INTERFACING AND COMPLEXITY ISSUES IN PROJECT MANAGEMENT: A CASE STUDY OF A CONDOMINIUM CONSTRUCTION PROJECT IN KLANG VALLEY

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A dissertation submitted in partial fulfilment of the requirements for the award of Master of Project Management

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May 2016

DECLARATION

I hereby declare that the dissertation is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

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DEDICATION

To:

My Beloved Family and Lulu Tan.

Sincere thanks for your love, support and understanding over these past two years.

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I am grateful to the God for the good health and wellbeing that were necessary to complete this dissertation.

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ABSTRACT

INTERFACING AND COMPLEXITY ISSUES IN PROJECT MANAGEMENT: A CASE STUDY OF A CONDOMINIUM CONSTRUCTION PROJECT IN KLANG VALLEY

Tan Wei Oon

When a project is headed for failure, most of the project participants cannot distinguish whether project creates problems or human creates problems. This research studies two aspects of project which may initiate project management issues: interfaces and complexity. The literatures review summarised the type of interfaces in a typical project include time interfaces, geographical interfaces, technical and contractual interfaces, and organisational interfaces. The causes of complexity in projects are grouped into three broad categories: human behavior, system behavior and ambiguity which can be caused by ‘individual behavior’, ‘group, organizational, and political behavior’, ‘communication and control’, ‘organizational design and development’, ‘connectedness’, ‘dependency’, ‘system dynamics’, ‘emergence’, and ‘uncertainty’. This research involves a case study on an ongoing medium-sized private construction project in Malaysia. Five incidents which caused conflicting issues are analysed in detail in order to identify the types of interfaces involved and the categories of complexity and their possible root causes. It is found that the most common types of interfaces are organizational interfaces, technical and contractual interfaces, geographical interfaces, and time interfaces; the categories of the complexity are human behavior, system behavior, and ambiguity; and the causes of the problem mostly arise from organizational design and development, emergence, connectedness, group, organizational and political behavior, and dependency. This research study introduced the interfacing issues and project complexity in the construction industry in Malaysia. The research findings are to be useful to both academics and practitioners. This study distinguishes the types of interface issues and project complexity which cannot be eliminated, but it can be controlled by implementing good interface management in the initiation phase of a project. In addition, this study also demonstrates the importance of a good interface management to improve project performance regarding quality, cost, time and safety as well. The present findings should help to reinforce the project practitioners to identify the potential interface issues and project complexity which may impact to the project lifecycle execution. Once identified, action can be taken to minimise any impact and with constant monitoring areas of critically that deviate from the plan can be quickly addressed and brought under control.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Project failures in the construction industry are a global phenomenon, no exception in Malaysia or elsewhere. However, the Construction Industry Development Board (CIDB) reported Malaysia had enjoyed a strong run in the construction industry since independence in 1957. From an average RM 51 billion construction output in 2001-2005, it contributed RM 128 billion in 2012 and RM 131 billion in 2013. In 2014, construction work for 6,927 projects worth RM 136 billion was kicked off, of which 78% involve private sector participation. It is clear that the nation has come along in just 50 years and will continue to move strongly until the end of the 11th Malaysia Plan, 2016-2020 (Scribd, 2015).

While the figures are exceptional, and the construction industry has continued adopting great technological advances, but its still characterised as adversial and inefficient and in need of structural and cultural reform. In today’s flat world, construction projects are far more complicated than ever before in which involve greater capital investments, embraces numerous disciplines, widely dispersed project stakeholders, tighter schedules and strict quality standards (Kamarul, 2012). At the same time, contractors are under great pressure in a competitive market on factors such as cost, time-to-market and quality (Tomiyama

& Meijer, 2006).

Oftentimes, interface issues and complexity occur in construction projects. It is one of the great certainties in the construction industry, the equivalent of death and taxes in life more generally. Projects are outsourced to several contractors due to enormous size consequence the increases of interface issues and complexity during the project lifecycle execution. These projects involve many stakeholders from different geographical locations and working cultures in which each party have to be tightly coordinated to achieve project objectives.

1.2 Problem Statement

There are 39% of projects succeed and delivered on time, on budget, and with required features and purposes. The balance 61% are challenged and failed due to delay, cost overruns, and/or with less than the required features and purposes, either cancelled before completion or delivered and never used (Bonnie, 2013). Therefore, such problems are sadly all too common in projects and improving success rates is one of management greatest challenges (Goatham et. al, 2016).

When a project is headed for failure, all signs are there: time overrun, budget overruns, and quality flaws. Very few project managers and companies want to admit their failure, even sometimes fear to discuss the causes of project failure (Fretty, 2006).

What is notable about these “failures” is that the most expensive mistakes and delays can be traced back to interface problems and complexity issues between the project parties either by off-site or on-site project team. These problems usually caused by two things where things the team did do (but did poorly) or things that the team failed to do, while poorly handle of these problems may lead to deficiencies in the project cost, time, and quality throughout the project lifecycle execution, or may result in failure after the project has been completed (Goatham et al., 2016).

Much written material related to tips, resources, and guidelines on project management. However, one of the least discussed topics is project failure in which caused by interface problems and project complexities. While the list of all possible interface issues and complexities are recognized only through a review of the literature and pilot study of the interviews rather than by using a realistic project to examine the existence of the interfaces and complexity.

1.3 Research Aim and Objectives

1.3.1 Research Aim

The aim of the research is to examine the interfaces and complexity problems in a real-life project.

1.3.2 Research Objectives

In order to achieve the research aim, the following objectives are formulated:

i. Explore the existing interfaces and complexity issues of the selected project.

ii. Categorise the issues according to the types of interfaces and complexity problems.

iii. Identify the root causes of the problem and recommend measures for improvement.

This research purports first to define and elaborate the interfaces and complexity based on a real-life construction project in which five incidents of an ongoing project are studied in depth.

1.4 Research Method

This research conducts a case study on an ongoing project to define and explore the main factors causing the interface problem and complexity of the project to make a conclusion of the occurrence of the problem and recommending measures to pre-empt the reoccurrences of the problems.

1.5 Report Structure

Chapter 1 introduces the background issue of this research, formulate the research problem, determine the research aim and objectives, and also outline the research methods and delimit the scope of the research.

Chapter 2, a literature study is conducted. Two main subjects are examined and described. In here, the literature on interfaces and interface management in the construction industry as well as project complexity is examined and described.

Chapter 3 explains the research design that four stages which this research consists of and the research approach in this study involve a case study of a construction project with real-life incidents and also the research constraints are described.

Chapter 4 consists of a case study, which provides details of five incidents happened on the studied project which is inter-organizational communication issues, submittals submission processes, design and approval issues, communication between on-site and off-site project team, and procurement processes within an organisation.

Chapter 5 analyses the five incidents using four (4) core interfaces: time interfaces, geographical interfaces, contractual and technical interfaces, and organisational interfaces as well as three (3) broad categories of complexity. Furthermore, findings reveal the most import factors leading to integration problems.

Chapter 6 concludes the findings, review the achievement of the objectives, and their implications for the industry, reflect the limitation of the study and recommend further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, a literature study is conducted. The definition of interface management is described in Section 2.1, and it follows by an explanation of the project complexity in the construction industry in Section 2.2.

2.2 Interface Management

Most of the construction practitioners agree that good interface management is crucial like improve alignment between stakeholders and diminish project issues and conflicts if the project is to succeed. Or else, there may be project failure. Today, construction projects are becoming more and more complex and larger in scale due to advance in technology and operations, yet enormous pressure in a competitive market on factors such as cost reduction, lead-time reduction and quality improvement (Tomiyama & Meijer, 2006). It is proving that the construction projects are harder and harder, more and more complexity as well which attribute to multiple stakeholders and contractors involvement and these parties are from different working cultures and backgrounds, and also located at various geographical.

2.2.1 Definition of Interface Management

Most of us know interfaces seemingly, and we do not have an entire definition, and no consensus definition produces by previous studies. Stuckenbruck (1988) proposed that any project involving numerous people, parties, and units must be cautiously and effectively integrated into a single unit if it aims to run smoothly so as to avert incurring extra costs. An interface as a dimension among two firms or organisations that can mutually influence each other (Ku, 2000; Shokri et al., 2012). Lang and Madnick (1993) emphasise that interfaces do not only occur within an organisation, but also between the organisation, but the environment as well. Where external interfaces refer its the relationships, an organisation has with its surrounding environment.

Construction projects are usually outsourced to several contractors due to enormous size. There always be a sponsor (client), design consultants (architect and engineer), construction team (main contractor and subcontractor), manufacturer and supplier (material and machinery), statutory authorities, local authorities, and so forth, on the whole, are complex and involved many activities that create several interfaces. Each interface would provide a link between two or more entities, construction components, stakeholders and project scopes (Shokri et al., 2012).

A boundary across which two independent systems meet and act on or interact with each other (Walker, 1996). Huang et al. (2008) further proposed that the matters required to be physically and functionally coordinated or cooperated with among two or more subjects.

A project can be viewed as an assemblage of organisations, teams, work, information, and other attributes that have to be integrated to achieve project objectives. In today's flat world, projects are becoming increasingly complex with greater specialisation in multiple disciplines. The ability to manage the many interfaces among the diverse specialised work divisions will determine the overall success of the project (Chua and Godinot, 2006).

Healy (1997) opined interface management is not a new concept, but it has been given little attention which is so pervasive in project management that no-one notices it, rather like the air we breathe. The reason might be because it is hard to describe it succinctly without appearing trivial. Interface management consumes much energy and skill. It is a sea of detail that needs to be managed and simplified wherever possible.

Time interfaces may be imposed to ensure a certain kind of work is finished before another starts; geographical interfaces may involve taking work off-site so as to allow other production processes to commence; technical interfaces may be imposed to ensure that certain technologies come together; and social interfaces may be imposed to keep certain groups apart (Healy, 1997).

According to Nooteboom (2004), interface management refers to the administration of boundaries common between people, systems, equipment and concepts. Kelly and Berger (2006) defined interface management as "the systematic control for ensuring timely and effective verbal and written communications among participants."

Moreover, the interface management is crucial to projects as it creates an understanding for handling interfaces, the requirement of resources and their organisation at the job site (Chen et al., 2007). While, Wideman (2002) defines it as the management of communication, coordination, and responsibility across a common boundary between two organisations, phases, or physical entities which are interdependent; managing the problems that often occur among people, departments, and disciplines rather than within the project team itself.

However, ultimately, interface management is essentially a communication task wherein adequate communication flows and coordination among the diverse teams are necessary for full technical integration of a system (Healy, 1997). Interfaces are generally managed through meetings, which must gather technically knowledgeable, committed, and empowered people for communicating, controlling interface issues, and resolving interface conflicts when they arise (Chua and Godinot, 2006).

2.2.2 Types of Interfaces

Construction production process consists of substantial activities, right from the inception of the project design and right through its implementation, completion, commissioning, occupation and goes up to the maintenance, also called as the whole lifecycle of the project. Therefore, it involves and generates some interfaces between the various participants with different disciplines to carry out the separate but interrelated activities of the construction process from commencement to the end.

Most of us know interfaces seemingly, and we do not have an intact definition, and no consensus definition produces by previous studies. For instances, Stuckenbruck (1988) identified three (3) main interfaces such as personal interfaces, organisational interfaces, and systematic interfaces. Lang and Madnick (1993) proposed three (3) kinds of interfaces such as psychological interfaces, material interfaces, and information interfaces. Furthermore, Healy (1997) proposed four (4) main interfaces, namely, time interfaces, geographical interfaces, technical interfaces, and social interfaces. Ku (2000) proposed five (5) different perspectives to analyse interface management, namely, contract interface, technology interface, monitor interface, execution integration interface, and interacting behavior in the interface. Laan et al. (2000) identified three (3) main interfaces, such as functional interfaces, physical interfaces, and organisational interfaces. Also, Pavitt and Gibb (2003) proposed interfaces into physical interface, contractual interface, and organisational interface.

All these interfaces must be managed, and the category of the interfaces also needs to be identified and to determine how to solve them (Pavitt and Gibb, 2003).

2.2.3 The Importance of Interface Management

Interface management is essentially the project manager’s job: planning, coordinating and controlling the work of others at project interfaces (Morris, 2015). Although, industry leaders believe the lack of interface management in projects may result in deficiencies in the project time, cost, and performance aspects, or might even lead to failure after the project had been handed over. Grimes (2009) reported five dangers of poor project communication, for instances needless information, information silos, interruptions, mistimed details and unfocused meetings. All these can lead to big trouble during project lifecycle execution.

Whilst facing interface problems, the construction practitioners have to identify the main interface problems immediately and carefully resolve it through proper communication, coordination, and cooperation among their construction team. Staats (2014) emphasizes that the main factors leading to interface problems are overall unawareness of interface issues, ownership and responsibilities regarding the interfaces are not clear, lack of coordination among specialties, insufficient and inaccurate interface information, poor information flow, poor ordering of tasks, no overview of what the crucial interfaces are, and lack of a proper interface management organization.

A project prospers only through good management of communication, coordination, and responsibility through a common boundary among two organisations, phases, and independent physical entities. Interface management is vital as it creates an understanding of the interdependence between systems, the appropriate methods for handling interfaces, the requirement of resources and their organisation at the workface and the respective responsibilities of the parties to manage the interface (Chen, Reichard and Beliveau, 2007).

Interface management encourages communication among the participants. It provides each with an understanding of the limitations inherent in their respective data generation cycles. The early identification of issues with the potential for impacts to cost or schedule, to minimise or eliminate their impact and promote clear, precise, timely, and constant communication with organisations for exchanging interface information. Communication between project participants early in the design cycle is a major factor in achieving execution excellence and providing each with an understanding of the constraints inherent in their respective data generation cycles (Caglar and Connolly, 2007).

Huang et al. (2008) stated that successful interface management in a construction project should carefully integrate all the technical and managerial matters among the involved parties and emphasise their coordination and cooperation. Otherwise, counteractions will emerge in the interface and cause damages to all the participants in the construction project.

2.2.4 Interface Management in the Construction Industry

Many interface problems that hamper the collaboration of an interdisciplinary team (Töper, 1995). The lack of cooperation, limited trust, and ineffective communication leading to an adversarial relationship among all these project stakeholders induce project delays, difficulty in resolving claims, cost overruns, litigations, and compromise project quality (Mosley et al., 1991).

The following entries in Table 2.1 are the latest noteworthy-troubled construction projects from around the world due to grey areas in the interfaces.

Table 2.1 Example of failed construction projects

No	Project	Country of origin	Type of failure
1	Railhead Project	USA	Lack of communications; Lack of oversight/ poor project management.
2	Census Bureau	USA	Lack of communications; Failure to establish appropriate control over requirements and/ or scope.
3	NHS Care Records Service	UK	Failure to address culture change issues.
4	British Airways Terminal 5 transitions	UK	Poorly planned/ managed transitions.
5	Qantas Airlines	Australia	Failure to engage stakeholders
6	Westjet – New passenger reservations system	Canada	Failure to establish appropriate control over requirements and/ or scope.

(Source: International Project Leadership Academy, 2016)

Interface management is becoming more important nowadays in the construction industry if the interfaces in a project are not managed well, huge problems could occur leading to delays and additional costs (Sebastiaan, 2014). But, it has been given little attention that no-one notices it (Healy, 1997). Also, Nooteboom (2004) mentioned that the negative impact of interface management is often underestimated in construction projects.

The lesson learned proposed by Collins et al. (2010) when developing a mega project as below:

- Establish the position of an interface manager in the owner's team. This person should be a senior member of the team and have a broad base of experience, preferably including project development, process, engineering, commercial and contract wording/ interpretation.
- Think through the logical stages of defining, progressing and managing the interfaces, to identify the best options for allocation of responsibility for their management.
- Include as many definitions as possible in the enquiry documentation, to minimise the risk to contractors arising from potential interfaces.
- Establish contract obligations for contractors, which are as clear as possible without loading excessive interface risk for unrealistic or undefined requirements.
- Ensure each contractor understands the interface issues and its obligations to manage them.
- Follow this all through to the project execution and do not lose track of the issues.

- Accept new issues will arise and have the personnel and infrastructure in place to handle them.

2.3 Project Complexity

The construction production process consists of substantial activities, right from the onset of the project design and right through its implementation, completion, commissioning, occupation and goes up to the maintenance, also called as the whole lifecycle of the project. Therefore, it necessitates the inputs from large numbers of participants like proposer (client), designer (architect and engineer), construction team (main contractor and subcontractor), manufacturer and supplier (material and machinery), statutory authorities, local authorities, and so forth in the project lifecycle, on the whole, are complex and involved many activities that create several interfaces and these different disciplines are to carry out the separate yet interrelated activities of the construction process from commencement to the end.

2.3.1 Definition of Complexity

Every country in the world has complex projects but not every country has resources qualified to manage these complex projects. Complexity theory has been liberally applied over the last decade in many disciplines as disparate as astronomy, biology, physics and finance in an attempt to solve complex problems (Whitty and Maylor, 2009).

On the one hand, some the construction project is growing around the world and opportunities to use lesson learnt to improve performance. One the other, most projects are late, cost overruns and fail to achieve their original objectives (Morris and Hough, 1991; Holmes, 2001; Flyvbjerg et al., 2003). The concept of complexity is tantamount to the impact of interface management in which receives little or no attention and underestimated in construction projects (Healy, 1997; Davies and Mackenize, 2014).

In today's flat world, project managers cannot control complex projects with the same management style and tools that are used with traditional projects because, conventional project management practices like PMBOK® Guide, encourage linear thinking and lots of structure and control (Kerner, 2013).

No one, especially in construction fields, wants to envelop with complexity. Construction projects are typically referred to as unique, huge, diverse and enormously complex. The management of project transpires in a complex environment (Thompson, 1967; Bertelsen, 2003). Also, Thompson (1967), Morris and Hough (1991), Bertelsen (2003) indicate the considerable potential for conflict both internal (within the team) and external (between the team and the client) as a result of the nature of construction projects.

The Merriam-Webster defines complexity as "the quality or condition of being difficult to understand or of lacking simplicity". Nevertheless, complexity and uncertainty are connected where uncertainties range from a known or foreseeable event whose impact on the project can be anticipated in advance to entirely unforeseen events with unpredictable consequences (Smith, 2006). A further example, complex projects contain several internal sources of uncertainty. First, the introduction of new technology into project increases the possibility that it will delay, cost overrun, and fail to achieve its original specifications. Second, the novelty or uncertainty of the project's outcome on completion of a project at a future point in time is associated with difficulties in defining user requirements and customer needs up front. Third, the urgency or criticality of the time available to complete the project is a source of temporal uncertainty (Eisenhardt and Tabrizi, 1995; Smith, 2006; Mulenburg, 2008).

Lucas (2000) argues that complexity can be associated more with the interconnection structures that link various objects and not the objects themselves. Efforts to define the complex nature of projects often refer to systems theory and the idea that an organisation can be treated as a complex system of interacting component parts (Boulding, 1956; Edmonds and Von Bertalanffy, 1977). While, complex projects are often difficult to coordinate and have to devote considerable resources to integration because they have highly differentiated cross-functional structures involving in-house units and multiple parties (Galbraith, 1973; Morris, 2013).

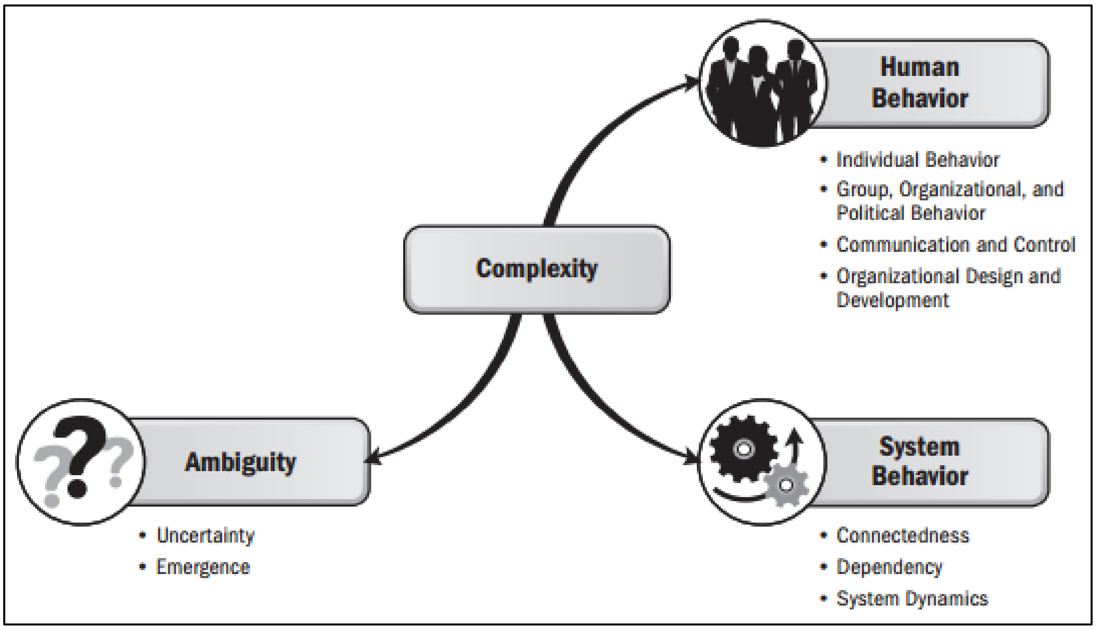
Curlee and Gordon (2011) opined complexity theory is about harnessing chaos in a manner that allows the project manager to increase his or her team's effectiveness by allowing a certain degree of individuality to move a project forward. Often permitting the random walk of the determined individual allows some level of creativity to become successful. An effective team can be more effective than an individual; allowing an individual to plow forward can often drive the team further and faster. Complexity is the manifestation of empowering and delegating tasks to allow individuality to support the hive.

2.3.2 Types of Complexity

Throughout history, vast majority projects have enveloped with elements of complexity, but often we do not notice the influences of these complexities.

In today's world, no matter how well we manage a project, but we are still increasingly confronted with a seemingly endless float of complexity in the project lifecycle. However, these elements of complexity that arise can be classified into three broad categories: human behaviour, system behaviour, and ambiguity (Project Management Institute. Navigating Complexity: A Practice Guide).

Project Management Institute (2014) grouped the causes of complexity into three broad categories: human behavior, system behavior, and ambiguity. Figure 2.1 provides an overview of the causes of complexity as associated with each category.



(Sources: PMI. Navigating Complexity: A Practice Guide)

Figure 2.1 Three categories of complexity and associated causes

Besides, the characteristics of complexity are as shown in the table below.

Table 2.2 Characteristics of complexity

Characteristics	Brief Description
Human Behaviour	The source of complexity that may arise from the interplay of conducts, demeanors, and attitudes of people. The associated causes are • H1 - Individual behavior. • H2 - Group, organisational, and political behavior. • H3 - Communication and control. • H4 - Organisational design and development.

System Behaviour	A collection of different components that together can produce results not obtainable by the components alone. The associated causes are • S1 - Connectedness. • S2 - Dependency. • S3 - System dynamics.
Ambiguity	A state of being unclear and not knowing what to expect or how to comprehend a situation. The associated causes are • A1 - Emergence. • A2 - Uncertainty.

(Sources: PMI. Navigating Complexity: A Practice Guide)

Human behaviors usually give rise to complexity. It may be the result of factors such as changing power relationships, political influence, and individuals' experiences and perspectives. These factors may hinder the clear identification of goals and objectives, and six examples of individual behaviors (H1) contributed to complexity such as optimism bias and planning fallacy, anchoring, framing effect, loss aversion, resistance, and misrepresentation as tabulated in Table 2.3.

Table 2.3 Individual behavior (H1)

Characteristics	**Brief Description**
Optimism bias and planning fallacy	The natural tendency of individuals to believe that they are less likely than others to experience negative outcomes. Planning fallacy results when a person tends to

	underestimate probable costs and time and overestimate probable benefits of efforts in which they or their organisations will be involved.
Anchoring	A bias that occurs when great significance is attached to information acquired early in projects when the least amount of information about the work is clearly understood.
Framing effect	The manner in which information is presented and who presents that information affect how that information is perceived or interpreted. These actions have a direct impact on decision making.
Loss aversion (sunk cost effect)	When a great deal of emotion, energy, and resources are invested in a troubled project, people are reluctant to terminate it despite clear indications that recovery may be impossible.
Resistance	All projects produce deliverables that result in change. Change is difficult for individuals to embrace but rather the transition to the modification. Transitioning from one state to another involves letting go of the familiar (with its known consequences, good or bad) and accepting new (with unknown consequences, good or bad), which increase the degree of a project’s complexity.

Misrepresentation	The act of knowingly conveying false information to achieve desired ends. This typically occurs in circumstances with significant political pressures and/ or economic incentives, in which case misleading others seems to be the most desirable course of action.

(Sources: PMI. Navigating Complexity: A Practice Guide)

As of that, Table 2.4 tabulated the behaviors such as tribal mindset, groupthink, groupshift, self-organization, and lack of stakeholder commitment pertain to the group, organisational and political behavior (H2) that contribute to complexity.

Table 2.4 Group, organisational and political behavior (H2)

Characteristics	**Brief Description**
Tribal mindset	Tribal mindset involves rivalries with members of other groups.
Groupthink	A phenomenon in which the group's desire to achieve conformity and harmony takes precedence over rational decision making.
Groupshift	A phenomenon in which discussions among the group lead individuals to take more extreme positions than normal.
Self-organization	People have a natural tendency to self-organize and band together in ways that may or may not align with the established project organisation.

Lack of stakeholder commitment	It's hard to achieve success without the explicit commitment and support of its key stakeholders. Misrepresentation, hidden agendas, organisational politics and personal agendas are also the reasons for lack of commitment. Wavering stakeholder commitment may create the uncertainty that, in turn, increases the degree of complexity in a project.

(Sources: PMI. Navigating Complexity: A Practice Guide)

Table 2.5 further describes the complexities of communication and control (H3), such as varying legal perspectives and cultural diversity.

Table 2.5 Communication and control (H3)

Characteristics	**Brief Description**
Varying legal perspectives	Laws have developed over the centuries and reflected society's perspective on ethics and morality. Naturally, legal considerations differ from country to country and these differences present complexities in planning and control for program and project managers. Not only can laws be open to varying interpretations, but what's legal in some countries may not be legal in others. This opens the door for potential misinterpretation and ethical dilemmas for the delivery manager.

Cultural diversity	Cultures vary from country to country and even within individual countries. These differences may affect common understanding as well as how stakeholders communicate and interact with one and other. They may even affect whether stakeholders trust each other. There are various cultural dimensions that could increase complexity when a project is conducted in a cross-cultural environment; these may include the tolerance for inequality in levels of authority in organizations and institutions, the degree to which people tend to operate within a group or autonomously, the distribution of roles between men and women, or the levels of comfort with unstructured situations.

(Sources: PMI. Navigating Complexity: A Practice Guide)

Table 2.6 shows the misalignment and opacity attribute to organisational design and development (H4).

Table 2.6 Organisational design and development (H4)

Characteristics	**Brief Description**
Misalignment	Various types of fir or alignment that, if not appropriate, may lead to an increase in the degree of complexity in a project, for instances, misalignment occurs • Between the project and the organisation's strategic goals. The probability of misalignment may increase without the presence of an effective portfolio management process. • Between the features of governance and the types of programs and projects that an organisation undertakes in pursuit of its goals. • Between any authorised project and the organisation's ability to staff it, either internally or through external means with sufficient numbers of appropriately skilled resources. • Among stakeholders and the project goals and objectives. Lack of alignment may result in conflicting priorities and direction for the project team.
Opacity	The manner in which an organisation conducts its business (i.e. makes decisions, determines strategies, and sets priorities) goes far toward determining the trust given to it by its stakeholders, both internal and external. Hidden agendas, secretive decision-making processes, and suspect

	promotion and reward processes may inevitably lead to a lack of trust by a project's stakeholders. If these processes are not transparent, consequent mistrust among team members may lead to complexities that the practitioner encounters when assembling and managing the project team.

(Sources: PMI. Navigating Complexity: A Practice Guide)

In addition, Table 2.7 shows the causes of complexity in projects, under system behavior, are connectedness (S1), dependency (S2) and system dynamics (S3).

Table 2.7 System behavior

Characteristics	**Brief Description**
Connectedness (S1)	A relationship that exists between two or more components of a project. Complexity increases with the number of connections, and when large numbers of seemingly unrelated components are connected, then complexity increases significantly.
Dependency (S2)	A potential cause of complexity that occurs when work packages are dependent on other work packages. Some work packages cannot start until one or more work packages are completed; also some work packages cannot start until other work packages start. The greater the number of dependencies among schedule activities, the more complexity is likely to be

	encountered within the project.
System dynamics (S3)	The connectedness and interdependency of many components that interact so as to cause change over time.

(Sources: PMI. Navigating Complexity: A Practice Guide)

Ambiguity is a common aspect in projects with complexity, the causes of ambiguity contributes to emergence (A1) and uncertainty (A2) as tabulated below, Table 2.8.

Table 2.8 Ambiguity

Characteristics	**Brief Description**
Emergence (A1)	The unanticipated change, spontaneous or gradual, that occurs within the context of a project that arises from the dynamic interrelationships among and between project components.
Uncertainty (A2)	The state of being unsure, of knowing an issue or situation. The existence of unknowable unknowns and the inherent inability to address and act upon these situations may enhance uncertainty.

(Sources: PMI. Navigating Complexity: A Practice Guide)

2.3.3 Complexity in the Construction Industry

Complexity is a term often used when discussing construction industry in which the construction process is one of the most complex and risky businesses undertaken in any industry and this industry has a very poor reputation for managing risk, with many projects failing to meet timeline and cost targets (Baccarini, 1996; Wood and Gidado, 2008; Mills, 2001). Whilst, Wood and Gidado (2008) support this further, the construction process should be perceived as a complex, dynamic phenomenon in a complex and non-linear setting.

The construction industry is now facing different stages of complexity as the increasing of energy, material and labor costs which are to a great extent mitigated by the other industries by implementing the new technologies especially communication and information technology as well as the advanced management strategies.

Moreover, today's construction industry is very dissimilar from other manufacturing industries and therefore difficult to reach similar performance, mostly due to its uniqueness in the scope, position and complication due to the varied non-uniform working conditions from one project to another. Thus, it gives the impression to be underachieving when compared to many other industries. As of that, the production, value for money, and overall customer satisfaction in the construction sector are relatively low compared to other industrial sectors, for instances, low and discontinuous demand, numerous changes in requirement, inappropriate (contractor and client) selection criteria, inappropriate allocation of risk, low quality, incompetent methods of construction, poor management and investment, an adversarial culture, and a fragmented industry structure (Cox and Townsend, 1998).

The lack of effective communication and implementation leads to significant negative effects, low production, cost and time overruns and finally ends up in conflicts and dispute. A major influential factor to the poor performance of construction industry was the adversarial relationships that occurred among the construction organizations, consultants and customers and between contractors, subcontractors and suppliers (Ukessay, 2016).

Lastly, all interfaces and complexities discussed above which may not conform to the scope that to discuss in this research. Hence, this study adopts the interfaces, such as time interfaces, geographical interfaces, technical interfaces and contractual interfaces, and organisational interfaces, whereby the elements of complexity like human behavior, system behavior and ambiguity are selected and tailored for this research.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the research methods adopted in this study. It includes a case study of an ongoing project to explore the root causes of interfaces and complexity issues. The case study is on a construction project involves a 30-storey apartment block in the outskirt of the Kuala Lumpur (KL) city which worth approximately RM 100 million based on traditional contract. The project is expected to complete in the year 2017. There are six (6) nominated subcontractors involved the works, such as electrical works, air-conditioning and mechanical ventilation (ACMV) works, fire protection system, cold and hot water plumbing works, swimming pool, and water feature work. The main contractor site team is made up of seven (7) persons for the respective disciplines.

At the time of this study, the contract has reached half of its contract duration, but only 40% of the work has completed.

3.2 Research Design

Verschuren et al. (2010) recognised five strategies to approach a research, namely survey, experiment, case study, well-founded theoretical approach, and desk research. According to Creswell (2009), the approach to research is not about choosing between the qualitative and quantitative ones and is not restricted to methods of data collection. Each involves a set of assumptions. Parikh (2015) opined a mix of methods of data collection comprise interviews, observation of managers in meetings, field visits, focus groups, document analysis and newspaper articles.

This research will use a single case study to explore and to discover the interfaces and elements of complexity in a construction project. The case study selection criteria are crucial. Glaser and Strauss (1967) present formulating selection criteria based on the research question and sampling strategy is critical.

This research includes four stages which are:

i. Reviewing the published literature to identify the existing theories related to the interface management and project complexity.
ii. Conducting field study of the ongoing project.
iii. Analysing the data collected and compare with the existing theories.
iv. Concluding the findings by identifying the similarities with existing theories and highlight the differences and inference the key findings.

The first stage of this research is literature review which involves scanning the pages of any published literature like books, collection, paper, magazine, and the like. It is a systematic, explicit and reproducible method for identifying, evaluating and interpreting the existing body of recorded work produced by researches, scholars and practitioners to find out what is already known about the intended research topic (Robinson and Reed, 1998; Fink, 1998). The literature review of this research involved with exploring published literature on interface management and theories related to the project complexity in the construction industry.

The literature review aims to focus on the following issues:

- What are the interfaces and project complexity issues confronted the construction industry?
- Does the industry has a structured approach to handling the interfaces and project complexity issues?
- Any available lessons learned and best practices to manage project interfaces and complexity? How successful are they?

The second stage involved conducting a field study of an ongoing project. The purpose of the field study is to select the conflicting incidences happened and analyse the nature of the interfaces involved and nature of the complexity of the incidence. This is aimed to categorise the types of interfaces and complexity of the conflicting incidence for further analysis their root causes and possible pre-emptive measures.

In narrating an incident, any interfaces and complexity problems between two parties from inter- or intra-organization and information passed up or down through the company will be noted down and tabulated for evaluation. The first step in the data analysis is to determine what data is useful and how best it could be dissembled and then reassembled in order to identify the existing point of contacts (interfaces) and categorise into four core interfaces, namely time interfaces, geographical interfaces, technical and contractual interfaces, and organisational interfaces. Secondly, the elements of complexity must be done through analysis of the points of contact and problems between two parties. Each problem must be determined and sorted into the associated causes which under the three (3) broad categories of complexity as described in Section 2.3.2.

The e-mail correspondences between the project parties are examined to determine the interfaces involved. The e-mails provided a means to understand and track chronologically how a small issue is being snowballed to a big problem which affects inter- or intra-organization during the project execution.

Using company e-mail as a source of data provides very rich information to develop an understanding of phenomena in a way that is similar to observation but without actual being present at the site (Wakkee et al., 2003). Data contained in e-mails are created independently of the research and due to the personal and often informal nature of e-mails, it offers the opportunity to come as close to the reality as perceived by the sender. Daft and Lengel (1983) identify four criteria: (a) the availability of instant feedback; (b) the capacity of the medium to transmit multiple clues such as body language, voice tone and inflexion; (c) use of natural language;

(d) the personal focus of the medium. This research will concentrate on the availability of instant feedback and the personal focus of the medium.

Face-to-face communication is the richest communication medium. However, e-mail can be considered a warm and personal medium, also a valuable source of data (Miles and Huberman, 1994; Walther, 1996; Pantelli 2003; Uky.edu, 2003), carrying equivalent levels of information richness to face-to-face interaction, including characteristics of both written and spoken language.

The third stage involved with analysing the data. Each of the selected incidents is being studied in detail to identify the interfaces involved and elements of complexity. Tabulation of the findings is used to compare the similarities and differences of each incident on the types of interfaces and nature of complexities.

Lastly, the conclusion will be drawn from the analysis to identify if measures can be recommended to pre-empt reoccurrences of such conflicting incidents in the future project.

CHAPTER FOUR

RESULTS

4.1 Introduction

An ongoing construction project in Klang Valley chosen for the present study. A total of five (5) incidents of events that involved interfacing issues are selected for this study. These incidents include managing of internal interfaces as well as external interfaces where interdependencies exist across boundaries and where responsibilities for the interdependencies changes across the boundaries. The types of interfaces consist of time interfaces, geographical interfaces, technical and contractual interfaces, and organisational interfaces.

The first real-life incident involved with communication issues with a newly appointed project manager assigned to a new project by the management. The second incident is about the submission of shop drawings by the subcontractors and main contractor to the consultant team. The third incident involved with design and approval of the changes to the sample submitted by the nominated subcontractor. The fourth incident involved with the procurement and communication between the onsite project team and its headquarters. Lastly, the fifth incident involved the procurement process of the main contractor's organisation.

4.2 Project Particulars

The main contractor secured a contract to construct and complete a 30-storey apartment block project in the outskirt of the Kuala Lumpur (KL) city. The contract worth approximately RM100 million, due for completion in the year 2017, and comprises a 30-storey unique wavy design apartment block features 250 apartments and penthouses base with a curvy facilities floor and 7-storey car parks, TNB substation, refuse chambers, guardhouse, and hardscapes works. The construction contract arrangement relies on the traditional contract. At the time of this study, the contract is at about 50 percent of its contract duration, and as work gets underway on the site is about 40 percent completion. The liquidated damage for the delay is RM50,000 a day.

On the other hand, the project team of this project included organisations of the developer, architect, civil and structural consultant, mechanical, electrical and plumbing (MEP) consultant, costing consultant, landscape designer, the main contractor, domestic subcontractors and nominated subcontractors. These nominated subcontractors involved with electrical works, air conditioning and mechanical ventilation (ACMV) works, fire protection system, cold and hot water plumbing works, and swimming pool and water feature work.

However, the nominated subcontractors are selected by the client and imposed upon to the appointed main contractor, which is entitled to add its marks up and attendance costs in relation with main contractor to provide services to the nominated subcontractors, for instances, material handling at the site, site guards, rubbish clearance, passenger hoists, welfare facilities (i.e. Temporary power and water supplies), scaffolding and so forth.

The site management team of the main contractor is made up of a project manager, which had 15 years of construction experience; a mechanical, electrical and plumbing (MEP) coordinator, who had 20 years of experience; a resident engineer, who had 12 years' experience. Subsequently, they are assisted by three (3) full-time site supervisors. These site supervisors are responsible for organising and supervising the construction activities. Two of three supervisors are responsible for reinforced concrete structure works, and the third supervisor is in charge of the architectural works of the project.

4.3 Selected Incidents

In today's world, project managers are increasingly facing more and more complexity and interfacing issues. In order to get a better understanding of the causes of complexity and interfacing issues, five (5) incidents of adverse events are selected for this study. The causes of interface issues and complexity, as implicated in real-life cases, are examined and described in this chapter.

The following are incidents give rise to interface issues and complexity.

i. Incident 1: Communication problems with a newly appointed project manager assigned to a new project by the management.

ii. Incident 2: Shop drawings submission processes between main contractor and sub-contractor to the consultant team.

iii. Incident 3: Design and approval of the changes to the sample submitted by the nominated subcontractor.

iv. Incident 4: Procurement and communication between the onsite and offsite project team.

v. Incident 5: Procurement processes of the main contractor's organisation.

4.3.1 Incident 1: Communication Issues with the Newly Assigned Project Manager to a New Project by the Management.

A pre-tender interview was held before the contract was awarded to the contractor. The interview was attended by the client's general manager and client's consultants. The main contractor was represented by the top management team, which included the managing director, executive director, project director and senior contracts manager. The managing director of the main contractor promised to the client's general manager that they would provide a stationary concrete pump for the concrete work on the entire contract, and further promised that there would be no additional monetary charges to the client for doing this without thinking of underbids in the tender submitted.

One week after the pre-tender interview, the client invited a meeting to finalise the tender, and the managing director again confirmed in this meeting that stationary concrete pump would be used to construct the entirety building with no changes in the tender sum. Eventually, the contractor won the contract and the provision of a stationary concrete pump not stated in the letter of award.

After receiving the letter of award, the main contractor calls for a project start-up meeting which is only attended by the project team members of the main contractor. The meeting was chaired by the executive director, other in attendance are the newly appointed project manager, senior contracts manager, contracts executive and purchasing manager.

Several issues discussed at the start-up meeting which include

- Organisational structure that will be adopted (i.e. The composition of the project team members);
- Site information – location, project details;
- Work methods;
- Project execution plan;
- Work program;
- Safety and health issues.

In the meantime, the executive director handed over a set of contract documents that included the working drawings, bills of quantities and project specification to the project manager.

Towards the end of the project start-up meeting, the project manager asked the possibilities of restructuring the project team members to assign all experienced workers to give the project the best prospects for success instead of young and inexperienced ones to handle the project. However, the executive director rejected the proposal, and the project manager stopped furthering any questions about the particular areas of the project. At last, executive director did not transmit to his project manager the information as regards stationary concrete pump that promised to the client.

Shortly after project commencement, the main contractor's project manager has placed a mobile crane as one of the needed resources for the construction work. The construction work started smoothly, until the first pour of concrete to basement slabs. The client's general manager was unhappy with the way of pouring concrete by using a mobile crane at the site and verbally instructed to cease the concrete work abruptly.

When the main contractor's project manager receives the cease work order and gets shocked because he did not know about all concrete work must be carried out with the stationary concrete pump in this project. The project manager, therefore, pleads with the client's general manager that he overlooked this unknowing mistake and yet blamed that not one person transmitted this information to him from day one.

Later, the news of ceasing work order quickly went to the main contractor's headquarters. At the meantime, the project manager questioned the senior contract manager that the stationary concrete pump whether is a "must" for the entire concrete work. But nonetheless, the senior contract manager asked the project manager to clarify with the executive director.

The project manager called the executive director to clarify this issue and confirmed by the executive director that they had verbally promised to the client that stationary concrete pump would use for the entirety building construction during the tender interview. After clarifying with the executive director, the project manager immediately placed a purchase requisition of the stationary concrete pump.

After everything is organised, the project manager gently approaches to the client's general manager that a unit of the stationary concrete pump has already been ordered, and it will be used until the project completion. However, the client's general manager agreed to continue the concrete work on the second (2^{nd}) zone of basement slab if a copy of stationary concrete pump's purchase order, as well as the machinery submittals, provided to him.

Meanwhile, the preparation and installation of timber formwork and steel bar cutting, bending and bar fixing for steel reinforcement work were proceeded as normal. However, the pouring of concrete was continuously stopped for the next five (5) days until the executive director contacted the client's general manager by confirming the delivery date of the stationary concrete pump and the project manager proposed the stationary concrete pump position and site logistics plan as well.

The client's general manager was permitted to resume the concreting work after main contractor's project manager has proven the document as requested by the client's general manager. Eventually, the client's general manager had on hold the concrete work on Level 2 basement slab for ten (10) days and this holdup start encountering delays on work progression that are the fault of the string in inter-organization interfaces, as well as the mobile crane idled in the construction site. Also, the project manager placed aside the mobile crane and served as a standby in case the client's general manager allows resuming the concrete work using a mobile crane.

4.3.2 Incident 2: Shop Drawings Submission Processes between Contractor and Subcontractor to the Consultant Team.

According to the contract document, it specifies that one (1) month from the outset of the project by which the coordination drawings on each floor must be submitted to the consultant team for review and approval.

One week before the project started, the main contractor's senior contract manager wrote to client's consultant team, the architect, civil and structural engineer, and MEP services engineer to request the construction drawings in digital format, (i.e. Computer aided design, CAD). Three (3) days after the email sent to all consultants by main contractor's senior contract manager, the architect and structural engineer forwarded their drawings to the main contractor's senior contractor manager. MEP services engineer responded by saying it would send via email by the next day. Meanwhile, the landscape designer is not appointed by the client yet.

One day later, MEP services engineer sent the CAD version of mechanical, electrical, and plumbing (MEP) drawings to the main contractor's senior contract manager. After that, the senior contract manager handed over those drawings to his project manager. The project manager requested his project director to designate an MEP services coordinator to handle and to prepare the coordination drawings of the building services. However, the project director said that an experienced MEP services coordinator would report for duty one (1) month later and asked the project manager to prepare the aforesaid drawing temporarily for execution of building work.

During the construction of the basement and ground-floor slab, the underground building services constructed following the construction drawings supplied by the client's consultant team. No technical issue was arising on the integration and coordination between the client's consultant team and the main contractor.

One month later, an MEP services coordinator who employed by the main contractor reported to the project manager of the project site. By then a set of construction drawings were handed to the former and instructed to prepare the building services coordination drawings for each floor of the project.

The MEP services coordinator completed the mezzanine level and first (1^{st}) floor building services coordination drawings one week later. The project manager then forwarded the completed drawings to the senior contract manager for submission to every client's consultants (i.e. Architect, structural engineer, MEP services engineer and cost consultant) for review and approval.

After three (3) days, the client's clerk-of-work (COW) commented the coordination drawings via email, the comments listed below:

- Not up-to-date drawings used for coordination drawing preparation.
- Electrical trench incorporated in superseded drawings, i.e. incorrect shapes, sizes, and location.
- An incorrect depth of sanitary service manhole.
- Incomplete rainwater down pipe (RWDP) discharge routes and insufficient quantity at areas, i.e. ramps/drain, water feature pump room, and the green area inside air well.
- Lack of fire protection piping at drop off area.
- Incoming cold water (CW) pipe from meter rack should expose at high-level due to different floor-finishes-levels (FFL).
- For exposed pipes & cables, the arrangement cannot be below or beside the cold-water piping.
- Coordination drawings were not included with fire protection system, air condition mechanical ventilation (ducting) and RWDP.
- Cold water system incorporated in superseded drawing.
- Lift lobby - light & smoke detector points are overlapped.
- Please do include section view to show the clearance height at lowest point/ critical area.

The MEP services coordinator felt the comments were something irregular and found that superseded construction drawings were used. He was forthwith queried the project manager about this issue, and the latter called directly to the client's MEP engineer to make sure that the correctness of the drawings, but the answer was "No. We are still changing some piping routes and will distribute it after three (3) working days." Thus, the project manager wrote to MEP services engineer requesting for the latest MEP services drawings.

Three (3) days later, the MEP services engineer forwarded the latest MEP services CAD drawings to the main contractor's project manager. Hence, both of the main contractor's project manager and MEP services coordinator quickly revise the coordination drawings based on the latest MEP services drawings and submit the revised mezzanine and 1st-floor coordination drawings to the client's consultants for review and approval again after a week. Thereafter, the main contractor's MEP services coordinator submitted the second (2^{nd}) floor coordination drawing a month later.

One (1) week later, there was no response from the client's consultants about the coordination drawings. The main contractor's project manager presumed that the coordination drawings are in order and started to pour the concrete to the first (1^{st}) floor slab after completing the carpentry and reinforcement work.

Next day, the client's project manager was made his rounds of the first (1^{st}) floor slab and realised two (2) power points for closed-circuit television (CCTV) system were not installed on the beam. The client's project manager questioned the main contractor's project manager how this would happen? While, based on the immediate explanation from the latter and the client's project manager found that the drawings used for the construction work at the completed floor slab were not approved by consultant team. The client's project manager instructed his clerk-of-work to issue a non-compliance-report (NCR) to the main contractor to cease the concrete work for next zone before the consultant has approved the coordination drawings.

The main contractor's project manager told the client's project manager that they had submitted the coordination drawings for ground floor until second (2^{nd}) floor, but had not received any response from their consultant. Besides, the main contractor's project manager pleaded for more understanding the difficulties he faced and requested for resuming the next zone concrete work.

The client's project manager called the MEP services engineer whether the coordination drawings are acceptable for construction. The MEP services engineer affirmed that the building services design in the coordination drawings main contractor submitted is accepted for construction up to first-floor slabs; however, they are still reviewing the remaining coordination drawings. After confirmation, the client's project manager allowed the main contractor to resume and proceed to the next zone of concrete work.

Two (2) weeks later, the main contractor's MEP services coordinator arranged the second coordination meeting. This meeting was between client's MEP services engineer, main contractor's project manager and nominated subcontractors such as electrical, air-conditioning and mechanical ventilation, fire protection system, and plumbing to finalise the samples of material submitted and also discussed the revised coordination drawings submitted by the main contractor one (1) month ago. At last, this discussion reached a consensus over the revised coordination drawings and the material submittals. Thus, the client's MEP services engineer requested the main contractor to refine and revert the coordination drawings to the client-consultant team.

The main contractor's MEP services coordinator returned a set of latest coordination drawings to the consultant team (i.e. Architect, structural engineer and MEP services engineer) three (3) days' later. Meanwhile, the architect informed that the client had appointed a landscape designer for this project. Therefore a copy of the latest coordination drawings was forwarded to the newly appointed landscape designer too.

After one (1) week, the architect responded the most recent coordination drawings via email and several comments were pointed to the main contractor, as described below:

- To revise sanitary manholes' position away from planting area.
- To get the landscape designer confirmation on the position of manhole & sump.
- Hardscape's MEP services to refer Landscape Designer requirements.
- To provide MEP services routes to the guardhouse.
- Gully trap to relocate onto side apron.

All these points were the new requests of the architect upon the latest coordination drawings submitted one (1) week ago, thus, the main contractor's project manager arranged a discussion between MEP services coordinator and nominated subcontractor to resolve the comments. At the meantime, the main contractor continues with the concrete work, which was approaching to second (2^{nd}) floor slab without officially endorsed coordination drawing.

Ten (10) days later, the architect wrote to main contractor requesting for the revised coordination drawings. The main contractor's MEP services coordinator responded that the comments incorporated in the ground floor coordination drawing, but nevertheless they still in the midst of preparing the coordination drawings for first (1^{st}) floor until third (3^{rd}) floor slab.

Two (2) months after the comments highlighted by the architect, the main contractor reverts the revised coordination drawings of the ground floor until third (3^{rd}) floor to client and consultants (such as architect, structural engineer, MEP services engineer, landscape designer and costing consultant.) for review and approval. At this time, the concrete work is approaching to third (3^{rd}) floor slab without official endorsed third (3^{rd}) floor coordination drawings, and the concrete work to the fourth (4^{th}) floor slab is around in a week.

One (1) week later, the third (3^{rd}) coordination meeting was arranged in the presence of client's project manager, client's consultants (i.e. Architect, Structural Engineer, MEP services engineer, landscape designer and costing consultant) and main contractor's project team (i.e. Project Manager and MEP services coordinator).

The conclusion of the meeting as outlined below:

- Landscape designer to revise the seventh (7th) floor landscape design drawing and distribute to all parties in three (3) days.
- Structural engineer to alter the seventh (7th) floor structure layout plan upon receiving the landscape design drawing.
- Structural engineer to issue the seventh (7th) floor structure layout plan within ten (10) days and structural details drawings to the main contractor in two (2) weeks.

After three (3) days, the main contractor again reverted the revised coordination drawings for ground floor until third (3rd) floor and continued submitting the coordination drawings for fourth (4th) until sixth (6th) floor, whereas the concrete work is approaching fifth (5th) floor slab in two (2) weeks.

Finally, the client's consultant team endorsed the coordination drawings (i.e. Ground floor until fifth (5th) floor) around one (1) month after submitted by the main contractor. The sixth (6th) floor coordination drawing is still under review status by the client's MEP services engineer. At the same time, the main contractor's project manager called the client's structural engineer and requesting for seventh (7th) floor structural layout plan together with structural details drawings that should be ready by the date fixed in the previous coordination meeting. Nevertheless, the structural engineer responded that the drawings are not available yet and promised it would be done within two (2) weeks.

In two (2) weeks, the concrete work is approaching to the sixth (6^{th}) floor slab, but the coordination drawing for this area still maintains the status quo. The main contractor's project manager and MEP services coordinator requested the structural engineer to provide the seventh (7^{th}) floor structural layout plan and details drawings during the project site meeting. Therefore, the client's structural engineer promised that they would forward such drawings within a week.

Lastly, the client's structural engineer forwarded the seventh (7^{th}) floor structural layout plan and details drawings to the main contractor. The main contractor's MEP services coordinator incorporated all the building services into the seventh (7^{th}) floor drawings to discover whatever issues, collisions, and also carry out the clash detection.

After one (1) month, the complete coordination drawings for seventh (7^{th}) floor until thirty-fifth (35^{th}) floor was sent to client's consultant team for review and endorsement. Subsequently, the main contractor's project manager and MEP services coordinator inquired the client's consultant team concerning the status of the rest of the coordination drawings during the following site meeting. The consultant team was verbal responded with one voice that they have no further comment on the remainder of the coordination drawings, yet they would return the endorsed coordination drawings early possible.

Four (4) days later, the concrete work is approaching to seventh (7^{th}) floor slab before receiving the endorsed seventh (7^{th}) floor coordination drawing from the client's consultant team. After that, the main contractor continued the concrete work based on the coordination drawings, which approved verbally by the consultant team during the previous site meeting.

4.3.3 Incident 3: Design and Approval of the Changes on Sample Submitted by Nominated Subcontractor

The procurement strategy of the project used by the client is a traditional method of general building works done by the main contractor, and services and all other the works (i.e. Air conditioning and mechanical ventilation (ACMV), electrical, fire protection system, plumbing, swimming pool including water feature) by the nominated subcontractor.

When the project began, all services and other works were awarded except the swimming pool and water feature. The tendering process took two (2) months after the project began, to appoint the ‘nominated subcontractor’ for the aforesaid works. Indeed the ‘nominated subcontractor’ entered into a direct contract with the client, but the main contractor needs to coordinate with him.

Five (5) days after, the main contractor’s MEP services coordinator sent an email to the swimming pool’s nominated subcontractor requesting for details of swimming pool’s light. The MEP services coordinator forwarded the material as mentioned earlier to the client’s consultant team (i.e. Architect, structural engineer, MEP services engineer and landscape designer) for review and approval thereafter.

On the fourth (4th) month, the swimming pool's nominated subcontractor requested the construction drawing in Computer Aided Design (CAD) format for developing shop drawing via telephone call with the main contractor's project manager. After being informed, the main contractor's project manager wrote a Request For Information (RFI) to the architect for such drawing.

Two (2) days later, the architect responded to the RFI and attached the CAD drawing as requested. Hence, the main contractor's project manager then forwarded the CAD drawing to the nominated subcontractor directly. In three (3) days, the swimming pool's nominated subcontractor handed a set of shop drawings and included the swimming pool light's samples to the main contractor's project manager. These documents are for client's consultant team to review and to verify that they comply with design drawings and specification. But nevertheless, the main contractor's project manager and MEP services coordinator found the material samples that the nominated subcontractor supplied would not suitable for the swimming pool structure design, for instance, the thickness of proposal (swimming pool's light) is 225mm whereby exceeding the swimming pool's wall thickness in 200mm.

The main contractor's project manager raised the issue relating to the proposed underwater light is inappropriate during the site meeting held a day later. Conversely, the architect verbal accepted this proposed underwater lights due to functional and aesthetical purposes. In the meantime, the architect requested the structural engineer to revise their swimming pool structural design to embed the 225mm underwater lights.

After one (1) week, the client's structural engineer wrote an email to the client's MEP services engineer and main contractor's project manager requesting for the approved swimming pool's light details and also the swimming pool shop drawings. Hence, the main contractor's project manager instructed his MEP services coordinator to forward the documents above to the client's structural engineer by the next day.

The client's structural engineer wrote an email to re-iterate the client's MEP services engineer to provide the swimming pool's light details and overflow drain's design drawings in soonest possible. The client's MEP services engineer forwarded the swimming pool's light details and overflow drain design drawings by the next two (2) days. After receiving the aforesaid document, the client's structural engineer responded to all parties via email, as below:

- Swimming pool shop drawing not tally with the landscape drawing.
- To revert smaller-sized underwater light to suit the original swimming pool structure design.
- No provision of overflow drain for swimming pool in the original design drawing.

The next day, the client' project manager invited all consultants to attend a discussion to resolve the disputes and to ensure that the swimming pool's designs to be properly coordinated. The architect, structural engineer, and costing consultant attended this discussion, whereas the MEP services engineer and landscape designer did not turn out. Therefore, the client's project manager wrote to the latter two professionals and requested them to propose a solution within three (3) days.

After a long silence, the architect orally instructed the main contractor to revert smaller-sized underwater light due to no solution has been proposed by the MEP services engineer and landscape designer. The main contractor followed the instruction accordingly to instruct the swimming pool's nominated subcontractor to revert a smaller-sized underwater light, where applicable to the present swimming pool structure.

One (1) week later, after receiving the new and smaller-sized underwater light proposal, the main contractor's project manager forwarded it to the client's consultant team forthwith. The main contractor's executive director wrote a formal letter to the architect informing that they have ceased the swimming pool's carpentry work due to the overflow drain and underwater light still not yet resolved. The ceasing in swimming pool's carpentry work delayed the project progression and the subsequent trade works, for instance, carpentry, steel reinforcement work, and concrete work.

The architect approved the new proposed underwater light immediately, besides that he instructed the structural engineer to incorporate the overflow drain into the swimming pool as well. In four (4) days, the structural engineer issued revised working drawings incorporated with a swimming pool's overflow drain to the main contractor for construction.

After receiving the latest structural working drawings, the main contractor resumed the carpentry work at swimming pool area thereafter, and the subsequent trade works were continuing as usual.

4.3.4 Incident 4: Procurement and Communication between the Onsite and Offsite Project Team

Shortly after the project begins, the main contractor's project manager places the order of a new portable office cabin via Material-Requisition-Form (MRF) according to the company procedure. The main contractor's project manager attached a sketch of the portable office cabin with the detailed information (i.e. Cabin dimensions, specifications and needed furniture) in the MRF. After that, the MRF was sent to the main contractor's purchasing manager in headquarters to proceed with the purchase.

Three (3) days later, two (2) units of badly-damaged office cabins were delivered to the project site in which not the new cabins as requested by the project manager.

The contract document stated, 'contractor shall provide new and sufficient numbers of insulated portable site office for consultants' site staff comprising one room for a resident engineer, one room for two persons of clerk-of-works (COW) and a meeting room for minimum 20 persons. The architect shall approve the size of each, and must be air-conditioned and furnished".

The project manager called forthwith to the purchasing manager to find out why the delivered cabins are not the new cabins as per requested in the MRF. Unexpectedly, the purchasing manager answered this is an instruction from the project director to reuse and refurbish the old office cabins because of budget cuts.

Therefore, the project manager started to restore these office cabins and one (1) week spent to make repairs upon these old office cabins.

Ten (10) days later, the client's general manager found that the delivered site office cabins were different with the specifications in the contract document, for instances, it should be new office cabins and air-conditioned and furnished. He felt unhappy and hence verbally informed the main contractor's project manager that he rejects all these office cabins. Meanwhile, the client's general manager reminded the latter that to provide all office cabins according to the contract specifications. The main contractor's project manager responded that he would check with project director about this.

The next day, the main contractor's project manager then called to his project director to clarify. However, the project director denied that he had instructed the purchasing manager to deliver the old office cabins to the project site. The project director was then called the purchasing manager and told to order new office cabins according to the contract specification to the project site.

Two (2) weeks later, two (2) units of new office cabin were delivered to the project site. The main contractor's project manager apologised to the client's general manager that they would follow what contract document has specified, and they will not overlook such issues again in future. Unfortunately, there was no response from the client's general manager to the main contractor's project manager.

The main contractor's project director gave an order to purchasing department that all materials and supplies to this project site must be following contract specifications. Consequently, the project manager arranged to transport the old cabins back to store due to the constraint of project site's space.

The main contractor had spent at great expense on transportation and refurbishment upon the badly-damaged office cabins as below for reference.

- Transportation fees – RM 800.00
- Refurbishment cost – RM 1,050.00
- Duration of refurbishment – One (1) week
- Number of worker – Three (3) persons

4.3.5 Incident 5: Procurement Processes of the Main Contractor's Organisation.

After five (5) months of the project begins, the main contractor's project manager sent the latest construction drawings (i.e. Structural drawings, architectural drawings, electrical drawings and mechanical drawings), and a work program attached to the domestic subcontractor, who specialized in aluminum system formwork for preparing shop drawings by the latter.

In accordance with the contract document stated, "Contractor shall give a reasonable time to the architect for requirements with regards to instruction, detailed drawings, etc. and in the absence of advance written notification to the contrary it will be assumed that the progress of the works is not affected by want of such information."

Two (2) weeks later, the domestic subcontractor supplied a set of shop drawings for aluminium system formwork to the main contractor's headquarters. Increasingly, the domestic subcontractor forwarded the digital shop drawings (CAD) to the main contractor's project manager for checking and electronic handling purpose. At the meantime, the main contractor's senior contract manager officially sent these drawings to the client's consultants (i.e. Structural engineer, architect and, MEP services engineer) for review and approval.

The client's structural engineer called the main contractor's project manager a couple of days later and informed that they have no time to check the shop drawings. Besides, the structural engineer responded that it is contractor's duty to check and verify the shop drawings. The main contractor's project manager did not put in written record or raise doubts about this point yet considered that it is main contractor's duty to verify those shop drawings.

The main contractor's project manager awaited the response from client's consultants for three (3) weeks after he sent the shop drawings to the latter.

However, there were no responses from either the architect or engineers concerning the shop drawings during that period. Therefore, the main contractor's project manager presumed the shop drawings to be corrected and requested the domestic subcontractor to print out eight (8) copies of shop drawings and instructed the domestic subcontractor to start fabricating the aluminium formwork for construction purpose. The main contractor's project manager took this action without written a note to inform neither the client nor consultants.

Just when it seemed progression was going well, the architect responded via e-mail with a list of comments about the shop drawings as outlined below:

- No kink at soffit of entrance slab for every unit (as per attached layout). Structural engineer to amend, this issue was highlighted in the design review meeting.
- Entrance drop not tally with architectural drawing.
- Discrepancies in shop drawings. The dimension of the master bedroom in shop drawing not tally with architectural drawing (i.e. shall be19.61m^2 instead of 19.94m^2). Structural engineer to check and make sure the shear walls' positions as per architectural drawing.

The main contractor's project manager noticed that these discrepancies were due to the structural engineer disremembered to incorporate into his structural drawings. Immediately, the main contractor's project manager called the domestic subcontractor to stop printing the shop drawings, but as told by the domestic subcontractor that they had completed printing of the shop drawings.

The client's structural engineer revised the structural drawings in two (2) days and forwarded to the main contractor's project manager forthwith. The main contractor's project manager sent the structural drawings to the domestic subcontractor to amend the shop drawings.

In two (2) days, the domestic subcontractor reverted the revised digital shop drawings via email to the main contractor's project manager for second times submission. The architect discovered three (3) discrepancies in the shop drawings as below:

- AC ledge and balcony slab shall be the same level (as per attached layout). Structural engineer to take note and this information is shown in details drawings.
- Unit (Type A), yard – Height of windows do not tally with architectural drawing (refer to elevation plan). Structural engineer has to take note and amend it accordingly.
- Window (W12) is missing at lift lobby (Refer to architectural details drawing).

The main contractor's project manager swiftly highlighted the discrepancies in the 2nd submission shop drawings and brought to the attention of the client's structural engineer to quickly do correction in his latest structural drawings. The structural engineer forwarded the revised structural drawings to the main contractor's project manager a couple of days.

The client's project manager was in the loop of email and received a notice from the main contractor's project manager of the structural drawings were fraught with many discrepancies and the potential impacts of delayed approval by his consultants. Consequently, the client's project manager instructed the structural engineer to expedite and provide whatever needed information to the main contractor to avoid further delays in the shop drawings delivery process and approval.

All consultants finally approved the shop drawings after three (3) and half months of submittal turn-around between the client's consultants (i.e. Architect and structural engineer), main contractor, and domestic subcontractor. Hence, the aluminium formwork fabrication works were proceeding smoothly, and the whole process of submittal turnaround took about fourteen (14) weeks to complete, and, contrariwise, it would be one (1) month ahead if there were no discrepancies between the architectural and structural drawings.

CHAPTER FIVE

ANALYSIS AND DISCUSSION

5.1 Introduction

The five (5) incidents reported in the previous chapter contained four (4) core interfaces cover time interfaces, geographical interfaces, technical and contractual interfaces, and organisational interfaces. Besides, the complexity of incidents can be grouped into three (3) broad categories, known as human behavior, system behavior, and ambiguity.

This chapter will analyse and discuss the type of interfaces involved and elements of the complexity of the incidents in which according to the following steps.

1. Identify the existing interfaces and distinguish the categories of complexity.
2. Explore what has been the root cause of the problem.
3. Find out the basic knowledge of navigating the avoidable mistakes.

5.2 Data Analysis

The first incident is about the communication issues with the newly appointed project manager for a new project. The type of interfaces and categories of complexity is presented in Table 5.1.

Table 5.1 Types of interfaces and categories of complexity in incident 1

Item	**Incident 1**	**Type of interface involved**	**Categories of Complexity**								
			Human Behavior			**System Behavior**			**Ambiguity**		
			H1	**H2**	**H3**	**H4**	**S1**	**S2**	**S3**	**A1**	**A2**
1-1	Main contractor's managing director (MD) verbal agreed to client's general manager (CGM) in which stationary concrete pump would be used for the entire concrete work; however, no provision of the stationary concrete pump is stated in the letter of award.	Technical and contractual interfaces; Organizational interfaces	O	O		O	O			O	
1-2	Main contractor's top management did not inform project manager (PM) about the matter of stationary concrete pump to be used for the project during kick-off meeting.	Technical and contractual interfaces	O	O	O	O	O				
1-3	During constructing stage, CGM verbal instructed PM to cease the concrete work due to main contractor did not execute the commitment.	Technical and contractual interfaces; Organizational interfaces		O		O					O
1-4	PM pleads with the CGM that not one person transmit this information to him from day one.	Organizational interfaces		O			O			O	

1-5	PM questioned his Senior Contract Manager (SCM) about what was agreed earlier. SCM asked PM to clarify with Executive Director (ED).	Geographical interfaces; Organizational interfaces		○			○			○	
1-6	ED responded PM that they had verbal agreed with the CGM, a stationary concrete pump would be used for the entire concrete work.	Geographical interfaces; Organizational interfaces		○							
1-7	ED called CGM by confirming the stationary concrete pump is already rented and also committed its delivery date.	Geographical interfaces; Organizational interfaces	○					○			
1-8	CGM permitted to resume concrete work after PM provide the needed documents.	Organizational interfaces									○

Based on incident 1, ‘organisational interfaces’ involved the most and followed by ‘geographical interfaces’ and ‘technical and contractual interfaces’.

The key issues involved ‘organisational interfaces’ were item 1.1 until 1.8, except item 1.2. Whilst, item 1.1 and 1.7 existed between client and main contractor’s top management to negotiate contract details to reach a mutual agreement in a tender interview before signing the contract, and also confirm the implementation of the stationary concrete pump. Likewise, item 1.3, 1.4 and 1.8 involved communications between client’s general manager and main contractor’s project manager concerning the nonfulfillment of a requirement by the latter in which subsequently caused a work stoppage during the construction phase. Moreover, item 1.5 related to the main contractor’s senior contract manager pushed the responsibility to executive director when questioned by the project manager. Item 1.6 depicted the executive director admitted to the project manager that they had indeed agreed with the client that stationary concrete pump would be used for the entire concrete work during the tender interview.

‘Geographical interfaces’ arises where a project team was carried out work on the construction site which is remote to the head office operations (item 1.5 and 1.6), and main contractor’s executive director had obtained permission to resume the concrete work from client’s general manager via telecommunication resulted in item 1.7.

Item 1.2 is related to main contractor’s top management did not clearly transmit critical information to their project manager. Meanwhile, item 1.1, 1.2 and

1.3 are also related to ‘technical and contractual interfaces’, where simply knowledge transfer resulted poorly understood of project manager about the project scope and customer requirements. For instances, item 1.1 and 1.3 were between different organisations which the client and main contractor where the client had not followed proper procedure and merely forced the main contractor to cease the concrete work abruptly due to the latter did not keep his word to use the stationary concrete pump for concreting work.

In addition, Table 5.1 analyses the categories of complexity encountered in Incident 1. Most of them are related to the ‘human behavior’, followed by in ‘system behavior’ and ‘ambiguity’. Among the sub-categories of ‘human behavior’ issues, the majority of them were caused by ‘group, organisational and political behavior’. Among the ‘system behavior’, most of them resulted by connectedness, and the ‘ambiguity’, which due to ‘uncertainty’.

The second incident depicts the submission process of mechanical, electrical and plumbing (MEP) services coordination drawings between client’s consultants, main contractor, and nominated subcontractor. Henceforth, the types of interfaces and complexity involved in Incident 2 as tabulated in Table 5.2 below.

Table 5.2 Types of interfaces and categories of complexity in incident 2

Item	Incident 2	Type of interface involved	Categories of Complexity								
			Human Behavior			System Behavior			Ambiguity		
			H1	H2	H3	H4	S1	S2	S3	A1	A2
2-1	Senior Contract Manager (SCM) sent an email to client's consultants requesting for digital working drawings; Once received the aforesaid drawings, he forwarded to his Project Manager (PM) who stationed project site.	Geographical interfaces; Organizational interfaces			○						
2-2	Main contractor's PM requested his Project Director (PD) to assign a MEP Services Coordinator for building services coordination.	Organizational interfaces		○				○			
2-3	Main contractor's PM passed the digital working drawings supplied by consultants to his newly employed MEP Services Coordinator (MEC) for preparing coordination drawing.	Time interfaces; Organizational interfaces						○			
2-4	Client's Clerk-Of-Work (COW) pointed out twelve (12) discrepancies in the coordination drawings due to superseded MEP drawings were used by the main contractor's MEC for producing the drawings above.	Technical and contractual interfaces; Organizational interfaces	○			○		○		○	

2-5	Main contractor's PM sent an email to client's MEP Services Engineer (MEE) for latest working drawings. Meanwhile, he insisted on proceeding concrete work without the aforesaid drawings.	Geographical interfaces; Organizational interfaces	○						○	○	○
2-6	Client ceased the entire concrete work by issuing an NCR to the main contractor who made errors like used superseded drawings in consequence of missing M&E services on the completed 1st-floor slab.	Technical and contractual interfaces; Organizational interfaces		○		○			○		
2-7	Main contractor's PM appealed to client's PM for resuming the concrete work after they reverted the coordination drawing to MEE for review and approval.	Organizational interfaces						○		○	
2-8	Client's PM permitted MC to resume the concrete work after received confirmation from his consultant, MEE.	Technical and contractual interfaces; Organizational interfaces		○	○		○				
2-9	After three months, somewhat 12 coordination meetings were carried out, but the project team does not fully finalise the coordination drawing.	Technical and contractual interfaces;	○	○		○	○				○

The results reported in Table 5.2 show that most of the interfaces involved are ‘organisational interfaces’ and ‘technical and contractual interfaces’, and it follows by ‘geographical interfaces’ and ‘time interfaces’.

‘Organisational interfaces’ (the most frequently occurred) existed in almost all the elements in the Incident 2, except item 2.9. As a whole, the ‘organisational interfaces’ existed in item 2.1, 2.2, and 2.3 among the main contractor consisted of the project director, senior contract manager, project manager, and MEP services coordinator where they were working together on producing the coordination drawings for construction purposes. On the contrary, the ‘organisational interfaces’ existed on item 2.1 as well as items 2.4 to 2.8 were between three parties such as client, consultants, and main contractor. For instance, the main contractor’s senior contract manager sent an email to every consultant to request for documentation of the project (item 2.1). Likewise, the client’s clerk-of-work pointed out the discrepancies found in the coordination drawings where superseded drawings were used by the main contractor on producing such coordination drawing (item 2.4).

Therefore, main contractor’s project manager sent an email to client’s MEP services engineer requesting for latest working drawings (item 2.5). The client ordered a work stoppage to the main contractor via non-conformance report (item 2.6), and the main contractor’s project manager appealed to client’s project manager for resuming the concrete work after they reverted all of the requested documentation (item 2.7). Subsequently, client’s project manager revoked the work stoppage and gave permission to the main contractor for resuming the concrete work (item 2.8).

Table 5.2 reveals that ‘technical and contractual interfaces’ as most frequently occurred after the ‘organisational interfaces’. For example, item 2.4 where the client’s clerk-of-work discovered the discrepancies resulted from technical foul-ups, therefore, delayed the preparation of coordination drawings. Item 2.6 depicts client ordered work stoppage to the main contractor under the proper procedure, such as a non-conformance report (NCR) issued by client representative and item 2.8 derives from client revoked the work stoppage through verbal instruction after he is satisfied with the explanation. Also, item 2.9 is about coordination drawings were not finalised for three consecutive months due to technical foul-ups.

‘Geographical interfaces’ existed in items 2.1 and 2.5, where main contractor’s senior contract manager at head office forwarded the latest working drawings to project manager who at the construction site. Another example is the main contractor’s project team requested documentation from client’s consultant who stationed offsite through an email (items 2.5).

There are a matter related to ‘time interfaces’ where the project manager delivered the digital working drawings to his MEP services engineer and a completion of documentation transaction (item 2.3).

Also, Table 5.2 analyses the categories of complexity encountered in Incident 2. As a whole, most of them are related to the ‘human behavior’, followed by ‘system behavior’ and ‘ambiguity’. Among the sub-categories of ‘human behavior’, majority were caused by ‘group, organisational and political behavior’, followed by the ‘system behavior’ which caused by ‘dependency’, and most of the ‘emergence’ fall under ‘ambiguity.'

The third incident is narrated about the disagreement occurrence between consultants, main contractor and nominated subcontractor at the outset of the swimming pool construction. Thus, the sequence of events and types of interfaces involved in Incident 3 as tabulated in Table 5.3 below.

Table 5.3 Types of interfaces and categories of complexity in incident 3

Item	**Incident 3**	**Type of interface involved**	**Categories of Complexity**								
			Human Behavior			**System Behavior**			**Ambiguity**		
			H1	**H2**	**H3**	**H4**	**S1**	**S2**	**S3**	**A1**	**A2**
3-1	Main contractor realised that the swimming pool's samples submitted by Nominated Subcontractor (NSC) would not be suitable for the swimming pool structure construction.	Technical and contractual interfaces						○		○	
3-2	Architect (AR) approved the inappropriate swimming pool's light due to aesthetical purpose, yet instructed the Structural Engineer (SE) to redesign the swimming pool's structural members to suit the swimming pool's light.	Technical and contractual interfaces; Organizational interfaces	○								
3-3	SE sent an email to all parties that to maintain original structure design and requested main contractor's MEP Services Coordinator (MEC) to revert smaller-sized underwater light, never highlight the discrepancy between overflow drain and working drawing.	Geographical interfaces; Organizational interfaces	○						○	○	
3-4	Client's Project Manager (PM) arranged a discussion among all the consultant, but Landscape Designer (LD) and MEP Services Engineer (MEE) did not turn out.	Organizational interfaces			○	○	○	○			

3-5	AR verbally instructed main contractor to propose smaller-sized underwater light after a long silence and no solution from the consultant team.	Technical and contractual interfaces; Organizational interfaces		○					○	○	
3-6	Main contractor's Executive Director (ED) wrote a notice to AR regarding the unresolved swimming pool issue which disrupted the work progression.	Technical and contractual interfaces; Organizational interfaces									○
3-7	Client's SE issued revised structural drawing which incorporated with overflow drain at swimming pool after instructed by AR.	Organizational interfaces						○		○	

In the results that above, the most frequently occurring is ‘organisational interfaces’ and followed by ‘technical and contractual interfaces’, whilst the ‘geographical interfaces’ appeared only once in item 3.3, like client’s structural engineer dealing with MEP services coordinator who works in a remote construction site.

As a whole, all events except item 3.1 were related to ‘organisational interfaces’. For examples, the architect instructed structural engineer to revert a new swimming pool’s structural components (item 3.2) and main contractor to revert a new underwater light to incorporate into the original swimming pool’s structure design (item 3.5). The item 3.3 depicts the structural engineer instructed all parties via an email that no design change, yet requested main contractor to repropose a new material to integrate with the original design. For item 3.4 where client’s project manager presided a meeting interacting with all consultants to diminish the discrepancy, however, main contractor wrote a notice as an inkling to architect about the unsolved issue that caused damages to main contractor (item 3.6). The structural engineer has then incorporated all necessities in the revised drawing after instructed by the architect (item 3.7).

‘Technical and contractual interfaces’ appeared in item 3.1, 3.2, 3.5, and 3.6. For example, the architect and structural engineer that operated independently producing incomplete and unclear details in the working drawing consequent design not only change but also material change. All these items lead to serious inefficiency to the main contractor who is struggling in construction works disruption.

Table 5.3 analyses the categories of complexity encountered in Incident 3. Most of them are related to the ‘system behavior’, followed by ‘human behavior’ and ‘ambiguity’. Among the sub-categories of ‘human behavior’, the majority of them were caused by ‘individual behavior’ and ‘group, organizational and political behavior’, followed by the ‘system behavior’ which caused by ‘dependency’ and ‘system dynamics’, and most of the ‘uncertainty’, the highest scores which fall under ‘ambiguity.'

The fourth incident here is the interactions between onsite and offsite divisions throughout the procurement process. Table 5.4 below describes the points of contacts between the remote project team and headquarters management team, and also the complexity existing in this event.

Table 5.4 Types of interfaces and categories of complexity in incident 4

Item	Incident 4	Type of interface involved	Categories of Complexity								
			Human Behavior			System Behavior			Ambiguity		
			H1	H2	H3	H4	S1	S2	S3	A1	A2
4-1	Project Manager (PM) placed the order of a new portable office via MRF with detailed information to Purchasing Manager (PrM).	Geographical interfaces; Organizational interfaces						o			
4-2	PM called PrM for clarification about why they delivered the cabins are totally different with what had written in the MRF.	Geographical interfaces; Organizational interfaces	o			o					o
4-3	PrM responded that is Project Director's instruction to reuse and refurbish the old cabins due to budget cuts. Hence, the PM started to restore the old office cabins and took seven days for such remedial work.	Organizational interfaces		o		o	o			o	
4-4	Client's General Manager (GM) found the office cabins are different with contract specification, hence verbally rejected all the old office cabins and instructed main contractor's PM to provide new cabins as per contract specification.	Technical and contractual interfaces; Organizational interfaces					o			o	

4-5	Main contractor's PM then called and clarified with his PD, but PD denied and instructed the PrM to order new office cabins as per specification.	Geographical interfaces; Organizational interfaces				○			○		○
4-6	Main contractor's PM apologised to the client's GM, but the latter kept silent.	Organizational interfaces								○	
4-7	Main contractor's PD gave the order to PrM that all material purchased for the site must be of the contract specification. Therefore, the old office cabins were transported back to store with great expenses.	Technical and contractual interfaces; Organizational interfaces								○	

In the results that above, the ‘organisational interface’ is most frequently occurred and followed by ‘technical and contractual interface’ and ‘geographical interface’.

‘Organisational interface’ is implicated in all events where the points of contact at which project manager used a detailed material requisition form (MRF) to transport information to purchasing manager (item 4.1); project manager called purchasing manager to clarify the dissimilar of the delivered office cabins, whereas the latter shifted the responsibility to others (item 4.2 and 4.3); client’s general manager verbal rejected the old office cabins due to contrast with contract specification and instructed main contractor’s project manager to change (item 4.4); the project manager, thus, called directly to his project director to clarify the truth of the information that given by the purchasing manager, but the project director denied and shortly afterwards he gave order that all material purchased for the project site must be in accordance with the contract specification (item 4.5 and 4.6); The project manager attempted to apologise to the client’s general manager, but no response from the latter (item 4.7).

‘Technical and contractual interfaces’ existed during the onset of the project, for example, client’s general manager found the office cabins provided by the main contractor did not comply with the contract specification (item 4.4) and he then verbally rejected such office cabins and instructed main contractor’s project manager to provide a new office cabins (item 4.5). Whereafter, the main contractor’s project director gave order that all material purchased for the project must comply with contract specification (item 4.7). All these matters involved with ‘technical and contractual interface’ in incident 4.

‘Geographical interface’ is the points of contacts between onsite and offsite project team where information exchange, for instances, project manager sent material requisition form (MRF) to headquarters for procurement purposes (item 4.1) and also the project manager called purchasing manager and project director who stationed at headquarters about the material delivery incident (item 4.2 and 4.5). Finally, all these resumed office cabins were transported back to store from project site due to space constraint, and the entire activities entailed great expense of not only money but time upon the main contractor.

Table 5.4 analyses the categories of complexity encountered in Incident 4. Most of them are related to the ‘ambiguity’, followed by ‘human behavior’ and ‘system behavior’. Among the sub-categories of ‘ambiguity’, the majority of them were caused by ‘uncertainty’, and followed by the ‘human behavior’ which caused by ‘communication and control’, and most of the ‘connectedness’ fall under the ‘system behavior’.

Lastly, the fifth incident depicts the shop drawings supplied by the main contractor were passing around among the consultants, main contractor and subcontractor. The interfaces and element of complexity are tabulated in Table 5.5 below.

Table 5.5 Types of interfaces and categories of complexity in incident 5

Item	**Incident 5**	**Type of interface involved**	**Categories of Complexity**								
			Human Behavior			**System Behavior**			**Ambiguity**		
			H1	**H2**	**H3**	**H4**	**S1**	**S2**	**S3**	**A1**	**A2**
5-1	Main contractor's Project Manager (PM) sent the latest working drawings and work program via email to Domestic subcontractor (DSC) for shop drawing preparation.	Geographical interfaces; Organizational interfaces					○				
5-2	DSC provided the shop drawings, and main contractor's Senior Contract Manager (SCM) submit formally to all client's consultants for review and approval.	Geographical interfaces; Organizational interfaces					○		○		
5-3	Client's Structural Engineer (SE) told main contractor's PM that it is contractor's duty to check the shop drawings. Therefore the latter carried out checking without inquiring others advice.	Organizational interfaces	○		○	○				○	
5-4	Main contractor's PM presumed the shop drawings to be corrected without confirmation by client's consultant team and requested DSC to print out the shop drawings for fabrication and construction purpose.	Time interfaces; Technical and contractual interfaces	○				○				

5-5	A list of comments from the Architect (AR) sent to the main contractor in which mistakes on the shop drawings caused by client's Structural Engineer (SE) disremembered to incorporate into his structural drawing after the design review meeting.	Geographical interfaces; Technical and contractual interfaces; Organizational interfaces				○		○		○	
5-6	Main Contractor reverted a set of latest shop drawing to AR after receiving from DSC. AR again commented the most recent shop drawings via email caused by lack of information from structural drawings.	Geographical interfaces; Technical and contractual interfaces; Organizational interfaces				○		○		○	
5-7	Main contractor's PM brought to the attention of the client's SE to quickly do correction in his latest structural drawings to minimise delay in submittals delivery progression.	Organizational interfaces	○		○				○		○
5-8	Client's PM instructed SE to expedite revising discrepancies after receiving a notice of delay from the main contractor.	Technical and contractual interfaces; Organizational interfaces			○	○					

‘Organisational interfaces’ is the most frequently occurred, and followed by ‘geographical interfaces’, ‘technical and contractual interfaces’, and ‘time interfaces’.

The matters that existed with ‘organisational interfaces’ were the interactions between the main contractor (project manager and senior contract manager) and subcontractor on preparing submittals (i.e. shop drawings) for construction purposes (item 5.1 and 5.2). While main contractor forwarded a set of latest shop drawings supplied by a subcontractor to all consultants for review and approval; the structural engineer said it is main contractor’s duty to carry out design checking, and the main contractor’s project manager was accustomed to performing the design verification. Conversely, substantial comments rose up by the architect on the aforesaid shop drawings (item 5.3 and 5.5). After that, the main contractor reverted the revised shop drawings based on architect’s comments, but architect again provided comments on such shop drawings as lack of information (item 5.6). The main contractor’s project manager brought to the attention of the client’s structural engineer to expedite the revision of his structural drawings, meanwhile client’s project manager also instructed the structural engineer to do so after receiving notice of delay from the main contractor (item 5.7 and 5.8). All these blips are related to the submittals passing up and down through the project participants, such as client’s consultants, main contractor and subcontractor.

The existence of ‘geographical interfaces’ while critical information exchange between client, consultants, main contractor, and subcontractor. For instances, the main contractor sent the working drawings and work program via email to his subcontractor for preparing shop drawings during the onset of the project (item 5.1). Subsequently, the main contractor officially submitted the shop drawings supplied by a subcontractor to every consultant for review and approval (item 5.2). However, substantial comments from the architect upon the shop drawings, wherefore the main contractor has reverted a set of revised shop drawings to the architect after receiving from his subcontractor (item 5.5 and 5.6).

‘Technical and contractual interfaces’ were appeared in item 5.4, 5.5 and 5.6. For example, main contractor’s project manager presumed the shop drawings to be corrected without confirmation of anyone else and requested his subcontractor to print out the shop drawings for fabrication and construction purposes (item 5.4). Whilst, item 5.5 and 5.6 depict the architect commented the shop drawings twice, once the technical aspects and then the insufficient information in such drawings. Besides that, the main contractor wrote a notice of delay to the client where the inefficiency of documentation processing caused disruption to construction work.

‘Time interfaces’ appeared in item 5.4 where the transition of work phasing such as design stage to the construction stage. Further in detail, the project manager permitted his subcontractor to proceed printing out the shop drawings for fabrication and construction purposes.

Furthermore, Table 5.5 analyses the categories of complexity encountered in Incident 5. Most of them are related to the ‘human behavior’, followed by in ‘system behavior’ and ‘ambiguity’. Therefore, the sub-categories of ‘human behavior’, most of them were caused by ‘organisational design and development’ and followed by ‘individual behavior’. Subsequently, among the ‘system behavior’ which resulted by ‘connectedness’, and the ‘ambiguity’, most of them were equally due to ‘uncertainty’.

All of these were defined as the mainstreams of complexity encountered which seems just a blip in each of the incidents, but why are they happening?

Figure 5.1 illustrates the interactions between various parties, such as client (i.e. Onsite and offsite team members.), consultants (i.e. Architect, structural engineer, MEP services engineer, and landscape designer.), main contractor (i.e. Onsite and offsite team members.), and subcontractors (i.e. Domestic subcontractors and nominated subcontractors.).

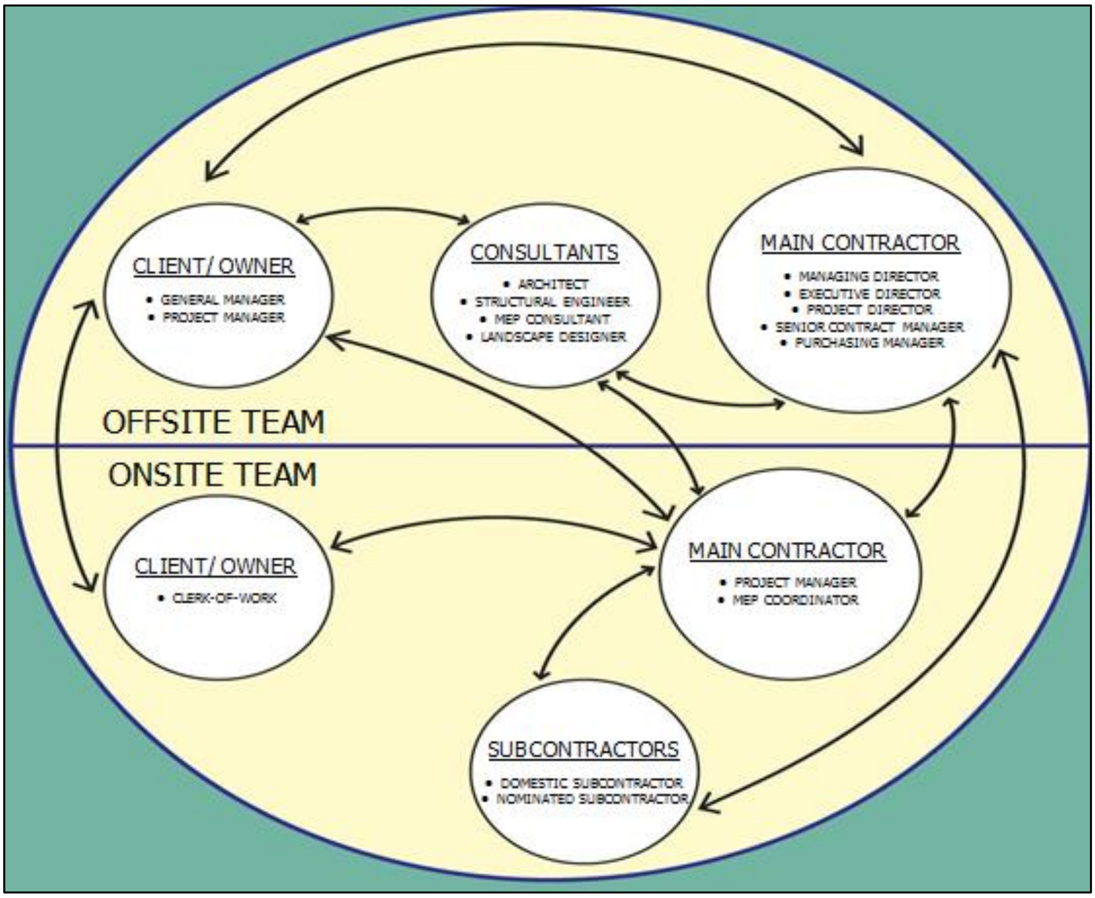


Figure 5.1 Onsite team and offsite team collaboration

When taking a closer look, each group of an organisation having contracts with each other, and the head of department or liaison personnel plays a significant role in handling interfaces (Figure 5.6). Therefore, it would be possible to create a score for each interface between two (2) organisations (agents) and both groups with either based at the project site (onsite) or headquarters (offsite). Likewise, a simple of count provides with information about the extent to which the interface that most frequently occurred between two (2) project participants as shown in Table 5.6 below.

Table 5.6 Interfaces existence between onsite team and offsite team

Item	Description	Time Interfaces	Geographical Interfaces	Technical and Contractual Interfaces	Organisational Interfaces
1	**<u>Offsite Team - Offsite Team</u>**				
	Client <==> Main contractor	0	1	2	3
	Client <==> Consultants	0	0	2	3
	Consultant <==> Main contractor	1	2	1	3
	Consultant <==> Consultants	0	1	1	3
	Main contractor <==> Main contractor	0	1	1	2
	Main contractor <==> subcontractor	0	1	0	1
2	**<u>Onsite Team - Onsite Team</u>**				
	Client <==> Main contractor	0	0	1	2
	Main contractor <==> Main contractor	1	0	0	1
	Main contractor <==> Subcontractor	0	0	1	0

3	<u>**Offsite Team - Onsite Team**</u>				
	Client <==> Main contractor	0	0	2	5
	Consultants <==> Main contractor	1	4	3	7
	Main contractor <==> Main contractor	0	6	0	8
	Main contractor <==> Subcontractor	1	1	1	1
		4	**17**	**15**	**39**

The occurrence of each type of interface was rescaled, and it appears that 'organisational interfaces' scored the highest (39), mostly due to the interactions between offsite teams (client, consultants, and main contractor) and onsite team (main contractor and subcontractor) and interactions among the offsite teams (client, consultants, main contractor and subcontractors). However, being the second is 'geographical interfaces' (17) in which the majority of them due to interactions among onsite teams (client, the main contractor, and subcontractor), 'technical and contractual interfaces' (15) related to the offsite team (client, consultants, main contractor and subcontractor). The 'time interfaces' scored the lowest (4) where the majority of them due to interactions among the onsite teams (client, main contractor, and subcontractor) as well as the interactions among offsite teams (client, consultants, main contractor and subcontractors).

In addition, a simple of count provides with information about the extent of which the elements of complexity that most frequently occurred based on five (5) selected incidents in the construction project as shown Table 5.7 below.

Table 5.7 Complexity in the construction project

Item	**Description**	**Human Behavior**				**System Behavior**			**Ambiguity**	
		H1	**H2**	**H3**	**H4**	**S1**	**S2**	**S3**	**A1**	**A2**
1	Incident 1	3	5	1	3	4	1	0	3	2
2	Incident 2	2	4	2	3	2	4	2	3	2
3	Incident 3	2	1	1	1	1	3	2	3	2
4	Incident 4	1	1	0	3	2	1	1	4	2
5	Incident 5	3	1	2	4	3	2	2	1	3
		11	**12**	**6**	**14**	**12**	**11**	**7**	**14**	**11**

Table 5.7 defines the mainstreams of complexity in each incident and the most frequently occurred complexity outlined as below.

i. Incident 1 & 2 : Group, organizational and political behavior (H2)

ii. Incident 2 & 3 : Dependency (S2)

iii. Incident 3 & 4 : Emergence (A1)

iv. Incident 4 & 5 : Organizational design and development (H4)

v. Incident 1 : Connectedness (S1)

The causes of complexity such as group, organisation and political, dependency, emergence, organisational design and development, and connectedness are significant impacts to the project performance and success as well. Therefore, those organisations that have taken the time and effort to manage the complexity are organisations that are competing in the global marketplace and being excel in project management.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Background

This research provides how interface and complexity issues of the project are being implemented in a typical construction project. This research investigated five (5) incidents that encountered by the construction parties in a construction project to categorise the interfaces and complexities in the project encompassing relationships between project performances.

This chapter explains the achievement of the research aim and objectives. Also, this chapter will highlight the implications of the study, reflects the limitations of the study as well as recommend the future study.

6.2 Achievement of Research Aim and Objectives

The research objectives stated in the introduction chapter are:

i. Explore the existing interfaces and complexity issues of the selected project.

ii. Categories the issues according to the types of interfaces and complexity problems.

iii. Identify the root causes of the problem and recommend measures for improvement.

The existing interfaces and complexity happened under each incident are tabulated as below.

Table 6.1 Existence of interfaces in the construction project

Item	**Description**	**Time Interfaces**	**Geographical Interfaces**	**Technical and Contractual Interfaces**	**Organisational Interfaces**
1	Incident 1	0	3	3	7
2	Incident 2	1	2	4	8
3	Incident 3	0	1	4	6
4	Incident 4	0	3	2	7
5	Incident 5	1	4	4	7
	Total	**2**	**13**	**17**	**35**

In Table 6.1, it appears that "organisational interfaces" is the most frequently occurring interface, which mostly due to the needs of interactions between off-site teams such as client, consultants and main contractor, and onsite teams such as main contractor and subcontractors. The "technical and contractual interfaces" is positioned second highest, which involve interactions mainly between the onsite project team, such as client, main contractor and subcontractor. The "geographical interfaces" and "time interfaces" are least happened, which the former involved between the offsite team (client, consultants, and subcontractor) and onsite team (main contractor and subcontractor). Besides, the time interfaces are involved among onsite teams like the client, the main contractor, and subcontractor.

Three (3) broad categories of complexity are human behavior, system behavior and ambiguity. While, the causes of complexity about human behavior are individual behavior, group, organisational and political behavior, communication and control, and organisational design and development; under system behavior, are connectedness, dependency, and system dynamics; two (2) associated causes contribute to ambiguity are emergence and uncertainty.

Table 6.2 Elements of complexity in the construction project

Item	**Description**	**Human Behavior**				**System Behavior**			**Ambiguity**	
		H1	**H2**	**H3**	**H4**	**S1**	**S2**	**S3**	**A1**	**A2**
1	Incident 1	3	**5**	1	3	4	1	0	3	2
2	Incident 2	2	**4**	2	3	2	**4**	2	3	2
3	Incident 3	2	1	1	1	1	**3**	2	**3**	2
4	Incident 4	1	1	0	**3**	2	1	1	**4**	2
5	Incident 5	3	1	2	**4**	3	2	2	1	3

Table 6.2 shows the elements of complexity that influenced the construction project. The mainstreams of complexity in each incident and the most frequently occurred complexity are outlined as below.

1. Incident 1 & 2 : Group, organizational and political behavior (H2)
2. Incident 2 & 3 : Dependency (S2)
3. Incident 3 & 4 : Emergence (A1)
4. Incident 4 & 5 : Organizational design and development (H4)

The causes of complexity such as group, organisation and political (H2), dependency (S2), emergence (A1) and, organisational design and development (H4) are significant impacts to the project performance and success as well.

The causes that contributed to the complexity associated with the group, organisational and political behavior (H2) occur in incident 1 and 2.

- Incident 1
    - Groupthink. The project manager of the main contractor made riskier decisions and persuaded his team to take greater risks. However, this results in an increase in risk-seeking behavior which could be detrimental to project. (Table 5.1, Item 1.1 in Chapter 5)
    - Self-organization. Main contractor’s top management did not transmit critical information about the spontaneous decision to the project manager. Perhaps, the top management presumes this information is not so important to their project team. Often, a spontaneous decision could be eventually causing to the detriment of the organisation. (Table 5.1, Item 1.2 in Chapter 5)
    - Main contractor's top management did not inform project manager (PM) about the matter of stationary concrete pump to be used for the project during kick-off meeting.
    - Lack of top management commitment. The main contractor’s managing director (MD) promised to the client that stationary concrete pump would be used for the concrete work of the entire contract. Eventually, top management delivered wavering commitment created uncertainty and mutual distrust to both client and project team, in turn, this paradox increases the degree of complexity yet raises potential which drives the project to failure. (Table 5.1, Item 1.4-1.6 in Chapter 5)

- <u>Incident 2</u>
  - Lack of team spirit. It is difficult for the project team to achieve success without explicit commitment and support from top management. For instances, late supplying needed resource likes MEP services coordinator to produce needed document. (Table 5.2, Item 2.2, 2.6, 2.8 & 2.9 in Chapter 5)

Dependency (S2) is a potential cause of complexity, and it occurs when work packages are reliant on other work packages. The following are causes of dependencies that caused complexity to the project.

- <u>Incident 2 & 3</u>
  - Dependency between design information and construction work. The incomplete MEP coordination shop drawings had caused disruption to the entire concrete casting work. A complete MEP coordination shop drawings is an essential prerequisite for clashes detection of the construction design (Table 5.2, Item 2.2-2.4 & 2.7; Table 5.3, Item 3.1, 3.4 & 3.7 in Chapter 5)

Emergence (A1) is the unanticipated change and is associated with ambiguity. Such emergence aroused:

- <u>Incident 3</u>
  - The main contractor highlighted a material sample submitted by subcontractor would not be suitable for the construction work. However, the architect still instructs to proceed with such material

and further instructed structural engineer to change the design to accommodate the use the material. (Table 5.3, Item 3.3 in Chapter 5)

  - The structural engineer disagreed to change his design and insisted the main contractor to propose an alternative material. (Table 5.3, Item 3.5 in Chapter 5)
  - In the end, the structural engineer issued revised drawings. These new drawings causing changes of work and schedule elongated. (Table 5.3, Item 3.7 in Chapter 5)

- Incident 4
  - The purchasing manager delivered old and damaged office cabins to project site due to the intention of cost cutting. These used office cabins are not in according to what was specified in the contract specifications. Consequently, client verbally rejected all these office cabins. (Table 5.4, Item 4.3-4.4 in Chapter 5)
  - The project director, in fact, had instructed the purchasing manager that all material shall be purchased as per contract specifications. This caused an increase in transportation cost for sending the rejected cabins back to the store. (Table 5.4, Item 3.7 in Chapter 5)

Two complexities associated with organisational design and development (H4) are misalignment and opacity. Such misalignment occurred:

- Incident 4
  - Between the project manager and purchasing manager due to lack of mutual understanding of the project requirements resulted in

conflicting instruction given to the project team. (Table 5.4, Item 4.3 in Chapter 5)

  - The project manager is confused as information received from the purchasing manager, and project director is not consistent. (Table 5.4, Item 4.7 in Chapter 5)

- Incident 5

  - The project manager has checked the shop drawings and instructed his subcontractor without confirmation by consultants to print out such drawings for fabrication and construction purposes. Therefore, this wrong instruction was given to the subcontractor. (Table 5.5, Item 5.3 in Chapter 5)
  - The structural engineer did not update the structural drawing caused the main contractor has to reproduce the shop drawings. (Table 5.5, Item 5.5 in Chapter 5)
  - The structural engineer did not provide sufficient information on the project requirements caused a delay in approving the shop drawing and affected the progress of construction work. (Table 5.5, Item 5.6 & 5.8 in Chapter 5)

The complexity in communication and control (H3) associated with human behavior seem insignificant to the project performance (Table 5.7 in Chapter 5). Because it rarely occurs in this project due to no varying legal perspectives and cultures diversity within the project stakeholders.

PMI (Navigating complexity: a practice guide, P.25) has suggested some useful complementary practices which will be useful for construction project managers in navigating complex landscapes in a construction project. The practices include: optimize the organizational structures, establish effective governance, diligently research the project before approval, match the manager and key team members to the project, listen to experts, manage integration effectively, focus on change management, encourage a resilient mindset, pay attention to small signs that may signify major changes, avoid oversimplification, and encourage reflective thinking.

In general, interface issues and complexity do not make project life miserable and may have a positive or negative impact. The causes of interface issues and complexity are 'new normal' and cannot be eliminated, but it can be controlled. Perhaps the most critical step to prevent these problems from occurring is implementing good interface management in the initiation phase of a project which will improve project performance regarding quality, cost, time and safety as well. Also, adequate risk and change management procedures should be in place to enable positive impacts and minimise negative impacts.

6.3 Implications of the study

There are substantial solid solutions can resolve the interface issues and complexity according to the practitioner own intuition instead of standards or guidelines. It needs to be instantaneously and wisely resolved via appropriate communication and coordination between each construction participants. Even the clearest writing is useless when it carries inaccurate information.

There are various types of alignment that, if not appropriate, may lead to an increase in the degree of complexity in a project. For instance, the misalignment occurs between project stakeholders. The insufficient communication process between intra- and inter-organization is also the bane of a project's life. According to Morris (2015), interface management is essentially the project manager's job: planning, coordinating and controlling the work of others at project interfaces. The following are all example of interface management principles:

i. Tight control of dynamic interfaces is essential to achieving project cost, schedule and scope targets.
ii. Static project interfaces should be kept clearly defined through the life of the project.
iii. Organisational factors should not be allowed to inhibit required project integration.
iv. Project organisation structures generally need to change as the project develops.
v. Early, firm control of design is essential for effective project control.
vi. The design/ production interface is the most critical project interface; it is also the most difficult to manage.
vii. The required amount of project management effort is a function of project size, speed, and complexity.

Browning and Ramasesh (2015) opined many project challenges and failures catch executives by surprise. Even projects that employ sophisticated techniques for risk management can encounter surprising derailments. Those methods, can only manage known risks instead of the things that don't know, namely "unknown unknowns". Fortunately, there are tools and strategies to help managers. The 11 approaches such as decompose the project, analyse scenarios, use checklists, scrutinise plans, use long interviews, pick up weak signals, mine data, communicate frequently and effectively, balance local autonomy and central control, incentivize discovery and cultivate an alert culture. Meanwhile, these toolkits are directing project manager toward uncovering the knowable unknown unknowns lurking in projects and converting them to known unknowns. By providing guidance on where and why "unknown unknowns" exist in projects and how to recognise their clues, managers can reduce the number and magnitude of unwelcome surprises and integration issues.

6.3.1 The Industrial Practitioners

On projects, problems require solutions within short timeframes, organisational conflicts abound, and compromises are inevitable. Therefore, having a formal interface management process has many advantages to industrial practitioners, particularly when there are many participants and stakeholders involved in a project.

According to Caglar and Connolly (2007), the effective exchange of information is crucial to successful execution of any project and use of the interface management process allows early identification of critical interfaces through a structured process leading to first definition of issues with potential for impact to the project “iron triangle” – time, cost and performance. Once identified, action can be taken to minimise any impact and with constant monitoring areas of critically that deviate from the plan can be quickly addressed and brought under control. The interface management process can only be effective if all project participants embrace the concept and incorporate it into their work processes making it a formal project communication method that benefits all involved in achieving flawless execution.

In turbulent and complex landscapes with rapidly changing technological platforms, even projects that employ sophisticated techniques, but many projects fail to meet their goals for time, cost and performance. It is all mainly due to integration issues and complexity. Sayles and Chandler (1971) recognised, efforts to cope with complexity can never eliminate uncertainty. Consequently, acknowledging the emergence of a problem is a necessary first step, allowing project manager to respond quickly and effectively. Some organisations assume that almost all problems can be prevented if the project manager is competent enough – resulting in project managers who are hesitant to admit that they are facing an emerging problem. In fact, a recent study indicates that project managers submit biased reports as often as 60 percent of the time. When upper management fosters an organisational climate that embraces problems as an inherent part of a project’s progression, project managers are able to detect and resolve problems more successfully (Laufer et al., 2015).

6.4 Limitation of the Study

This research had conducted in a single case and on forms of the traditional contracting project and specified project stakeholders such as client, design consultants, main contractor and subcontractor. The case studies of this research had limited with four (4) core interfaces: time interfaces, geographical interfaces, technical and contractual interfaces, and organizational interfaces and three (3) broad categories of complexity: human behavior, system behavior and ambiguity.

The conclusions and recommendations of this research based on the data analysis from an on-going medium-sized construction project and the information gathered were traced the corresponding e-mail, which confined to and between the contractor and client or consultants.

Therefore, the emergence of integration issues and project complexity between client and respective consultants were neglected and not been analysed.

6.5 Recommendations for Further Research

This research has its limitations on the solution of navigating the avoidable mistakes. During this research, several ideas for research could be furthering. However, these ideas have been disregarded due to its do not fit in the research objective.

The following subjects are worth studying and furtherance on helping the construction industry to improvement and be successful.

i. Future research into interface management and project complexity as well as both are likely to evolve over time.

ii. Research into the mega projects such as infrastructure project, oil and gas project, property development and so forth. Also, research throughout the whole project lifecycle, which different interfaces and complexity could be explored.

iii. Research into the different type of contracting project, for instances, design and build (DB), build-operate-transfer (BOT), bespoke contracts and so forth, where a different type of complexity could be explored.

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