
Frag14	0.156999	0.475347	0.440099	-0.573898	-0.351618	-0.413482	-0.542657	-0.233010	-0.533240	-0.242741	0.772563
Frag17	0.028549	0.094224	0.619363	-0.260351	-0.336240	-0.376167	-0.269576	0.013581	-0.287999	-0.397834	0.281650
Frag18	0.295936	0.177424	0.756477	-0.402440	-0.298925	-0.383894	-0.367859	-0.126616	-0.351833	-0.309742	0.337067
Frag19	0.785326	0.130371	0.136681	-0.202573	-0.179036	-0.134122	-0.170625	0.080243	-0.192617	-0.174006	0.024567
Frag20	0.863474	-0.002443	0.219127	-0.218212	-0.121957	-0.199344	-0.231768	0.010370	-0.207348	-0.132584	0.073224
Frag21	0.777735	-0.101351	0.126948	-0.091994	-0.164787	-0.188439	-0.142938	0.074523	-0.141725	-0.127757	0.090588
Frag22	0.802198	-0.038694	0.198085	-0.180159	-0.150541	-0.171189	-0.169022	0.048382	-0.192372	-0.136318	0.152344
Frag24	0.086412	-0.629291	-0.061299	0.237942	-0.003239	-0.054219	0.146676	0.359994	0.198353	-0.043496	-0.139597
Frag26	-0.034109	-0.808224	-0.174639	0.378370	0.082874	0.070298	0.295647	0.178596	0.349423	0.018489	-0.355504
Frag27	-0.020202	-0.896953	-0.367446	0.643596	0.330514	0.275508	0.554239	0.382963	0.580538	0.269347	-0.665713
Frag28	0.062577	0.552844	0.347303	-0.552566	-0.315893	-0.289564	-0.432198	-0.317606	-0.470566	-0.125382	0.822814
Frag29	0.042759	0.454767	0.321957	-0.551911	-0.210387	-0.279034	-0.395847	-0.264686	-0.394544	-0.165852	0.726746

Frag4	0.074611	0.311958	0.356159	-0.462535	-0.335621	-0.388866	-0.419804	-0.224971	-0.396257	-0.234960	0.652271
~~Frag5~~	0.037455	0.285266	0.399746	-0.513453	-0.408584	-0.410451	-0.461885	-0.225403	-0.527764	-0.301694	0.661895
Frag9	0.144302	0.307151	0.602107	-0.429370	-0.230308	-0.289795	-0.476524	-0.192732	-0.428887	-0.257095	0.450757
InterPL10	-0.244310	-0.333840	-0.402083	0.689156	0.518564	0.376360	0.519989	0.262621	0.568017	0.372840	-0.455312
InterPL11	-0.132411	-0.104819	-0.355793	0.355643	0.661984	0.337227	0.294229	0.142573	0.300059	0.301185	-0.275562
InterPL12	-0.126225	-0.026218	-0.328512	0.350603	0.763070	0.403311	0.332246	-0.036804	0.368498	0.398929	-0.262445
InterPL13	-0.076079	-0.166504	-0.217041	0.427918	0.638327	0.431919	0.334642	-0.036111	0.423519	0.367789	-0.324131
InterPL14	-0.119382	-0.329711	-0.324507	0.654803	0.382377	0.332812	0.477241	0.209011	0.505118	0.341439	-0.441263
InterPL16	-0.115418	-0.489239	-0.381454	0.763499	0.374381	0.356621	0.462537	0.438058	0.575997	0.217937	-0.548459
~~InterPL17~~	-0.211903	-0.396592	-0.403206	0.671754	0.432534	0.375097	0.526271	0.264595	0.511095	0.370941	-0.515117
InterPL2	-0.171212	-0.511720	-0.437295	0.780961	0.435266	0.368993	0.576790	0.339071	0.632284	0.332058	-0.570545
InterPL3	-0.147237	-0.359470	-0.413213	0.706141	0.459516	0.458009	0.574726	0.259667	0.543304	0.319514	-0.491229
InterPL5	-0.091728	-0.458806	-0.351179	0.688478	0.252194	0.311851	0.496200	0.224146	0.464765	0.124436	-0.535104
InterPL6	-0.174128	-0.338286	-0.360650	0.672781	0.366226	0.380842	0.446410	0.250253	0.498604	0.291465	-0.480010
~~InterPL7~~	-0.117943	-0.524062	-0.332031	0.674334	0.386586	0.334933	0.422021	0.324015	0.569401	0.299567	-0.567979
InterPL8	-0.148592	-0.328122	-0.318862	0.469949	0.777454	0.431801	0.468956	0.172285	0.483556	0.435390	-0.410372

InterPL9	-0.179220	-0.171942	-0.283696	0.418580	0.687837	0.348260	0.348789	0.078902	0.361777	0.378750	-0.290363
IntraPL11	-0.164422	-0.108790	-0.348089	0.357142	0.427529	0.711926	0.349624	-0.010322	0.339023	0.396945	-0.311369
IntraPL14	-0.208931	-0.221005	-0.386220	0.511746	0.434232	0.448259	0.685518	0.162365	0.480633	0.325001	-0.403414
IntraPL17	-0.144380	-0.466518	-0.456785	0.611725	0.363606	0.381541	0.817708	0.238603	0.620307	0.337968	-0.540033
IntraPL18	-0.139275	-0.331050	-0.328504	0.394560	0.305282	0.327475	0.695993	0.001264	0.449013	0.306366	-0.323842
IntraPL19	-0.216848	-0.194180	-0.401473	0.427144	0.453673	0.741771	0.437580	0.092373	0.401811	0.392997	-0.389206
IntraPL2	-0.095525	-0.223928	-0.300335	0.381566	0.304538	0.612711	0.271690	0.126735	0.369446	0.335242	-0.412603
IntraPL3	-0.106202	-0.052788	-0.337569	0.341768	0.369316	0.703357	0.409698	0.115143	0.330750	0.424107	-0.342317
IntraPL6	-0.140052	-0.353812	-0.395534	0.488415	0.326109	0.293260	0.608067	0.202288	0.467585	0.170137	-0.485026
IntraPL9	-0.132552	-0.050575	-0.294425	0.271865	0.316907	0.634698	0.274870	-0.018233	0.267502	0.363410	-0.208832
~~SupPL1~~	-0.183129	-0.473606	-0.271355	0.543984	0.313487	0.235131	0.487195	0.300037	0.684443	0.220881	-0.474298
SupPL13	0.015633	-0.315560	-0.234224	0.454207	0.381952	0.422298	0.418058	0.169851	0.609152	0.311718	-0.379766
SupPL20	-0.161688	-0.031185	-0.239378	0.231079	0.354522	0.373102	0.252217	0.027656	0.263410	0.735395	-0.135694
SupPL21	-0.119339	-0.032823	-0.274760	0.245469	0.360821	0.429239	0.283049	0.015516	0.305406	0.674920	-0.157445
SupPL22	-0.110197	-0.156298	-0.369921	0.304696	0.365161	0.408503	0.358075	0.042107	0.381921	0.729220	-0.215620
SupPL26	-0.123176	-0.208999	-0.368379	0.405389	0.441111	0.398104	0.276212	0.124719	0.434439	0.726246	-0.299281

SupPL27	-0.177511	-0.378473	-0.399781	0.551371	0.390432	0.334143	0.541382	0.281829	0.690684	0.419888	-0.470944
SupPL28	-0.195713	-0.363189	-0.374891	0.616261	0.445375	0.355478	0.560776	0.318222	0.750315	0.349249	-0.512602
SupPL29	-0.250449	-0.354252	-0.375444	0.487239	0.331680	0.362181	0.457752	0.134830	0.673856	0.348088	-0.327859
SupPL3	-0.171497	-0.353981	-0.455187	0.558852	0.412445	0.379420	0.486575	0.129137	0.720450	0.346313	-0.491318
~~***SupPL30***~~	-0.135521	-0.345199	-0.408384	0.509791	0.384424	0.341472	0.506522	0.108387	0.690023	0.386421	-0.417744
SupPL5	0.019374	-0.397067	-0.193897	0.418926	0.085114	0.115876	0.268600	0.903610	0.313451	0.057664	-0.366414
SupPL6	0.049719	-0.391340	-0.246751	0.406765	0.094224	0.116528	0.220954	0.900197	0.283532	0.093012	-0.346639
SupPL7	0.154669	-0.169214	-0.020948	0.183796	0.042248	-0.050284	0.079971	0.719482	0.131789	0.065242	-0.164974
SupPL8	0.111003	-0.091257	-0.015958	0.197552	0.061738	0.054367	0.067586	0.660425	0.195742	0.089965	-0.133067
SupPL9	0.021676	-0.338491	-0.132702	0.319042	0.078040	0.047408	0.124451	0.827814	0.225132	0.035554	-0.261844