

Teaching Module for

CIVIL ENGINEERING

Research Students



Sobri Harun • Ahmad Safuan A. Rashid • Nur Syamimi Zaidi • Libriati Zardasti • Ain Naadia Mazlan
Sitti Asmah Hassan • Nor Hasanah Abdul Shukor Lim • Ilya Khairanis Othman • Azman Mohamed
Ahmad Razin Zainal Abidin @ Md. Taib • Eeydzah Aminuddin

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Published by

School of Civil Engineering

Faculty of Engineering

Universiti Teknologi Malaysia (UTM)

81310 Johor Bahru

Johor, MALAYSIA

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Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

First Edition

Printed in Malaysia

eISBN: 978-967-2401-31-5

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Zainal Abidin @ Md. Taib • Eeydzah Aminuddin

PREFACE

Alhamdulillah, I am grateful to Allah SWT that the School of Civil Engineering (SKA) has successfully produced this Teaching Module for Civil Engineering Research Students.

Civil engineering which considered the second-oldest engineering discipline after military engineering is a very diverse discipline deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as transportations (roads, bridges, canals, railways, airports), water and wastewater (dams, sewerage systems, pipelines), structures and infrastructures including geotechnical aspect.

With such diverse area of disciplines comes many problems face by the civil engineers and designers on and off-site. Some of this problem requires testing and sometime longer observation to understand the mode and mechanism of failure and the properties of the materials. Research can find answers to things that are unknown, filling gaps in knowledge and changing the way that engineering professionals work. Also, research plays an important role in discovering new treatments and repair work to make sure that the materials use is green and not hazardous to the living things.

Before anyone start a research work, they must have a clear researchable problem. After the problem statement is established with the aim and objectives of research is clear, the methodology should be sound and follow scientific method. This is a very important stage in research, failing which makes the results questionable if not unreliable.

Research work can be costly and involved many activities. Materials and equipment's used sometimes not available at the school laboratories. They must pay commercial lab to get the result. Hence, high expectation of the output can be stressful. The output can be tangible and intangible. It can be a sellable product and generate income or solving community and industrial problem.

Among the outputs are Ph.D. thesis, journals and conference papers, books, book chapters, while patents/widgets/know-how/copyright (these are the commercial/technological outputs), and methodology/techniques/code that underpinning new scientific discoveries, and many more.

This book is meant for all who wish to teach on research in civil engineering discipline, to researchers be them juniors and seniors, undergraduates, and postgraduates. The chapters are written by SKA lecturers from different departments who themselves had experience and have undergone training in research and supervising researcher. Any feedback arises while reading this book are welcome and can be addressed to us.

Thank you.

Prof. Ts. Dr. Mohammad bin Ismail
Associate Chair (Research & Academic Staff)
School of Civil Engineering, Faculty of Engineering
Universiti Teknologi Malaysia

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CHAPTER 1

Introduction

1.1 DEFINITION OF CIVIL ENGINEERING

The term *civil engineering* has been used and evolved for more than 200 years. Civil engineering is a discipline that deals with the planning, construction, and maintenance of the physical and naturally built environment, including structure like roads, bridges, canals, dams, airports, sewerage systems and many others (Chen and Liew, 2002). In general, civil engineering comprises of six main disciplines as shown in Figure 1.1.

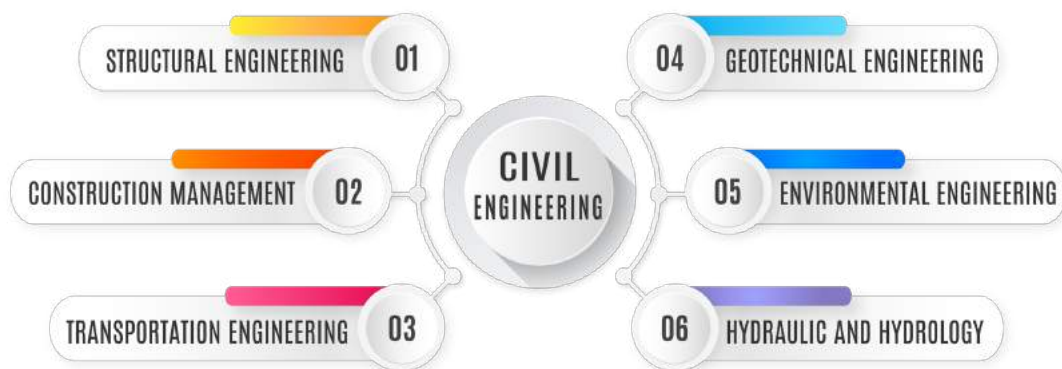


Figure 1.1 Main disciplines of Civil Engineering

1.2 FIELD OF RESEARCH IN CIVIL ENGINEERING

While this civil engineering discipline is categorized as one of the oldest discipline in the world, opportunities and potential for upgrading and improving the quality of life led to this disciplinary change constantly through research elements. There are a number of sub-disciplines within the broad main disciplines of civil engineering as shown in Table 1.1. There are lots of sub-disciplines under main civil engineering field, which means there is wide coverage of potential researches that can be undertaken respectively or by collaborating between sub-disciplines of civil

engineering. More potential researches therefore means more chances of life quality improvement in the near future.

Table 1.1 List of sub-disciplines within the field of civil engineering (Ricketts, Loftin and Merritt, 2004)

| Main Discipline | Sub-disciplines | Remarks |
|----------------------------|---|---|
| Structural engineering | <ul style="list-style-type: none"> • Earthquake engineering • Forensic engineering • Materials science and engineering | Structural engineering is about the structural design and analysis of buildings, bridges, towers, flyovers, tunnels, offshore structures, aero structure and others. Design considerations that can be research includes strength, stiffness and stability of the structure when subjected to loads, either static or transitory. Other considerations to be research include cost, constructability, safety, aesthetic and sustainability. |
| Transportation engineering | <ul style="list-style-type: none"> • Highway engineering • Traffic engineering | Transportation engineering involves specifying, designing, constructing, and maintaining transportation infrastructure, covers streets, canals, highways, rail systems, airports, ports, and mass transit. It includes transportation design and planning, traffic and pavement engineering, and infrastructure management. |
| Construction management | <ul style="list-style-type: none"> • Construction safety • Construction contract • Construction technology | Construction management governs human resources, material supply resources and law/contract. It is about project management techniques to oversee the planning, design and construction of a project, from beginning to end. The purpose of construction management is to control projects' time/delivery, cost and quality. |

Table 1.1 List of sub-disciplines within the field of civil engineering (Ricketts, Loftin and Merritt, 2004) (continue)

| Main Discipline | Sub-disciplines | Remarks |
|---------------------------|---|--|
| Geotechnical engineering | <ul style="list-style-type: none"> • Geology • Soil improvement | Geotechnical engineering studies rock and soil supporting applied science systems. Knowledge from the sphere of soil science, materials science, mechanics, is applied to economically design foundations, retaining walls, and other structures. Environmental efforts to safeguard groundwater and safely maintain landfills have spawned a novel area of research called geo-environmental engineering. |
| Environmental engineering | <ul style="list-style-type: none"> • Water and wastewater treatment • Environmental management • Air quality • Waste management | Environmental engineering deals with treatment of chemical, biological, water and air purification and remediation of contaminated sites. Among the topics that can be research are pollutant transport, water pollution control, air pollution, solid waste treatment, and hazardous waste management. Environmental engineering also deals with pollution reduction, green engineering, and industrial ecology. |
| Hydraulic and hydrology | <ul style="list-style-type: none"> • Coastal engineering • Water resources engineering | Hydraulic engineering deals with the flow of water, mainly related to the design of pipelines, water supply network, drainage facilities and canals. This field is associated with collection and management of water. It combines with hydrology, biological science, meteorology and resource management. This field relates prediction and management of both the standard and the quantity of water in both aquifers and lakes/rivers/streams resources. |

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Ricketts, J.T., Loftin, M.K., and Merritt, F.S., eds. (2004). Standard Handbook for

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CHAPTER 2

Conducting Literature Review

2.1 INTRODUCTION

Review of literature is one of the **most important steps** in the research process. It is an account of what is already known about a particular research topic. The main purpose of literature review is to convey the readers about the work that have been done, the knowledge and ideas that have been already established on particular topic of the research. Within a thesis, a literature review may appear in a single chapter – often being the first independent chapter after the introduction. However, reviews of literature can be dispersed across several chapters, each of which may focus on a different theme, concept, theory or method. Literature review is a laborious task, however it is **essential** in order to ensure success in the research process.

2.2 WHAT IS LITERATURE REVIEW?

Literature review is an integral part of the research process and makes a valuable contribution to almost every operational step. According to Queensland University (1999), literature review is an evaluative report of information found in the literature related to selected area of study. The review describes, summarizes, evaluates and clarifies this literature. It gives a theoretical base for the research and helps to determine the nature of research. A literature review is also defines as an account of what has been already established or published on a particular research topic by accredited scholars and researchers.

Literature review is a critical analysis of existing research in one's field. It highlights both the strengths and weaknesses of the existing research including the similarities, patterns, trends and differences across the existing research thus, allows researcher to gain a critical understanding of their research field. By identifying

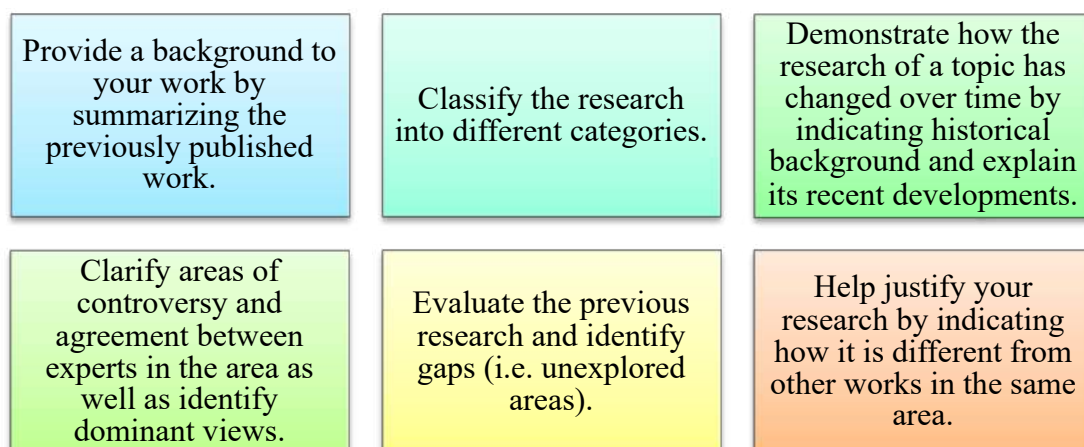
strengths and weaknesses, researcher will be able to think about what has not or needs to be done in their research field. This is what been called as the gap in the literature whereby it poses as a justification for one's research.

Definition of literature review from various authors is as follows:



2.3 PURPOSE OF CONDUCTING LITERATURE REVIEW

A literature review functions as a tool to:



Literature review is conducted upon on answering the research questions. In the initial stage of research, the literature review helps to establish theoretical roots of the study clarify the ideas and helps the researcher to develop their research methodology. Later in the process, the literature review serves to enhance and consolidate the researcher's knowledge base. Since it is an important responsibility in research to compare the findings with those of others, literature review plays an extremely important role. During the write-up of the technical report or thesis, the literature review helps to integrate the findings with existing body of knowledge by either supporting or contradicting. Higher the academic level of the research (Undergraduate to Doctor of Philosophy level), more thorough the integration of the findings with existing literature becomes. In relation to one's study, the literature review can help in **FOUR (4)** ways as shown in Figure 2.1.

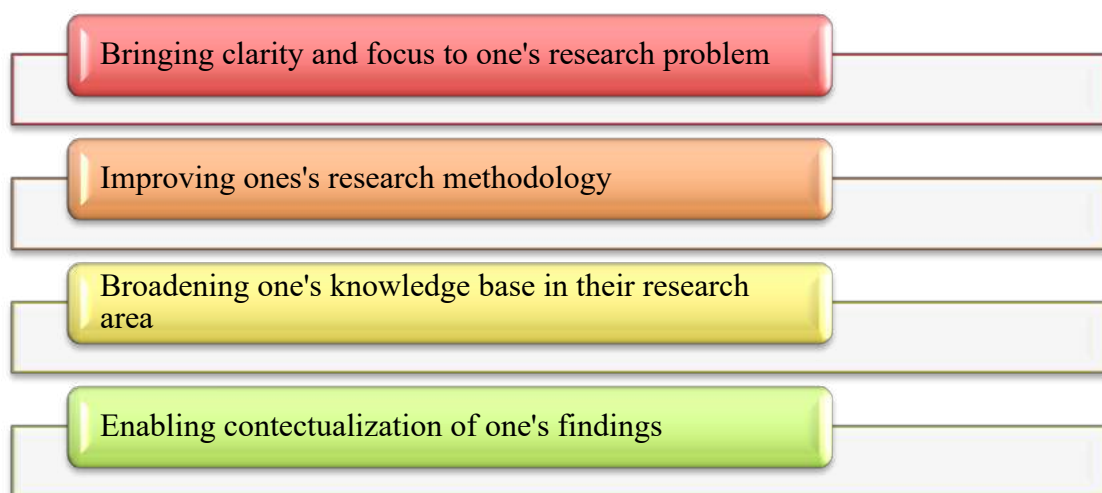


Figure 2.1 Benefits of literature review in research (Swales and Feak, 2012)

2.4 DIFFERENT TYPES OF LITERATURE REVIEW

Literature reviews exist among different types of scholarly works with varying foci and emphases (Figure 2.2). Short literature reviews can be presented in journal articles, book chapters, or coursework assignments to provide background for the research work and stipulate a general understanding of the research topic. However, the focus of literature review in a graduate research thesis is to identify gaps and argue for the need to pursue further research work. Depending on the aim of the

author and also the context within which the literature review are presented, a selective or comprehensive approach may be taken.

In the selective approach, a limited number of sources are reviewed (e.g. as in an annotated bibliography assignment or the introduction of a journal article). In contrast, a comprehensive approach requires the review of various books and articles (e.g. as in a review article), which can be presented as a substantial chapter in a research thesis or published on its own as a scholarly review article.

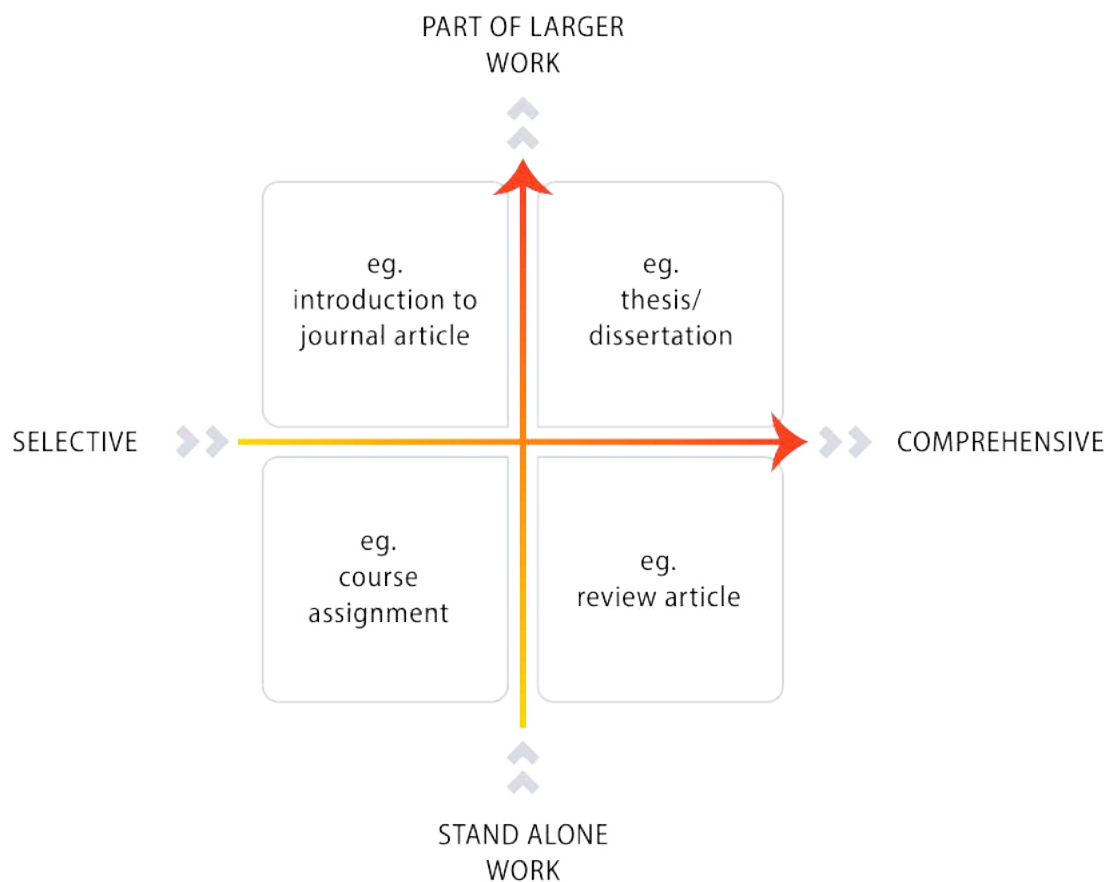


Figure 2.2 Types of literature review (<https://www.lib.ncsu.edu/tutorials/lit-review>)

2.5 SOURCES OF LITERATURE

Literature review typically includes scholarly journals, scholarly books, authoritative databases and primary sources. It can also include newspapers, magazines, other books, films and other secondary sources. All good research and writing is guided by

a review of the relevant literature. The literature review will be the mechanism by which one's research is viewed as a cumulative process. That makes it an integral component of the scientific process. In general, sources of literature can be divided into **two (2)** categories, which are **primary sources** and **secondary sources** (Figure 2.3 and Table 2.1).



Figure 2.3 Common resources of literature review

Table 2.1 Sources of literature reviews

| Primary Sources | Secondary Sources |
|---|---|
| Need when the researchers want to explore recent research works. | Need when the researchers want to find any research works that has been long established. |
| Example: Journals, research reports | Example: Textbooks, magazines and newspapers |
| The primary sources are used when the researchers want to find research gaps/novelty. | The secondary sources may be used when primary sources are not available or if the researchers want external opinions on an issue or problem related to the research topic. |

2.6 HOW TO CORRECTLY REVIEW THE LITERATURE?

Your review can be structured several ways, depending on how it suits the needs of your review. Typical structures may include the following below.

Funnel: This basically works as broad to narrow, starting by scoping background literature related to your general topic area rather than precise research question; moving on to discussing literature closer to what you are doing but not matched directly and dealing with these sources in more detail; finally critically analyzing research pertinent to your research question and looking a few key papers in much more detail as shown in Figure 2.4.

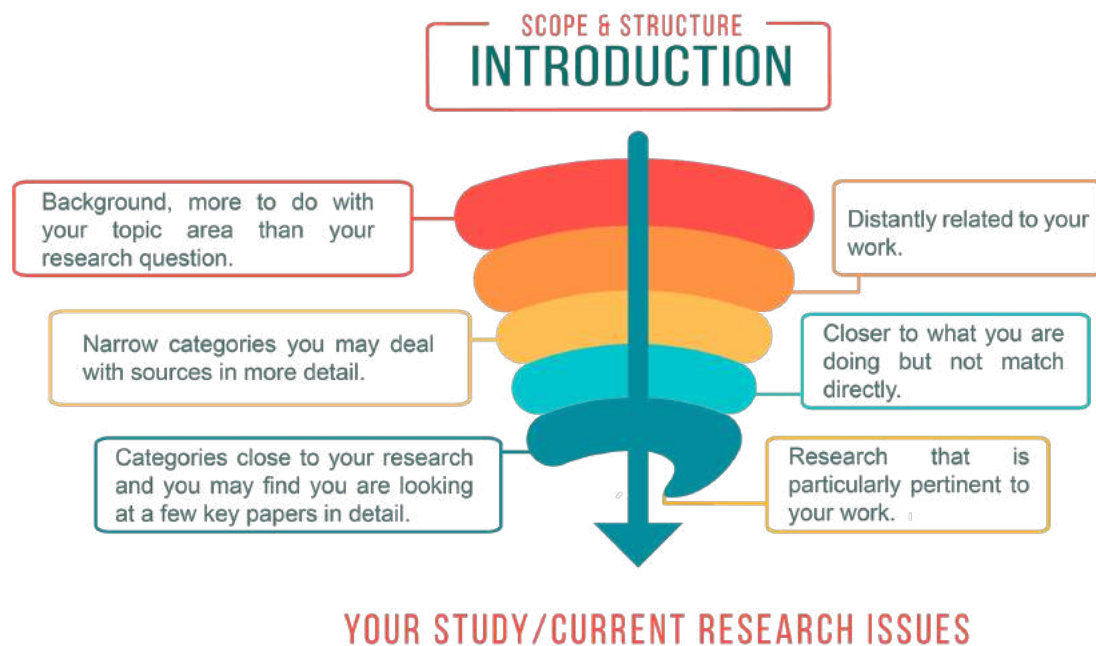


Figure 2.4 Structure using 'Funnel' to review the literature (<https://canvas.hull.ac.uk/courses/779/pages/writing-the-review>)

Chronological: Grouping and discussing your sources in order of publication, highlighting the changes in research in the field and your specific topic over time as shown in Figure 2.5.

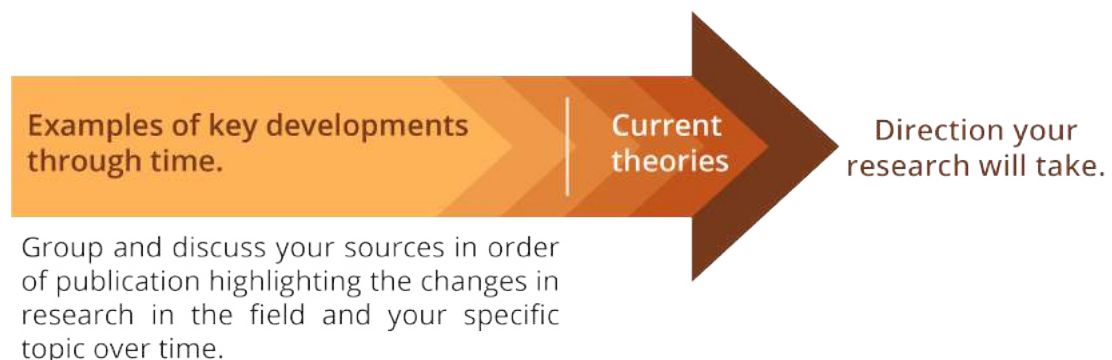


Figure 2.5 Structure using 'Chronology' to review the literature

2.7 BASIC STEPS TO WRITE LITERATURE REVIEW

Generally, there are **six (6)** steps to write literature review (Moll-Willard, 2019). It covers from selecting a research topic until performing a critique or arguments towards the literature found (Figure 2.6).

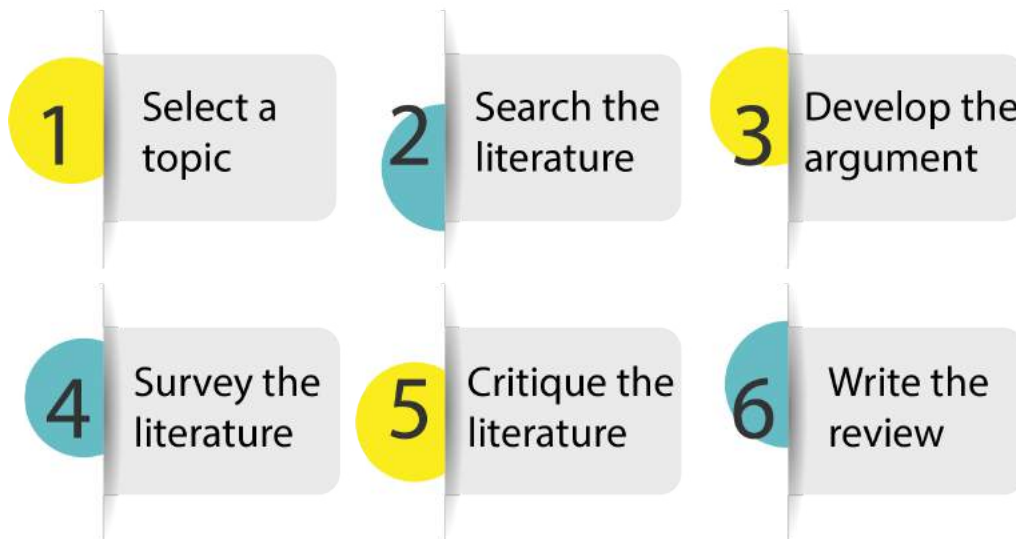


Figure 2.6 Six (6) steps to write literature review

Select a topic

For the selection of a topic, the researcher should ask him/herself on these following questions - Is this topic covers an area of current interest? Has the topic been widely researched? The literature review should be guided by a central research question. It is not a collection of loosely related studies in a field but instead represents background and research developments related to a specific research question, interpreted and analyzed by the researcher in a synthesized way.

TIPS!!!!

- ✚ Make sure the research question is not too broad or too narrow. Is it manageable?
- ✚ Begin writing down terms that are related to the question. These will be useful for literature searches later.

Search the literature

Start by creating a list of keywords related to the research topic and research question. There are some of useful databases to search for journals and articles and these databases may be different depending on the engineering discipline.



When a useful article is found, it is at best for the researcher to check the reference list of the article to find more relevant sources. In order to identify any important publications that did not show up in the early keyword search, take note of recurring citations. If the same authors, books or articles keep appearing in the reading, make sure to seek these out. Using Google Scholar or Scopus, the researcher can find out how many times an article has been cited. High citation counts mean the particular article has been influential in the respective field.

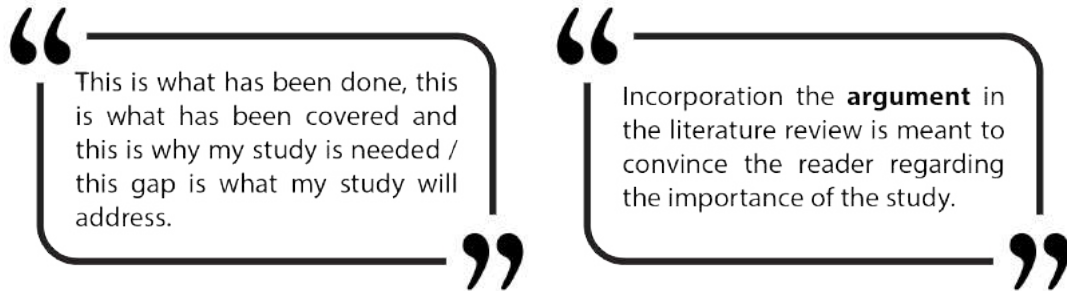
When searching the literature, a valuable technique that needs to be master by the researcher is to know how to skim read. Skim reading allows the researcher to quickly grasp what the article is about and its value (Moll-Willard, 2019).



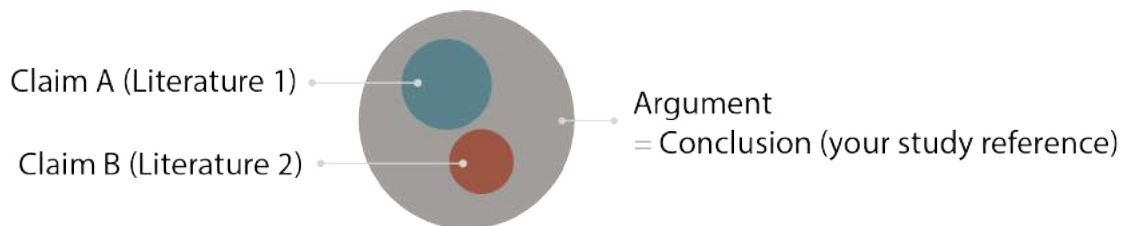
Reading an abstract alone **IS NOT** sufficient. Abstracts are made to 'catch' the eye and do not show the full value or lack of value of the article has for the study.

Develop the argument

A literature review is a little more complex than simply a summary of the literature. The researcher needs to add in the critical thinking skills, and relate the literature to the study for the purpose of showcasing reasons why the study is needed. In short, it is the reasoning for the study.



Developing this argument requires the researcher to also write in a way that makes sense:



There are **TWO (2)** different types of arguments, and it is worth using both of it in the literature review (Moll-Willard, 2019).

Argument of **DISCOVERY**

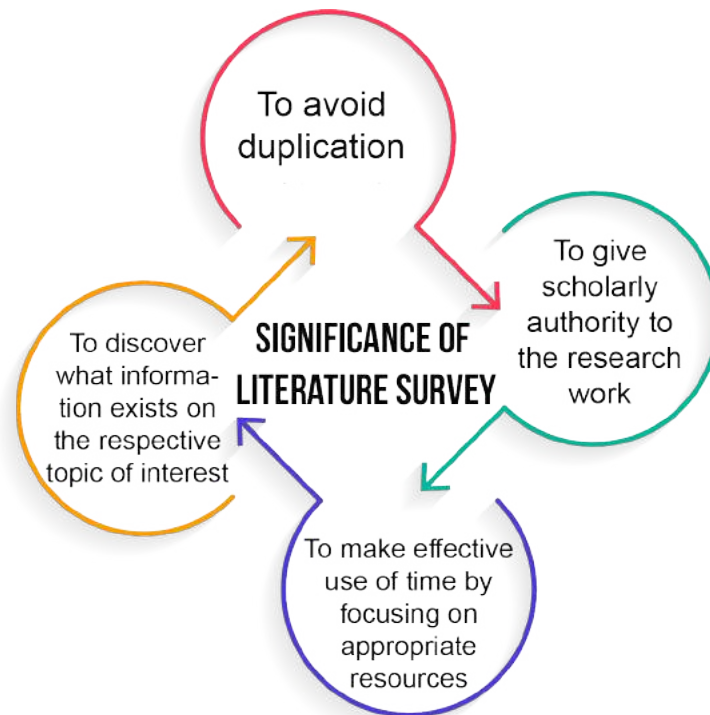
- Discusses and explain what is known about the subject
- Discovers the extent of the subject

Argument of **ADVOCACY**

- Analyses and critiques the knowledge gained from the synthesis of the data
- Use critical thinking and application to own study

Survey the literature

In this stage, the researcher need to perform a systematic and thorough search of all types of published literature as well as other sources including dissertation, theses in order to identify as many items as possible that are relevant to the research topic.

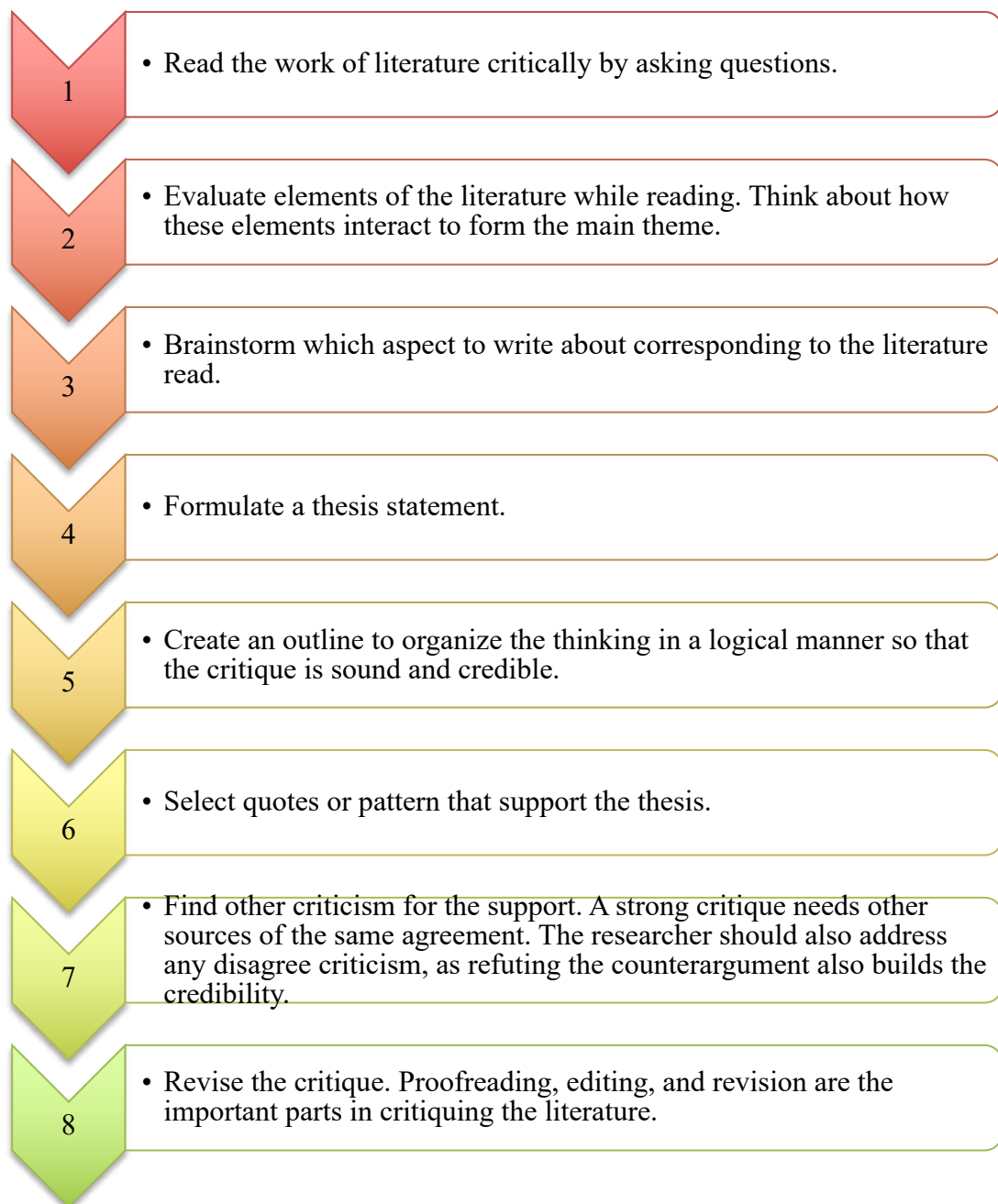


The following are some of the questions that can help the researcher to survey the literature for the purpose to analyze the research:

- What was the questions that you are trying to answer in the study? What do you plan to discover?
- Was the study initiated by a source that may change the outcomes?
- What were the methods to run the study?
- Was the study considered complete if: (i) the literature were critically reviewed? (ii) the samples and variables were identified correctly? (iii) the results were verified by previous literature? and (iv) the objectives of the study were successfully answered? What further questions does it raise?
- Do you find the study conflicted? If yes, what is it?
- Has the writing been cited in other works?

Critique the literature

A literature critique, or also called a literary analysis is an examination of a literature. The scope of literature critique is to look at one aspect of the work, or the add its entirety, and involves breaking the literary piece into its separate components and evaluating how they come together to accomplish the objectives. Critiquing the literature involves looking at the strength and weaknesses of the literature and evaluating the statements made by the authors. These are few steps that can be referred to apply the critical techniques (Hart, 1998).



Write the review

Like any other academic text, the literature review should have an introduction, a main body, and a conclusion. Simple tips of writing the body of the literature is summarized as in Figure 2.7 (Study & Learning Centre, RMIT, 2005).

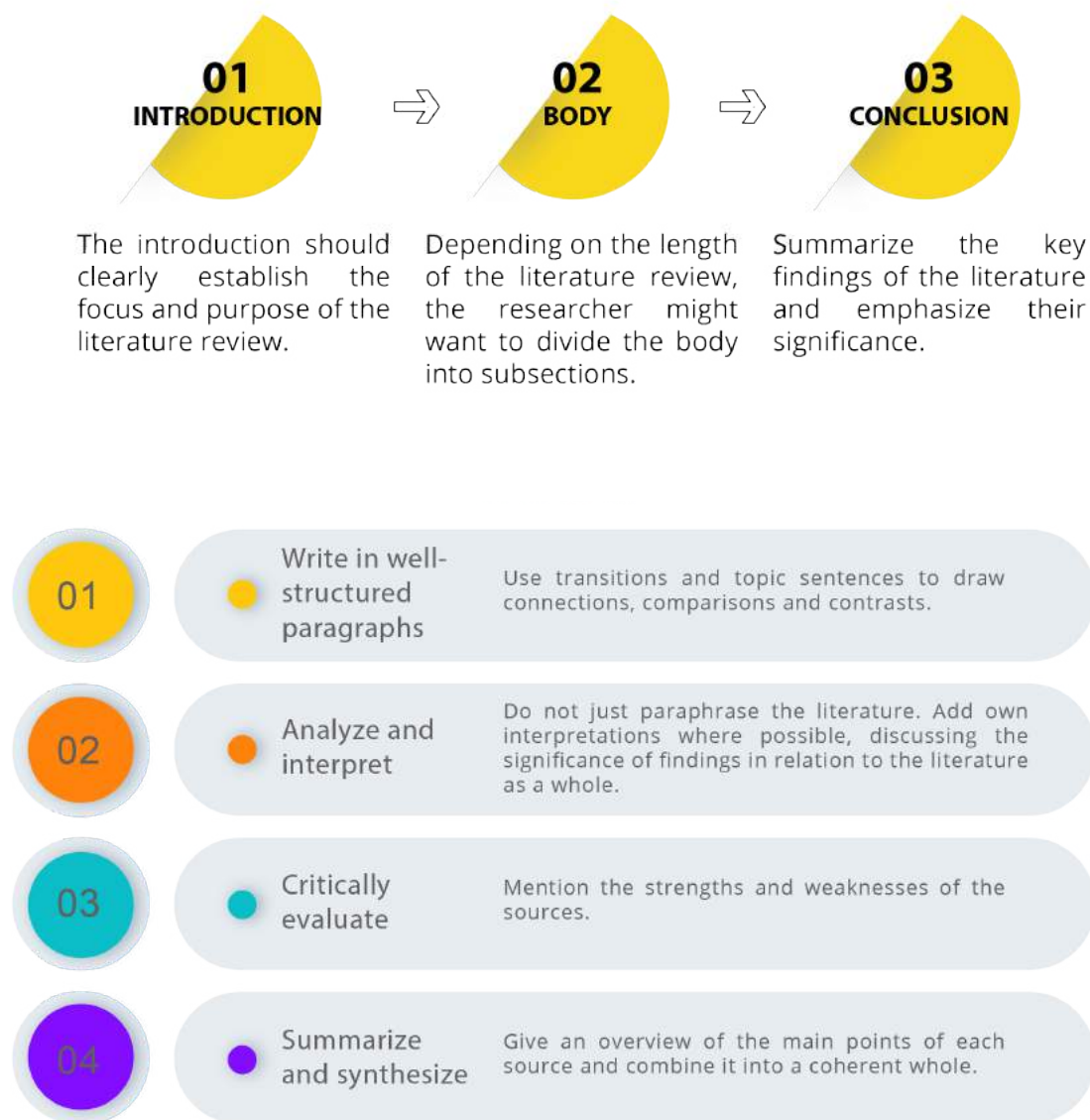


Figure 2.7 Tips of writing the body of the literature

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CHAPTER 3

Formulating Research Problem

3.1 INTRODUCTION

Formulating research problem meant to explain **WHAT** to research and **WHY** doing the research. Problem may be selected from personal practical experiences, critical study of the literature and interaction with others.

3.2 PROBLEM SELECTION CRITERIA

Uniqueness/Novelty

Findings from research should contribute to body of knowledge already in existence, not merely duplicate existing study. However, to pursue a study similar to one already in existence but change the methods used, or modify the design, or use a different sample, or choose to perform different statistical analyses.

Interest

If you are not interested in the area you want to research, what will the quality of the product be like? By being interested, you are more likely to read widely on the topic and have more thorough knowledge of the situation.

Size

Remember, a problem is often too large when it is first considered. Further analysis can reduce large problem into a smaller, manageable research problem.

Economy

Researchers are often confronted with practical constraints, usually time and money. If your problem situation is macro in size, is it possible for you to find the answers to your question? Do you have enough time and money?

Capabilities and Limitations

A researcher should not be too ambitious and must recognise your own capabilities. It is wise, especially at prior planning stage to seek advice from more experienced persons. If inexperienced in educational research, then it is highly likely that you will need some guidance.

3.3 FORMULATING RESEARCH PROBLEM

After all the criteria above have been considered, then write research questions under the area of your interest. For example, if you select flooding as your study area, your questions might be “ Why flooding occur at this particular area?”, “ Is it flash flood, coastal inundation or seasonal flooding?”, “What causes the flood?”, “What are the impact of the flood” and “How can we minimise the flood at this particular area?”. The more questions you prompt, the more idea will come to your mind. You need to write relevance questions in the form of problem statement. Problem statement is usually written in paragraphs, explaining the problems and aspects that require research. The statement must highlight which aspects of the problem that the present study will explore and addressed, which is also telling the reader the expected contribution of the present study.

3.4 FORMULATION OF AIM, OBJECTIVES & SCOPE

Researcher often confuse the concept of aim, objectives and scope. What are they actually? And how to write these statements. Statement below describes aim, objectives and scope in general (Hale and Whitlam, 1995).

- Aim: Describe new insights that the research will produce at the end of research that will help fill the knowledge gap identified in the problem statement.

- Objectives: Describe brief infinitive statement in order to achieve the aim of the research. The word used must be SMART (Specific, Measurable, Achievable, Relevant and Time-related)
- Scope: Describe the limitation in research. For example, limitation of variables, behaviors, analysis, etc.

While research problem formulation serves to describe the aim of research, the objectives provide an accurate description of the specific actions that will be taken in order to reach this aim.

Take a look at the problem formulation: *“Is the level of knowledge on research methodology practices related to the attendance status of students in research methodology class?”*.

The correspondent aim or main goal of the research should be written as an infinitive sentence. For example: *“To investigate the association between research methodology knowledge and attendance status of students in research methodology class”*.

From here, we can see that the aim (main goal) states exactly how we intend to address the research problem. Then, we have to explain a set of specific objectives to achieve the specified aim (usually between two and four). For example:

1. To assess the knowledge level among research methodology class attendees on the research methodology practices.
2. To assess attendance status of students in research methodology class.
3. To analyse the statistical association between level of research methodology knowledge and attendance status of students in research methodology class.

Each specific objective consists of one infinitive sentence and should be phrased in a way that makes it possible to draw a conclusion from within the scope of the research. The word used for objectives must be SMART (Specific,

Measurable, Achievable, Realistic and Time-related). What does it really mean to have SMART objectives?

1. **Specific:** The description is written in a way that anyone reading the objective statement will be most likely interpret it the same way. To ensure that an objective is specific, the objectives must be written in such a way that it is observable. Action-oriented verb can be used to describe those actions needed to fulfil the objectives. For example: to identify, to determine, to analyse, to develop.
2. **Measurable:** It refers to the extent to which something can be evaluated against some standard. We will know that the objective has been achieved because evidence is available from the procedures that we have conducted.
3. **Achievable:** The description of objective is written in such a way to answer questions “Can the objective be achieved by the researcher giving the time frame, opportunity and time frame?”.
4. **Realistic:** Realistic does not mean it should be easy. The objectives can be set in a demanding way but we must be realistic about the success chance in achieving the objectives in research.
5. **Time-related:** It refers to the fact that an objective has a deadline or time when the objective will be completed. In research, it is common to have several milestones for us to assess how well the research is progressing before it is finished so that modifications can be made when necessary to make sure the aim of the research is achieved.

It is essential to define explicitly the scope of research. It basically consists all the things that will be covered in the research project. It characterizes unmistakably the extent of content that will be covered by the means of the research so as to obtain progressively obvious end results and offer indisputable responses to the research. A comprehensive and valuable research scope explains why definite aspects of a subject were chosen and why others were excluded. In a normal circumstance when the research has been conducted on a sort of verifiable occasion or diverse key occasions in the past, then the researcher needs to convey others that the extent of the research is limited to these occasions just and not more.

Scoping is figuring out what, exactly, to explore for a study. We do not want the scope too broad, (or you will not see patterns appear in the data), but we don't want it too narrow as well, (or the participants/readers will tell you everything they have to say about it in five minutes). We want to get the scope just right—somewhere in between these two extremes.

3.5 SETTING OUT AIM AND OBJECTIVES

The aim and objectives are crucial part of your research. Aim is a broad goal or idea to achieve at the end of the research while objectives are steps to undertake in order to achieve the aim. Objectives are written in verb, reflecting the task that need to be carried out. In general, the objectives must fulfill five criteria (Figure 3.1). The verb used must be specific; to quantify, calculate, design, simulate. Avoid using general verb such as to study and to analyse since these verbs are too broad. However, they can be used in writing the aim. An objective must also be measurable, meaning that it has a specific measurable output so that the researcher can trace whether the objective has been answered or not. Achievable, relevant and time related means that the objectives are attainable, directly associated with your research scope and within the stipulated time of the research (Thomas and Hodges, 2010).



Figure 3.1 Criteria for writing objectives

Let say the aim of a research is to reduce flooding in an urban location that never flood before. The objectives might be; (1) To quantify the amount of rainfall and runoff, (2) To identify the source of problems from existing infrastructure, and (3) To propose a structure or method to reduce the flooding.

3.6 IDENTIFICATION OF MODEL

Several types of modelling should be carried out to achieve the objective of the study. Although the study will use numerical modelling, for instance, the review should be done for other modelling approaches to find the research gap on the study. For example on the geotechnical field, several modelling approaches could be used as listed below:

1. Semi-Empirical Model – because soils are complex materials, a lot of geotechnical engineering has had to be based on experience, eg. SPT, CPT, Vane Shear, Pressuremeter.
2. Theoretical Model – consists of analytical solution or numerical solutions. Theoretical models can be seen as elegant solutions looking for problems to which they can be applied: an initial step is often to assess how the observed soil behaviour can best be fitted into the framework that the theoretical model imposes. Once a theoretical model has been formulated there are two possibilities for its application: either the boundary conditions of the problem can be manipulated in such a way that an exact analytical result can be obtained; or a numerical solution is required.
3. Constitutive Model – idealisations of material behavior. Elasticity is convenient because of the wide range of analytical results to which access can be gained for elastic materials. However, it will become clear that linear isotropic elasticity can only provide a very inadequate representation of the observed response. The nonlinearity that is observed in soil behaviour is usually an indication of plasticity: permanent, irrecoverable changes in the fabric of the soil. A constitutive model is still governed by equations which ultimately describe the link between changes in strain and changes in stress for

any element of soil. Each constitutive model is itself certainly a simplification of soil behaviour but a simplification inspired by experimental observation.

4. Physical Models – full scale, small scale. Physical model is used to validate theoretical or empirical hypotheses. Physical model plays a fundamental role in the development of Geotechnical Engineering. The application of physical modelling is to advance the confidence in supporting the theoretical model in which the experiment was designed to probe. A well design physical model provide an important opportunity in the modelling cycle. Other types of modelling normally encapsulate the truth. Its only mention as a successful model that has not yet been falsified or refuted.
5. Geological Model - Model of stratigraphy of surface deposits deduced from borehole exploration (solid lines).
6. Classification Model - Soil classification is performed to determine what type of tests required to determine the mechanical properties. Eg. particle size distribution, liquidity index.

3.7 SELECTION OF DESIGN PARAMETER USING DIMENSIONAL ANALYSIS

Buckingham Pi Theorem

Dimensional analysis is a process for gathering components in form of a theoretical connection from the reflection of the variables and parameters that make up that connection. In order to understand a problem, dimensional analysis can assists in a depletion in the number of variables that must be studied. The main reason for applying this process is to create dimensionally homogeneous equations whose form does not rest on the measurement units. The dimensional analysis theory is summarised in Buckingham's π theorem. The number of the dimensionless group to be created is depending on the number of variables in a problem where these variables consist of several numbers of primary dimensions (e.g. Force, F; Length, L; Time, T). The choice of these quantities depends upon the measuring system e.g. whether to employ the MLT system (SI system) or the FLT system (British system).

However, in this work, since mass is the fundamental physical quantity, the latter are employed in deriving the dimensionless value of the equations. Fundamental quantities most commonly employed are based on Newton's second law which states that the rate of change in momentum of a body is proportional to the applied force. A simple notation is used to represent the number of variables and number of primary dimension as m and n , respectively. For example, if a problem has 5 variables, m and these variables contain 3 primary dimensions, n , the equation relating all the variables will have 2 dimensionless groups ($m-n = 2$). The dimensionless group is referred to as π groups and each π groups could not rely on each other by multiplying together the powers of other groups. This method is considered to be more simple than the method of solving simultaneous equations for obtaining the values of the indices (the exponent values of the variables).

There are **TWO (2)** conditions that need to be considered in producing the dimensionless equation:

- ✓ For each fundamental dimensions, it must be appeared in at least one of the 'm' variables. However, if the variable does not contain any fundamental dimension, number 1 will be used to describe the variable for example ° (degree).
- ✓ For each dimensionless equation, the equation should not be possible to form a dimensionless group from one of the variables within another group of equation.

Selection of the relevant independent parameters can be quite difficult, the resolution of the relating problem required sufficient experience. Dimensional analysis associated with Buckingham's π theorem provides a useful hint in determining the various factors involved in the analysis and relevant data to be collected.

An example of Buckingham π Theorem

The factor of safety (F_s) of a slope formed in purely cohesive soil.

- $f(F_s, H, \theta, c_u, \gamma, D)$; $n = 6$
- $f([1], [L], [1], [FL^{-2}], [FL^{-3}], L)$; $m = 2$
- $f(F_s, c_u/\gamma H, \theta, D/H)$; $n - m = 4$

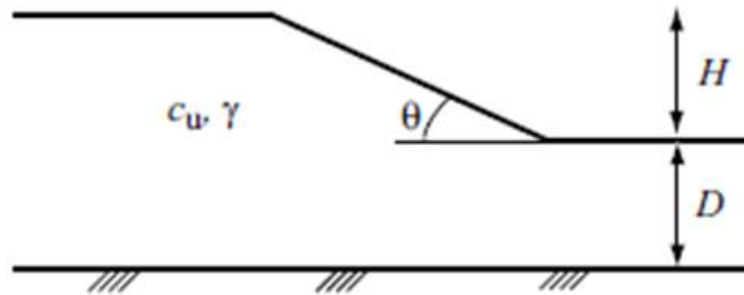


Figure 3.2 A slope formed in purely cohesive soil

Relationship ultimate load on a footing

- $f(P_u, L, B, d, c_u, \phi, \gamma)$; $n = 7$
- $f([F], [L], [L], [L], [FL^{-2}], [1], [FL^{-3}])$; $m = 2$
- $f(P_u/\gamma B^2 L, L/B, d/B, c_u/\gamma B, \phi)$; $n - m = 5$

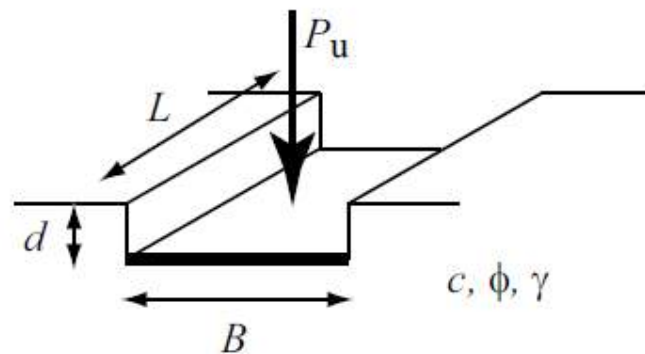


Figure 3.3 Ultimate load on a footing

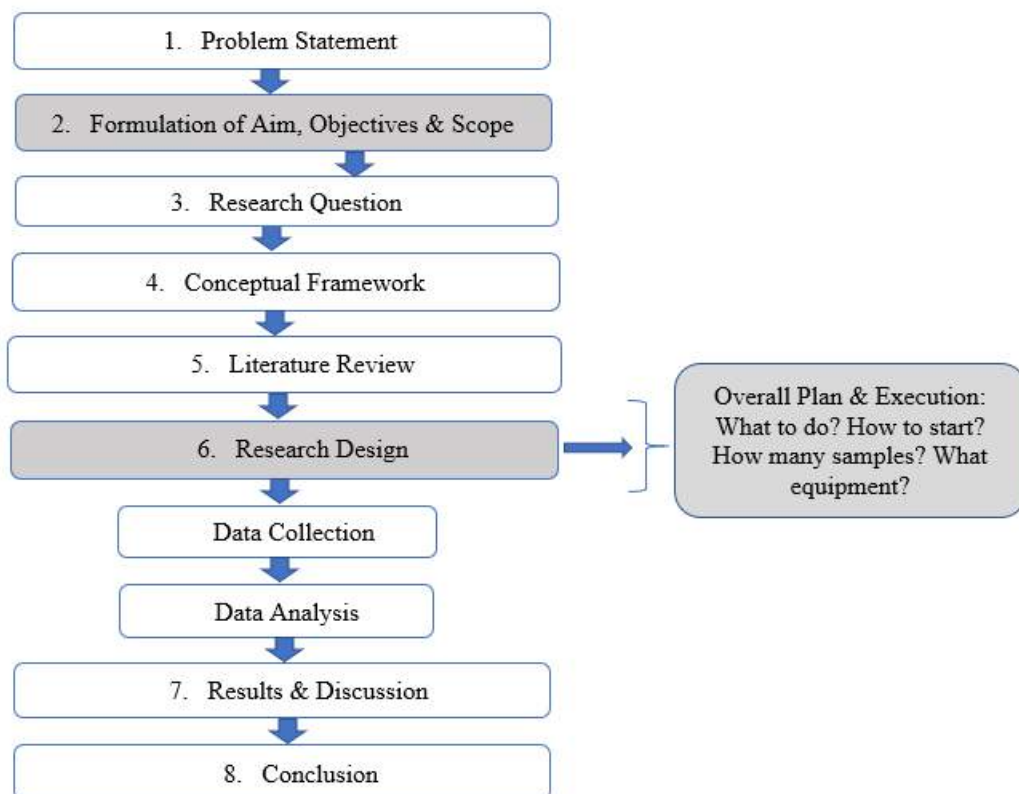
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CHAPTER 4

Framework of Research Design**4.1 INTRODUCTION**

This chapter focuses on discussion of formulation of aim and research design.. Research requires both analytical and creative knowledge, skills and abilities, therefore, it needs to be designed clearly. Misconception in research design can bring hazardous plan in research. Research design are constructed to help researchers in finding answers for research questions/problems. Research plans are executed to bring empirical evidence to bear on research problem. Framework of research design help researchers to align issues in research in order to deliver the insights that researcher needs. Overall research framework is organised into eight components as shown in Figure 4.1.

**Figure 4.1** Research Framework

4.2 RESEARCH DESIGN

A research design is the set of methods and procedures used in collecting and analysing measures of the variables specified in the research problem. Research design is the researchers' overall plan for answering the research questions or testing the research hypothesis.

4.2.1 Elements of Research Design

Elements of research design can be categorised into few elements as listed below:

1. Approach: qualitative, quantitative, both (with/without conceptual framework)
2. Population, sample and sampling technique
3. Time and method of data collection
4. Tool and methods
5. Method of analysis

After we have identified the approach of our research, we have to start thinking and planning on how to execute the research. Questions like these will help us in designing the research plan:

“How many samples will be required?”

“How can I obtain the data/sample?”

“What are the tasks involve in this research?”

“When should I start doing each of these tasks?”

4.2.2 Classification of Research

It is worth to understand the concept of research based on few types before we embark our journey in research.

Based on approach

Research is a systematic inquiry used to describe, explain, predict or control some observed phenomenon - the research topic. Research can be classified into four main types based on the specific purpose or approach as shown in Table 4.1.

Table 4.1 Classification of research based on approach (Dudovskiy, 2016)

| Approach | Description |
|---------------------|--|
| Basic Research | This research is descriptive in nature and is used to understand and explain a phenomenon. This type of research is often driven by curiosity and a desire to expand and advance knowledge. |
| Applied Research | This type of research is more prescriptive in nature and seeks to offer potential solutions to problems. The purpose of this research is to provide information that can be used and applied directly in real life. |
| Evaluation Research | The purpose of evaluation research is to examine the processes and outcomes associated with a particular solution/intervention to a problem. It could be in formative way in that it attempts to improve the solution/intervention or in summative way in that it attempts to evaluate the effectiveness of solution/intervention. |
| Action Research | This research is often conducted within a program, organization or community. The main characteristic of action research is collaboration between researcher and member of organization in order to seek solutions for organizational problems. The collaborators are involved in gathering data, studying themselves and take action in order to improve a problem. |

The process of conducting research is similar regardless of the classification of the research. Researchers may begin with a broad research topic due to professional and personal interests in the area. It then can be narrowed down by conducting a literature review to build up the researcher's knowledge base and to ensure the significance of the research. Research problem and specific research questions are

then developed. Based on this, research design is developed in order to have a good basis in data collection and data analysis procedures. A successful completion of the research is expected to achieve the research aims and objectives.

Based on method

There are two main approaches to a research problem - quantitative and qualitative methods. Therefore, research can be classified into two types based on methods as shown in Table 4.2.

Table 4.2 Classification of research based on method (Creswell & Creswell, 2017)

| Methods | Description |
|--------------|---|
| Quantitative | <ul style="list-style-type: none"> Quantitative methods are used to determine mathematical relationship between variables through statistical analysis. This type of research approach is a common choice in scientific research areas. |
| Qualitative | <ul style="list-style-type: none"> Qualitative methods are chosen when the goal of the research problem is to examine, understand and describe a phenomenon. This type of research approach is a common choice in social science research areas It is often used to study ideas, beliefs, human behaviours |

Once the main approach to the research problem has been determined, there are several research designs for each type of approach that may be considered.

4.2.3 Choosing a Research Design

Qualitative and quantitative research design can be classified into few types. Table 4.3 describes the design and focus for each of the research types under qualitative and quantitative research.

Table 4.3 Research design for various research types (Creswell & Creswell, 2017)

| | Design | Focus |
|------------------------------|---|---|
| Mixed Research Design | Involves both quantitative design and qualitative design. | Mixed design requires more time and more resources. The researcher has to develop expertise in qualitative and quantitative analysis techniques. Qualitative studies use numbers, counts and descriptive statistics. Using numbers does not mean the study has to be quantitative or mixed methods. |
| Quantitative Research Design | Correlational | Explore the relationship between two or more variables through a correlational analysis. The intent is to determine if the variables are related and the direction changes between variables. It does not find causal relationship between variables (it does not imply one causes the other) (McCombes, 2020). |
| | Causal Comparative | Compare two groups of variables. The intent is to understand the reasons or causes for the two groups being different. It is also known as explanatory research (Dudovskiy, 2016). |
| | Experimental | There is a control group and a test group. Individuals are randomly assigned to the two groups. One group gets the treatment (test group) and the other group (control group) does not get the treatment. Pre and post-test for both groups are then conducted in an experimental design. The intent is to determine if a specific idea, treatment, or program makes a difference in outcome (Creswell & Creswell, 2017). |
| | Quasi-experimental | It is the same as experiment except either it has no control group or no random assignment. Current groups are used as is rather than randomly assigning people to the two groups. Both groups receive the pre and post- test in a traditional design (Creswell & Creswell, 2017). |

Table 4.3 Research design for various research types (Creswell & Creswell, 2017)
(continue)

| | Design | Focus |
|-----------------------------|---------------------------|--|
| Qualitative Research Design | Case Study and Historical | The intent is to study and understand a history of situation or individual, which could be a leader, war or activity. Collect a variety of material in a specific and bounded time period. It provides contextual links from the past to the present (Given, 2008). |
| | Narrative | Describe the lives of individual(s) to get meaning from them. It intends to explore and conceptualize human experience into narrative chronology as it is represented in textual form (Salkind, 2010). |
| | Grounded Theory | Systematic discovery or construction of theory from data. The focus is to develop an understanding of a phenomenon or situation in order to be able to develop a theory/model (Chun Tie, Birks, & Francis, 2019). |
| | Phenomenology | Studies a human experience at an experiential level that coming from philosophy and psychology of individuals such as understanding what it means for a woman to lose a child. It is about understanding the essence or meaning of the experience and written in textual concept (Creswell & Creswell, 2017) |

Now we try to look at the whole scenario of research framework. How do we start the research and how do we plan to execute the research? Example scenarios as below can give clear insights on how do we plan the research design in order to answer the problem statement.

Quantitative Research Design: Correlational

Problem formulation: Is the criteria of shopping mall related to parking demand?

Aim : This research aims to investigate the association between two variables (the criteria of shopping mall and the parking demand).

Objectives : To achieve the aim, the following objectives are formulated:

- i. To determine criteria of shopping mall
- ii. To determine parking demand at shopping mall
- iii. To analyse association between criteria of shopping mall and parking demand

Based on the clear problem formulation, we specified our aim or main goal in research. Then, we formulate research objectives in order to answer the research question and achieve the aim. Figure 4.2 shows research design related to the research scenario formulated above.

Stage 1 in Figure 4.2 helps researcher to identify scope or limitations of research. Researcher will be able to define parameters scope (parameters to be included and to be excluded in the research), geographical scope (location or zone of the data collection) and sampling scope (number of samples required).

For correlation research above, the aim is to find the correlational association between criteria of shopping mall and parking demand. It could have positive correlation (both variables change in the same direction), negative correlation (both variables change in an opposite direction) or zero correlation (no association between these two variables).

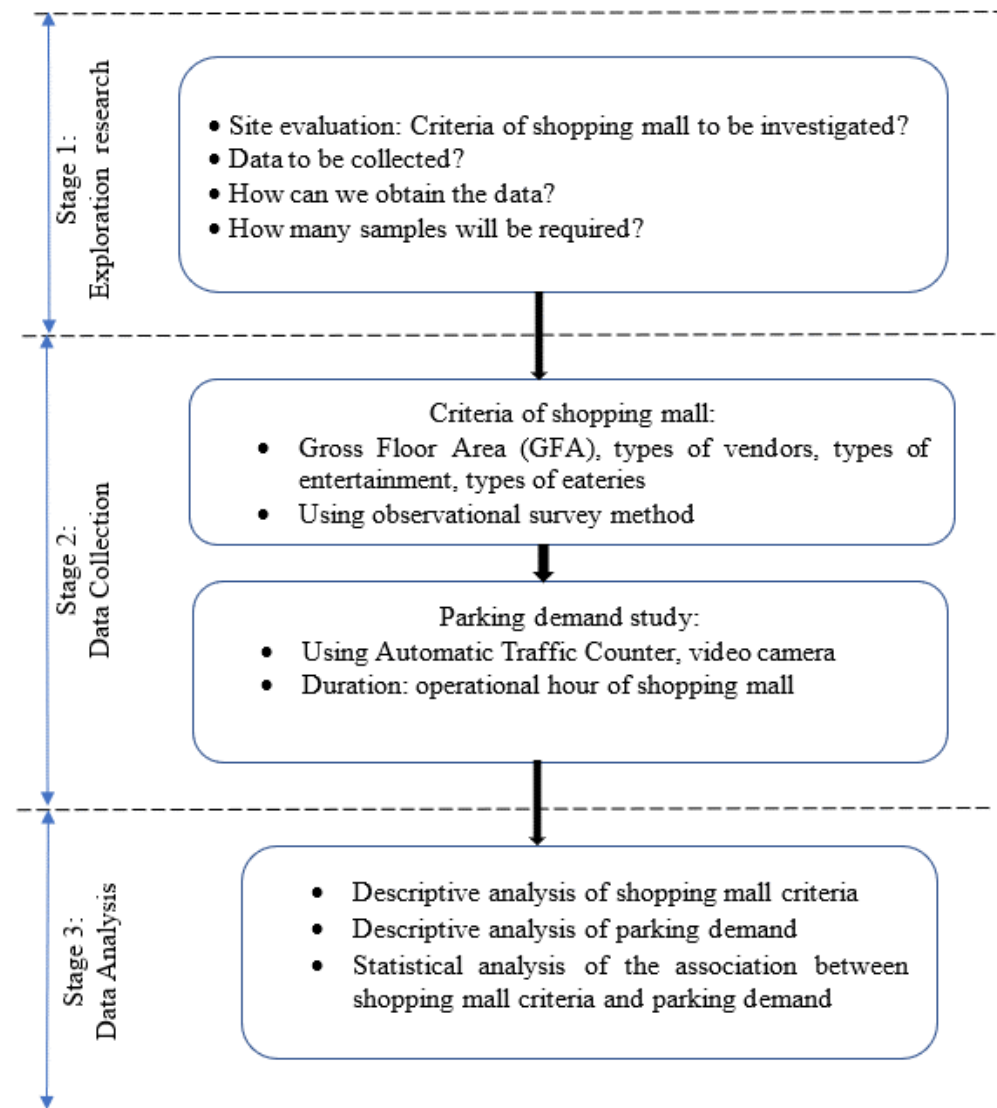


Figure 4.2 Research Design for Correlational Quantitative Research

Quantitative Research Design: Experimental (Simulation)

It is worth to question on why do we need to conduct the simulation research? Simulation research is conducted as a way of non-destructive and safe method in exploration research especially research that involve ethical issues. For example, we are interested to know whether it is possible for us to assess the changes on signal control operation systems at signalised crossings to give equal priority to both vehicle and pedestrian. We can ask that is it possible to conduct this study on

experimental based on site? It could be hazardous and fatal to bring it on the real site. Therefore, simulation research is justified in this case.

Now, we look into how can we formulate research design for this kind of research based on the following research scenario. Figure 4.3 shows research design related to the research scenario that been formulated.

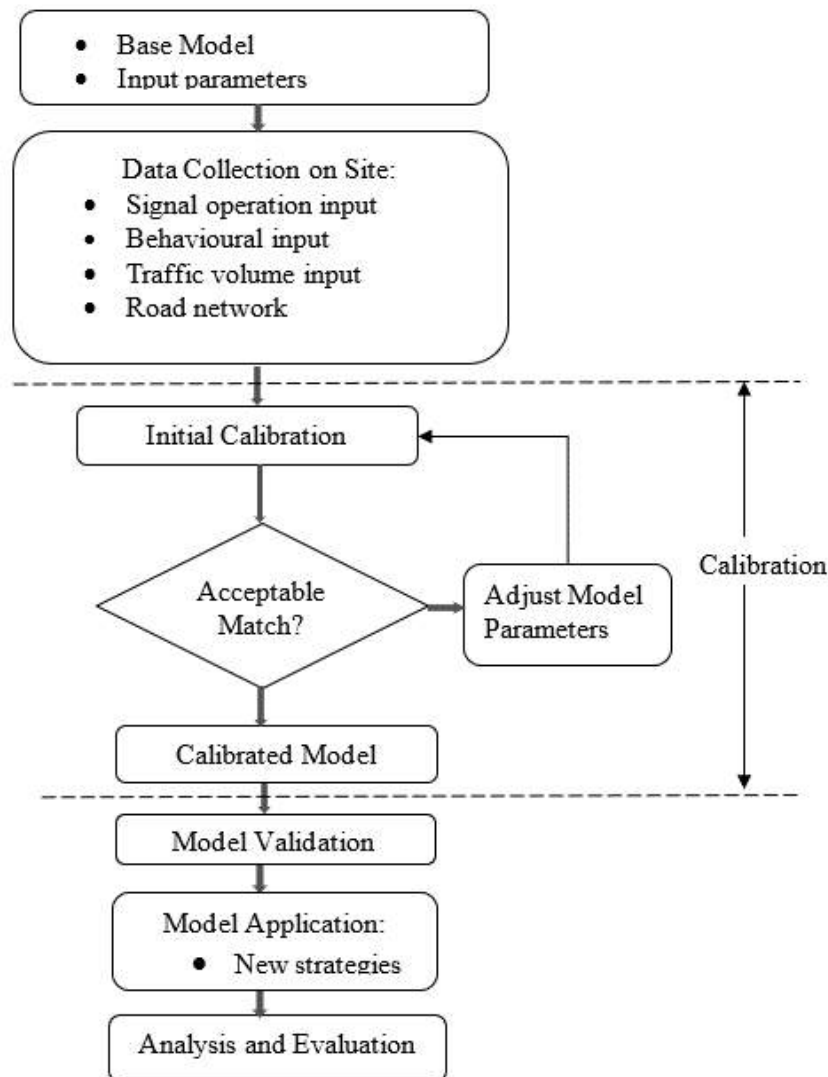


Figure 4.3 Research Design for Simulation Quantitative Research

Problem formulation: Can we provide equal priority for both vehicle and pedestrian at signalised crossings?

Aim : This research aims to improve signal control system at

- signalised crossings to provide equal priority to vehicle and pedestrian.
- Objectives : To achieve the aim, the following objectives are formulated:
- i. To assess current facilities at signalised crossings
 - ii. To develop new control strategies to improve facilities at signalised crossings
 - iii. To assess the impact of new control strategies on road users (vehicle and pedestrians) in a range of scenarios.

Research design for simulation qualitative research as shown in Figure 4.3 is designed in such a way it can help researchers in seeing the connection between the problem statement and what need to be done to achieve the aim of the research.

Qualitative Research Design: Case Study

Figure 4.4 shows research design related to the research scenario formulated above.

Problem formulation: Cement is a major component of concrete which is the most widely used construction material in the world. Is it effective to use green materials as supplementary cement replacement in Malaysia construction industry?

Aim : This research aims to determine the effectiveness of the implementation of green materials as supplementary cement replacement in Malaysia construction industry.

Objectives : To achieve the aim, the following objectives are formulated:

- i. To determine the level of awareness and compliance on the application of green materials as supplementary cement replacement.
- ii. To identify major challenges hindering the application of green materials as supplementary cement replacement.
- iii. To analyse key strategies that could be adopted to promote the application of green materials as supplementary cement replacement.

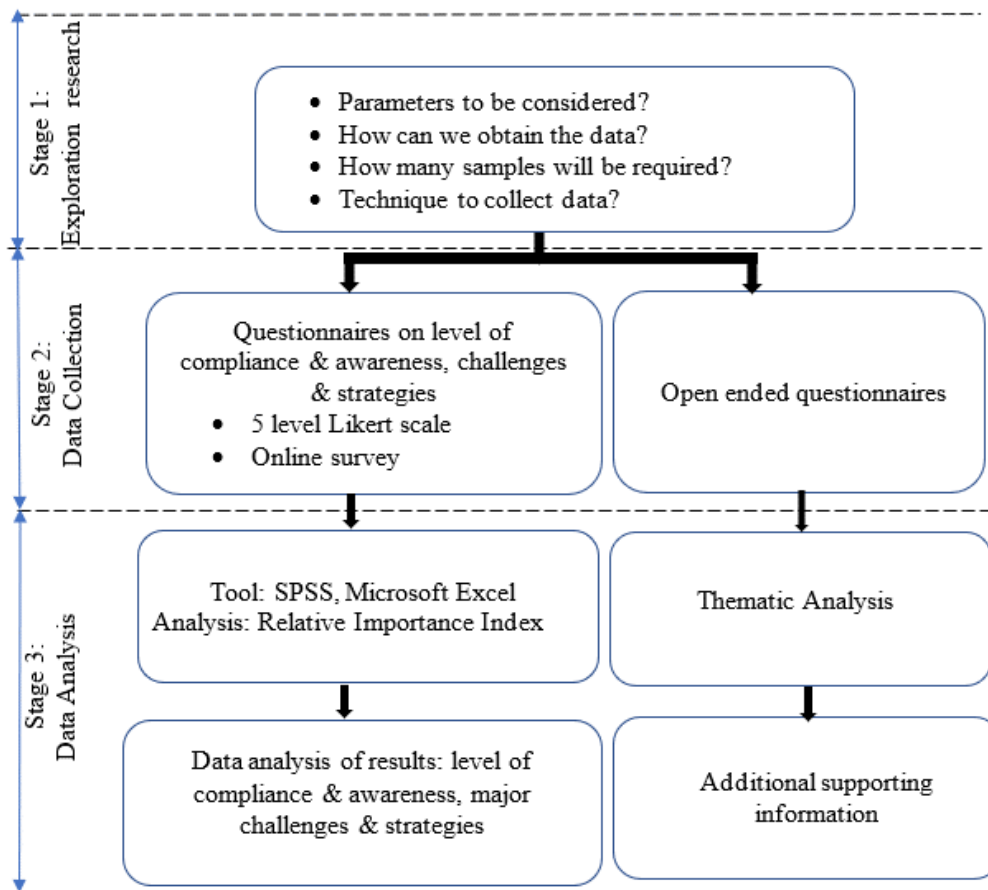


Figure 4.4 Research Design for Qualitative Research

4.3 SUMMARY

It is important for researchers to identify the type of research to be conducted. From this, an effective research design can be planned accordingly as to answer research problem and achieve the aim. This chapter provides researchers a connection between research problem formulation, aim and objectives, scope of research, and research methods. Research problem formulation and research methods are cyclical process. Too often, we have to go back to research problem or research methods in order to make sure that they are aligned. Researcher's personal interest, availability of resources such as materials or equipment, financial constraint and many others have to be considered to provide a more realistic view in the research process. Well-developed research design can help researchers in minimising errors in techniques to

be implemented in research. One of the techniques in research is experimental method. This technique is discussed in the next chapter.

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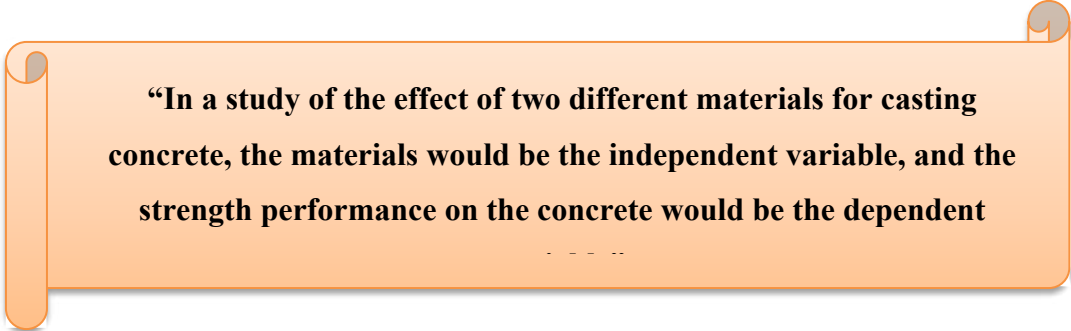
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CHAPTER 5

Experimental Method

5.1 INTRODUCTION

An experiment is basically a collection of research designs, guidelines for using them, principles and procedures for determining the quality of a study. Besides, the experimental method employs systematic and scientific research approaches, where one or more variables are manipulated, and any variable changes are controlled and measured. Generally, the aim of experiments is to evaluate how strong the targeted variables relate with each other. During the testing, the variable that influences others is termed as the independent variable, while that which those that are being influenced are the dependent variables (Oskar, 2008).



“In a study of the effect of two different materials for casting concrete, the materials would be the independent variable, and the strength performance on the concrete would be the dependent

The experimental research method is a quantitative method designed to discover the effects of presumed causes. The key feature of this method is that one thing is deliberately varied to see what happens to something else, or to discover the effects of presumed causes. For instance, people attempt various eating regimens or exercise to check whether they will shed pounds. Others may get training to check whether that will prompt a superior activity. Still others may change their eating routine to check whether it will bring down their blood cholesterol level (Christensen et al., 2004). As you can see, both scientists and non-scientists use experimentation to try to identify causal relationships. However, scientific experimentation differs

from non-scientific experimentation in that the scientist makes a deliberate attempt to make observations that are free of bias. Both methods attempt to identify causal relationships. These are what has been defined as Experimental Methods. Figure 5.1 shows the key elements in the experimental method.



Figure 5.1 Experimental Method

5.2 FIELD EXPERIMENTS

Field experiments take place in real-life settings such as a classroom, the work place or even the high street. Field experiments are much more common in construction management field than laboratory experiments. In fact, they hardly ever use lab experiments because the artificial environment of the laboratory is so far removed from real life that most of them believe that the results gained from such experiments tell very little about how respondents would actually act in real life. It is actually quite easy to set up a field experiment. As an example:

“If you wanted to measure the awareness of using Building Information Modelling (BIM) in real construction projects for example, all you would need to do is to get the respond from construction projects manager and players to check their awareness, type of projects and level of implementation on current projects.”

Besides, field experiments obviously have better external validity than lab experiments because they take place in normally occurring social settings.

Practically, it is possible to do field experiments in large institutions – in construction industries in which thousands of people interact for example which is not possible in laboratory experiments. However, it is not possible to control the variables as closely as with the laboratory experiments. The Hawthorne Effect may reduce the validity of the results. This effect is where respondents may act differently just because they know they are part of an experiment.

The Hawthorne Effect was an expression authored by Elton Mayo (1927) who researched into laborers' profitability at the Western Electric Company's Hawthorne plant. With the laborers understanding (they realized that a test was occurring, and the reason for the analysis), Mayo set about fluctuating things, for example, lighting levels, the speed of transport lines and can breaks. Notwithstanding, whatever he did, the laborer's profitability constantly expanded from the standard, in any event, when conditions were compounded. He reasoned that the respondents were basically attempting to satisfy the researcher. Figure 5.2 summarizes the advantages and disadvantages of field experiments compared to lab experiments.

5.3 LABORATORY EXPERIMENTS

Laboratory experiments happen in controlled environments and are the most method used should follow the established methods and standards. Previous researches have undertaken experiments to validate scientific theories regarding the melting and freezing temperatures of various substances, and the reactional outcomes of combining various chemical under set conditions. Rationally, the experimental method sets a controlled environment, where the researches can precisely determine the cause and effect relationships that exists among independent and dependent variables. Experimental outcomes enable the researcher to predict the probable future reactions of the dependent variable when put in similar or different conditions (Karl, 2016). The laboratory experiment and commonly used in civil engineering, where experiments are used to measure the laboratory scale specimens compared to the real sizes structures.

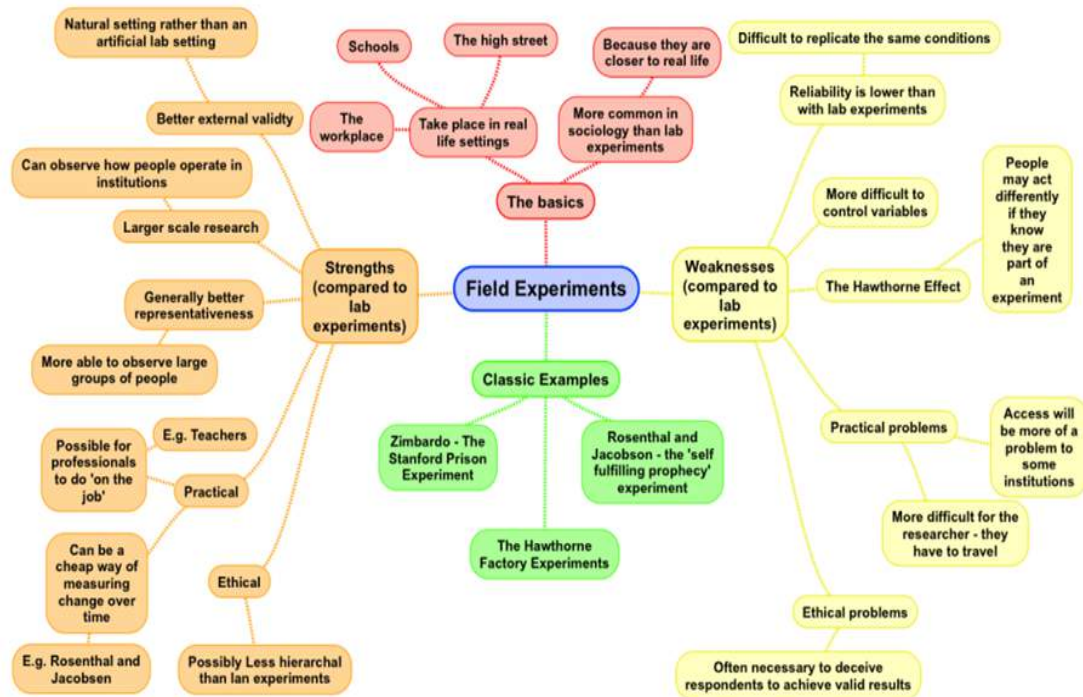


Figure 5.2 Advantages and disadvantages of field experiments compared to lab experiments (Karl, 2016)

Figure 5.3 shows the research flow for the laboratory experimental work. The controlled conditions of laboratory experiments allows the isolation of variables more effectively compare to other methods used in research. As a result, the researcher can precisely and exactly measure how the independent variables affect the selected dependent variables. Further, having controlled conditions is important in enabling the elimination of the influence of ‘extraneous’ variables. These variables are considered of no interest to the particular research and as a result undesirable since they might interfere with the experiment outcomes (Karl, 2016).

The excellent reliability of laboratory experiment is due to two main reasons. First, working in a controlled environment enables the replicability of the conditions used in the original experiment. Further, the replication is eased through the probability of outlining the exact procedure of the experiment. This approach is unlike that of field experiments where extraneous variables effects in the original experiment may interfere with the subsequent replicative experiments. Secondly,

laboratory experiments are reliable since the researcher and the respondent are almost completely detached from each other.

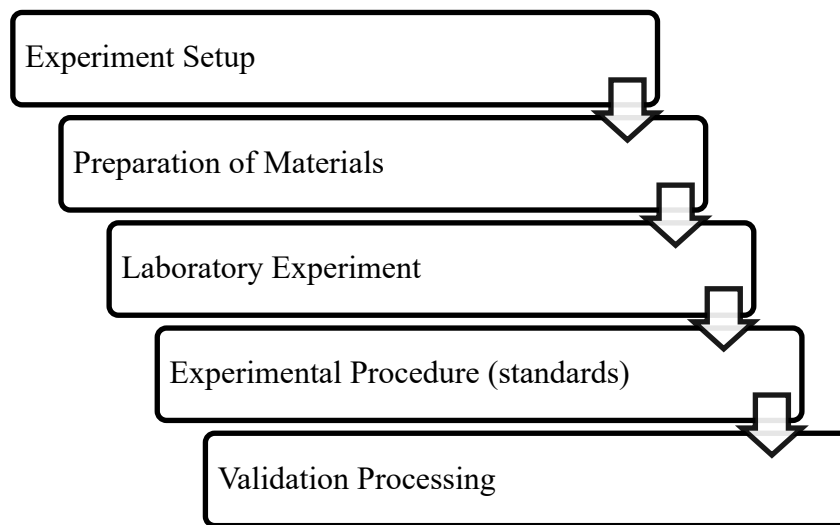


Figure 5.3 Research flow for laboratory experiments

During laboratory experiments, the role of the exporter is set to an ‘expert’ tasked with manipulating variables. As such the interaction between the researcher and the respondents is limited throughout the experiment. Therefore, the values of the researcher also do have little influence on the reaction of the respondents to the experiment (Karl, 2016). Table 5.1 shows the example of laboratory experiments in sub area in civil engineering.

Table 5.1 Example of laboratory experiments

| Research Area | Example of Laboratory Experiments |
|---------------|---|
| Structure | Investigation on the strengthening of column using different parameters (type of materials, spacing, numbers) on the strength and deflection of column. |
| Material | If researchers were trying to measure the effects of different types of cement replacement on reaction in concrete, keeping specimens in a lab means the specimens are curing in similar conditions (temperature, humidity, location) and testing for the same test (compressive strength). |

Table 5.1 Example of laboratory experiments (continue)

| Research Area | Example of Laboratory Experiments |
|----------------|--|
| Environment | The experimental testing to determine the effect of natural coagulant on coagulation performances based on residual turbidity and removal of organic compounds. A series of jar test is conducted under specific agitation speed and sedimentation time. To confirm the effectiveness of natural coagulant, a control using conventional coagulant such as alum needs to be tested under similar operating conditions. |
| Hydraulic | Investigation of sediment transport rate and direction in a river. Construct the scaled river model and measure the flow velocity and sediment profile using velocimeters and point gauge, respectively. |
| Transportation | The experimental testing for measurement of thermal conductivity of pavement material. The thermal conductivity of plate specimens was measured using a heat flow meter at temperature of 50°C, according to standard. |
| Geotechnics | The experimental testing was conducted to study the performance of bearing capacity on soft clay soil under vertical loading treated by kenaf fibre geotextile. A small-scale modelling test was carried out to investigate the effect of the kenaf geotextile depth laid beneath the rigid footing on the bearing capacity of the soft soil. |

5.4 DATA COLLECTION

Data collection is an important aspect of the research. If data is collected inaccurately, the experimental outcomes may be false. Data collection refers to the process of gathering and evaluating information regarding the chosen variables. The data collection process is often carried within a pre-set systematic order that is optimized to respond to the research questions, enables hypothesis testing, and comparing results. There are various data collection methods, and are vital regardless

of the choice of field of study. It is therefore, important that the data collection process is accurate to ensure the research integrity.

To ensure integrity of the research and eliminate mistakes, it is important that the research selects the most appropriate tools for collection of data, and well-defined guidelines. Undertaking a formal process of data collection is necessary since it ensures the accuracy and definitiveness of the collected data, which in turn ensure effective decision-making from the result of the data analysis. The data collection should therefore indicate a measuring standard, and to an extent the advancement choice (Belyh, 2017). Figure 5.4 shows the successful steps of data collection.



Figure 5.4 Successful steps of data collection

5.4.1 Data Collection Methods

There are several methods of acquiring data. These methods of data collection can be put into two groups. These categories are the secondary methods and the primary methods of collecting data. Figure 5.5 shows the methods of data collection.

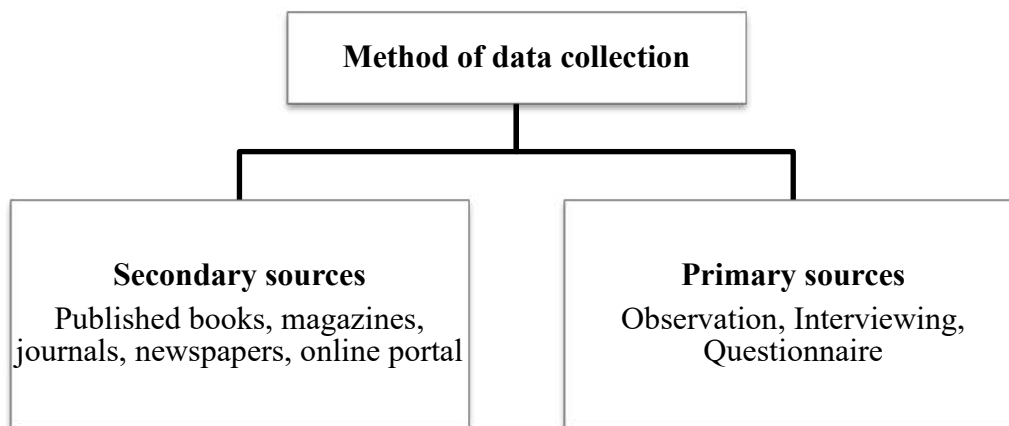


Figure 5.5 Methods of data collection

Secondary data can be obtained from published books, journals, magazines, newspaper, and online portals. Regardless of the area of research these sources are rich in information for discipline areas such as the environment, structure and geotechnics. However, it is the use of the right criteria set in the selection of secondary data that is important for enhancing the research's validity and reliability levels. The factors considered in setting a criteria for secondary data collection include the credentials of the writer, the date of publication of the source, the reliability of the source, discussion quality, the depth of analyses, and the relevance of the source towards addressing the objectives of the research among others (Dudovskiy, 2018). The advantages of use of secondary data collection methods include:

- Consumption and requirement of relatively less resources and labour
- Ease of accessibility of relevant sources
- Immediate availability of data
- Guaranteed quality of the collected data.
- The availability of alternative research methods.

- The researcher is aware of potential challenges relating to the research.

Primary data collection, on the other hand, can be divided into two-quantitative and qualitative methods. Quantitative data collection methods are based on mathematical calculations. Quantitative methods of data collection include close-ended questionnaires, correlation and regression procedures, and mean, mode, and medians. Preparing and employing the quantitative data collection methods is relatively cheaper and consumes less time. Further, these methods allows for easy comparison of outcomes since there are highly standardized. Qualitative research methods, on the other hand, do not involve mathematical calculations or involve numerals. Qualitative research methods employ words, emotions, sounds, colours and other elements that cannot be directly quantified. The main aim of qualitative studies is to ensure that the researcher acquires an in-depth understanding of the topic of interest. The methods for qualitative data collection include interviews open-ended questionnaires, observation, focus groups, case studies, and game or role playing (Dudovskiy, 2018).

5.5 DATA ANALYSIS

Data analysis is the process of evaluating data using analytical and statistical tools to discover useful information and aid in decision making. There are a several data analysis methods including data mining, text analytics, business intelligence and data visualization (example: graph, histogram, chart etc.). An analysis is aimed at providing observations that can be used in making appropriate conclusions. In the absence of undesirable variables that may compromise the outcomes, the results of the research can be generalized to a broader phenomenon (Shuttleworth and Wilson, 2008; Oskar, 2008). If the researcher suspects that the effect stems from a different variable than the independent variable, further investigation is needed to gauge the validity of the results. An experiment is often conducted because the researcher wants to know if the independent variable is having any effect upon the dependent variable. Variables correlating are not proof that there is causation (Oskar, 2008).

5.6 PERFORMANCE OF OUTPUT

Performance of an output is crucial to be evaluated in order to ensure a correct and precise presentation of data are answering the designated research questions. Otherwise, the outputs can sometimes misleading. The performance of an output can be evaluated based on data validation and control experimentation.

5.6.1 Data Validation

Data validation or input validation involves ascertaining that a clean and clear data is delivered to the process that utilize it including applications, programs, and services. The process of data validation involves checking for data integrity and validity through by running it through various software and components. The aim of data validation is to ensure that the data is compliant to pre-set requirements and quality standards.

Data validation ensures the accuracy, completeness, security, and consistency of the data set. To achieve this goal, the data is subject to routine validation checks and rules. Validation rules are contained within the data dictionary and are implemented through the use of data validation software (Data validation, 2017). Generally, validation indicates the soundness of the research, and specifically relates to the design, and methods used in the research. Valid data entry indicates that the researcher's findings are truly representative of the phenomenon being measured. Claims that are valid are considered valid (Henrichsen, 1997). As an example:

“We conduct experimental work in lab. The validation process is conducted by comparing the output of the experiment with the analytical theory. The output is considered validated if the experiment output is approximately similar to output of analytical theory or in a range of allowable error.”

5.6.2 Control Sample

In an experiment, a control refers to an observation that is meant to minimize the effects of the dependent variables, and are part of scientific methods. Control use enhances the result reliability, as it is a comparison between the measurements of the control and that of other variables. The use control eliminates alternative explanation of the experiment outcomes, including errors, and biases in the experiment. It is important that proper controls are selected and used (including eliminating confounding variables), although it is a difficult task (Scientific control, n.d.). For example:

“If a researcher immersed fifty concrete in sulphate solution and observes ten of them subsequently deteriorated which the underlying cause could be the solution itself or something unrelated. Other variables, which may not be readily obvious, may interfere with the experimental design. For instance, the solution might be mixed with a dilutant and it might be the dilutant which causes the effect. To control for the effect of the dilutant, the same test is run twice; once with the solution in the dilutant, and another done exactly the same way, but using the dilutant alone. Now the experiment is controlled for the dilutant and the experimenter can distinguish between solution, dilutant and normal condition.”

However, when a confounding factor cannot be easily eliminated from the main treatments it is important that a control is included. For instance:

“It may be necessary to use a tractor to spread fertilizer where there is no other practicable way to spread fertilizer. The simplest solution is to have a treatment where a tractor is driven over plots without spreading fertilizer and in that way the effects of tractor traffic are controlled.”

The most straightforward kinds of control are negative and positive controls, and both are found in a wide range of sorts of trials. These two controls, when both are effective, are typically adequate to dispense with most potential perplexing factors: it implies that the trial creates a negative outcome when a negative outcome

is normal, and a positive outcome when a positive outcome is normal (Scientific control, n.d.).

5.7 LIMITATION

Every study has limitations due to constraints on research design or methodology, and these factors may impact the findings of study. In any case, numerous researchers are hesitant to examine the constraints in their papers, groping that bringing impediments may undermine its exploration esteem according to perusers and analysts. Although limitations address the potential weaknesses of a study, writing about them at the end of the paper actually strengthens the study by identifying any problems before researchers or reviewers find them. Pointing out the limitations shows that researcher have considered the impact of research weakness thoroughly and have an in-depth understanding of the research topic. Since all studies face limitations, being honest and detailing these limitations will impress researchers and reviewers much more than ignoring them. Limitations that arise from situations relating to the researchers (whether the direct fault of the individuals or not) should also be addressed and dealt with, and remedies to decrease these limitations—both hypothetically in your study and in future studies—should be proposed (How to present study limitations and alternatives, n.d.).

Limited access to data

The problem of limited access to research respondents arises if the research involved studying specific people and organizations. Limited access to respondents necessitates the need to restructure the design of the research in a more manageable way. The researcher is thus expected to explain why there is limited access and also ensure that despite the limitations the available findings are reliable and valid.

Time constraints

Academic researchers face the challenge of meeting deadlines for journal manuscript submission, just like students rush to meet deadlines for class papers. The deadline of the assignment therefore limits the time available for studying the research problem

and measuring related changes. It is important that one chooses a research problem that they can complete before the set deadline. Also, it is important that any time constraints are mentioned alongside the need for future studies (such as longitudinal studies) to address such constraints.

Conflicts arising from cultural bias and other personal issues

Researchers are subject to bias in their views due to the cultural perspectives of certain events. This bias may affect the legitimacy of the study outcomes. Researcher bias can also be found towards certain hypothesis or arguments of their preference. Biases can be avoided through examining the appropriateness of the statement of problems and gathering of data.

5.8 SUMMARY

It is important to identify the type of experimental method to be conducted. An effective method can be planned accordingly in order to answer research problem and achieve the aim. The discussion in this chapter provides researchers an experimental method including fields or laboratory experiments. A formal data collection process is necessary as it ensures the data gathered are both defined and accurate and that consequent decisions based on opinions embodied in the results are effective. The performance of output should be validated by software or control sample. Well-developed experimental method can help researchers in minimising errors. Technique validating the data collection is discussed in the next chapter.

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CHAPTER 6

Questionnaire

6.1 INTRODUCTION

Why do you need questionnaire?

If you plan to collect information regarding on opinion from various stakeholders, questionnaire is the best option. Questionnaire is a suitable survey research instrument for problem that required trend, pattern and frequency. Student tends to assume that survey and questionnaire are alike. On the contrary, questionnaire is a subset of survey. Table 6.1 shows the differences between questionnaire and survey.

Table 6.1 Difference between questionnaire and survey

| | QUESTIONNAIRE | SURVEY |
|----------------|--|--|
| Definition | A set of questions or other types of prompts that aims to collect information from a respondent. | A method to collect data from a pre-defined group of respondents to gain information and insights on various topics of interest. |
| What? | Instrument of data collection | Process of collecting and analyzing that data |
| Characteristic | A part of survey | Consists of set of questionnaires, interviews and data collection |
| Cost | Economy | Expensive |
| Usage | Conducted on the target audience | Distributed or conducted on respondents |

6.2 PROCESS

A good questionnaire should consist of items that can stimulate the respondents so that they will develop an interest towards the questionnaire. Figure 6.1 shows the process to develop a good questionnaire.

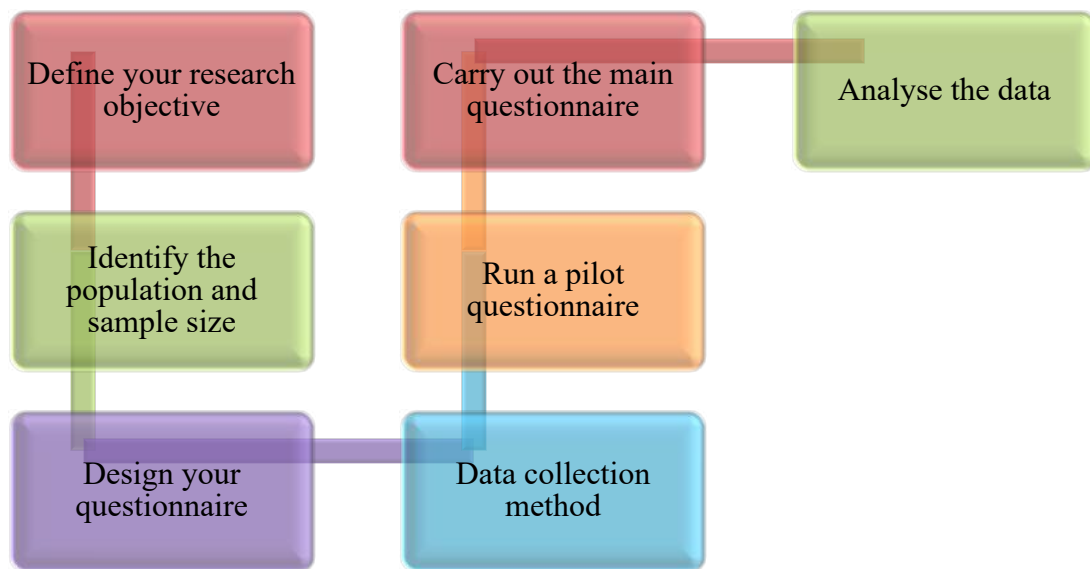


Figure 6.1 Process of questionnaire preparation

6.2.1 Define Research Objective

Based on the research objectives developed in Chapter 4, student has to choose which objective that requires questionnaire. For example, the objective of the research is to study the awareness of rainwater harvesting system among residential owner. Thus, the purpose of the questionnaire is to obtain the opinion of the respondent (residential owner) about the rainwater harvesting system in order to assess their awareness level.

6.2.2 Identification of Population and Sample Size

A population is known as the entire group of people, while a sample is a portion, which represents the population. Table 6.2 shows a formula to determine the sample size from a known population (Bartlett et al., 2001). Known population is a

population with a number of respondent that specified clearly in the research scope. On the contrary, for an unknown and outnumbered population, a sample size of 30 respondents is needed as a rule of thumb as well as for sample which is broken into sub-samples e.g. race, gender, etc. (Kumar et al., 2013).

Table 6.2 Minimum returned sample size for a given population size for continuous and categorical data (Bartlett et al., 2001)

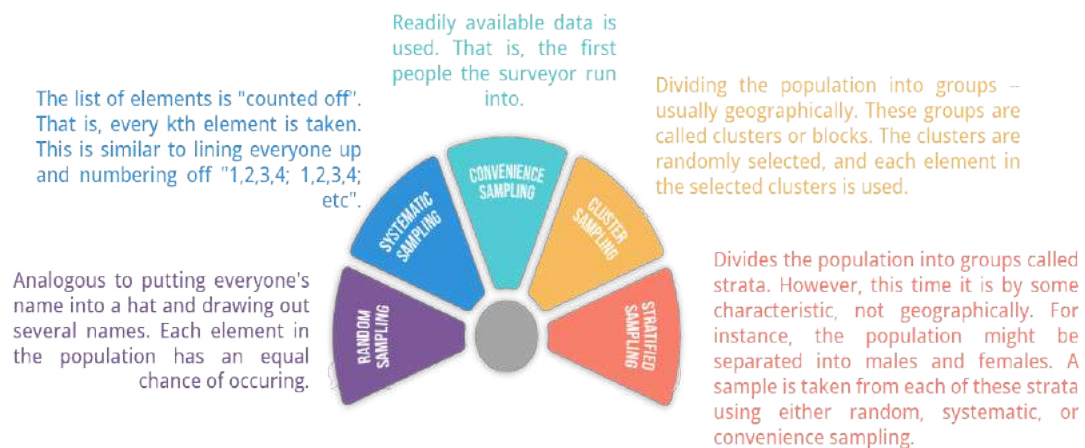
| Population size | Sample size | | | | | |
|-----------------|-----------------------------|-----------------------------|-----------------------------|----------------------|----------------------|----------------------|
| | Continuous data | | | Categorical data | | |
| | $\alpha = 0.50$ t = 1.65 | $\alpha = 0.05$ t = 1.96 | $\alpha = 0.01$ t = 2.65 | p = 0.50 t = 1.65 | p = 0.50 t = 1.96 | p = 0.50 t = 2.65 |
| 100 | 46 | 55 | 68 | 74 | 80 | 87 |
| 200 | 59 | 75 | 102 | 116 | 132 | 154 |
| 300 | 65 | 85 | 123 | 143 | 169 | 207 |
| 400 | 69 | 92 | 137 | 162 | 196 | 250 |
| 500 | 72 | 96 | 147 | 176 | 218 | 286 |
| 600 | 73 | 100 | 155 | 187 | 235 | 316 |
| 700 | 75 | 102 | 161 | 196 | 249 | 341 |
| 800 | 76 | 104 | 166 | 203 | 260 | 363 |
| 900 | 76 | 105 | 170 | 209 | 270 | 382 |
| 1000 | 77 | 106 | 173 | 213 | 278 | 399 |
| 1500 | 79 | 110 | 183 | 230 | 306 | 461 |
| 2000 | 83 | 112 | 189 | 239 | 323 | 499 |
| 4000 | 83 | 119 | 198 | 254 | 351 | 570 |
| 6000 | 83 | 119 | 209 | 259 | 362 | 598 |
| 8000 | 83 | 119 | 209 | 262 | 367 | 613 |
| 10000 | 83 | 119 | 209 | 264 | 370 | 623 |

Note: The margins of error in the table were .03 for continuous data and .05 for categorical data. Researchers may use this table if the margin of error shown is appropriate for their study; however, the appropriate sample size must be calculated if these error rates are not appropriate.

Generally, a sample size for research activities can be determined by the following equation (Krejcie and Morgan, 1970):

$$SS = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)} \quad (6.1)$$

where SS is the required sample size; X^2 is the table value of chi-square for 1-degree of freedom at the desired confidence level; N is the population size; P is the population proportion (assumed to be 0.50 since this would provide the maximum sample size; and d is the degree of accuracy expressed as a proportion (0.05).



6.2.3 Questionnaire Design

Questionnaire consists of multiple sections. Generally, it starts with demographic section. In this section, respondents answer questions about personal details such as gender, age, race, etc. This section usually used to categorize respondents according to specific groups. The purpose of demographic study is to provide easy questions to make the respondent feel comfortable answering next section.

Table 6.3 shows the type of questions can be used in questionnaire design. For example, the objective of the study is to obtain the perception of stakeholders towards the oil and gas pipeline owner, which its asset involved in an accident. The questions are related to the reputation loss-contributing factor towards pipeline owner. The respondent need to select the level of influence of each factor towards the loss of the pipeline owner's reputations.

Table 6.3 Types of Questionnaire

| Types | Details | Example |
|---------------------------|--|---|
| Open vs. Closed Questions | Open-ended questions are questions that can be answered in depth and allow for original, unique responses. Closed-ended questions are questions that can only be answered by selecting from a limited number of options, usually multiple-choice, 'yes' or 'no', or a rating scale | Open ended question: What is your opinion on rainwater harvesting concept? Closed ended question Do you use rain water harvesting in your house? |
| Ranked Responses | The Ranking question asks respondents to compare items to each other by placing them in order of preference. | Rank (1-5) the most important subject according to your preferences: Soil mechanics () Financial management () Highway () Law and Contract () Material () |
| Rated Responses | Three-point, five-point, and seven-point scales are all included in the umbrella term "rating scale". A rating scale provides more than two options, in which the respondent can answer in neutrality over a question being asked. | Five-point Scales (e.g. Likert Scale) Strongly Agree Agree Undecided / Neutral Disagree Strongly Disagree |
| Dichotomous Questions | A dichotomous scale is a two-point scale which presents options that are absolutely opposite each other. This type of response scale does not give the respondent an opportunity to be neutral on his answer in a question. | Yes- No True - False Fair - Unfair Agree – Disagree |

The last section will be questions in open-ended form, where the respondent can express their opinions or any additional information of the factors that was not included the previous section. The sections of the questionnaire not necessarily consists of three section, it depends on the requirement of the study. Student may refer to various previous example questionnaires to develop the idea to design the questionnaire. Figure 6.2 shows the flow of the sections involved in a questionnaire.



Figure 6.2 Questionnaire sections

6.2.4 Data Collection

The questionnaire can be distributed in various ways.



6.2.5 Pilot Study

Pilot study is a trial small scale test on the response of the respondents on the questionnaire. The function of this study is to evaluate feasibility, duration and improvement idea upon the study design prior to performance of a full-scale research project. In this stage, minimum 10 respondents are sufficient. Once the responses retrieved, main questionnaire is developed based on the comments in the pilot study.

6.2.6 Data Analysis

Data analysis tool

There are numerous number of data analysis tools available in the market. However, MS Excel and SPSS are among the popular choice selected by researchers. Most of the questionnaire analysis generate data based on simple statistical calculation (i.e means, median etc). Hence, the use of Microsoft Excel is already sufficient. On the other hand, SPSS is a widely used program for statistical analysis in social science. It is also used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners, and others (Leech et. al. 2014).

Frequency analysis

The frequency of an observation is the number of times the observation occurs in the data. Frequency analysis measures central tendency of the data and its dispersion, which is portrayed in tables or graph. It was used for all types of surveys and consists of multiple choice and ordinal questions. Responses were analyzed by number of frequency or percentage using data analysis tool such as Microsoft Excel and SPSS; the highest value shows the most preferred answer among respondents. The calculation of percentage is shown below.

$$\text{Percentage (\%)} = \frac{f}{N} \times 100 \quad (6.2)$$

where f is the frequency of an observation and N is the number of respondents.

Reliability analysis

Information relative to perceptions and opinions normally involve Likert-scaled questions as the available qualitative data is unable to be measured directly; this assessment of attitude was introduced by Rensis Likert in 1931 (Gliem and Gliem, 2003). It is required to calculate and report the Cronbach's alpha coefficient for internal consistency reliability when a Likert scale was used (Brown, 2002). The Cronbach's alpha reliability coefficient ranges between 0 and 1; the internal consistency of the scale increases as the value is closer 1.

The rule of thumb of the coefficients is shown in Table 6.4 (Gliem and Gliem, 2003). The reliability analysis was done on all preliminary and main questionnaire in order to obtain the internal consistency so that it achieves at least 0.70 of the Cronbach's alpha reliability coefficient, and the internal consistency is at the minimum acceptable.

Table 6.4 Cronbach's alpha reliability coefficient (Gliem and Gliem, 2003)

| Cronbach's alpha reliability coefficient, α | Internal Consistency Reliability Level |
|--|---|
| $\alpha \geq 0.9$ | Excellent |
| $0.9 > \alpha \geq 0.8$ | Good |
| $0.8 > \alpha \geq 0.7$ | Acceptable |
| $0.7 > \alpha \geq 0.6$ | Questionable |
| $0.6 > \alpha \geq 0.5$ | Poor |
| $\alpha < 0.5$ | Unacceptable |

6.3 SUMMARY

Questionnaire is a suitable survey research instrument for problem that required trend, pattern and frequency. A good questionnaire should consist of items that can stimulate the respondents so that they will develop an interest towards the questionnaire. Designing questionnaire for research required systematic approach, which include selection of suitable respondent, type of questions to be ask,

distribution platform, analysis and reliability tool. Well-developed questionnaire can help researchers in collecting effective information useful for research. Next, it is important to learn how to present the findings obtain from your questionnaire. This will be discussed in the next chapter.

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CHAPTER 7

Presenting Research Results

7.1 INTRODUCTION

Research findings are validated to determine the extent of the accuracy of the findings in representing the intended phenomena. The reliability of such study is determined to ascertain its reproducibility. The validity is sustained by several techniques such as respondent validation, triangulation use of contradictory evidence, constant comparison etc. Such findings could be represented using diagrams, graphs, charts, plots, tables and any other pictorial or suitable tabular forms.

7.2 GRAPHICAL DIAGRAMS

Graphical diagrams are visualized technique of presenting information using symbolic representations. They have been used for ages, although, now more pronounced in the current information ages. Graphical diagrams could be in two- or three-dimensional visualization but sometimes, the two-dimensional surfaces are a result of projections of the three-dimensional views. The words, graph and diagram are taken as synonyms depending on the context (Figure 7.1).

Charts are graphical illustrations of data in form of symbols such as using lines in a line chart, bars in a bar chart or slices in a pie chart. Charts are used to represent functions, numeric data or some kinds of quantitative information. They make such information easy to comprehend, compare and explain.

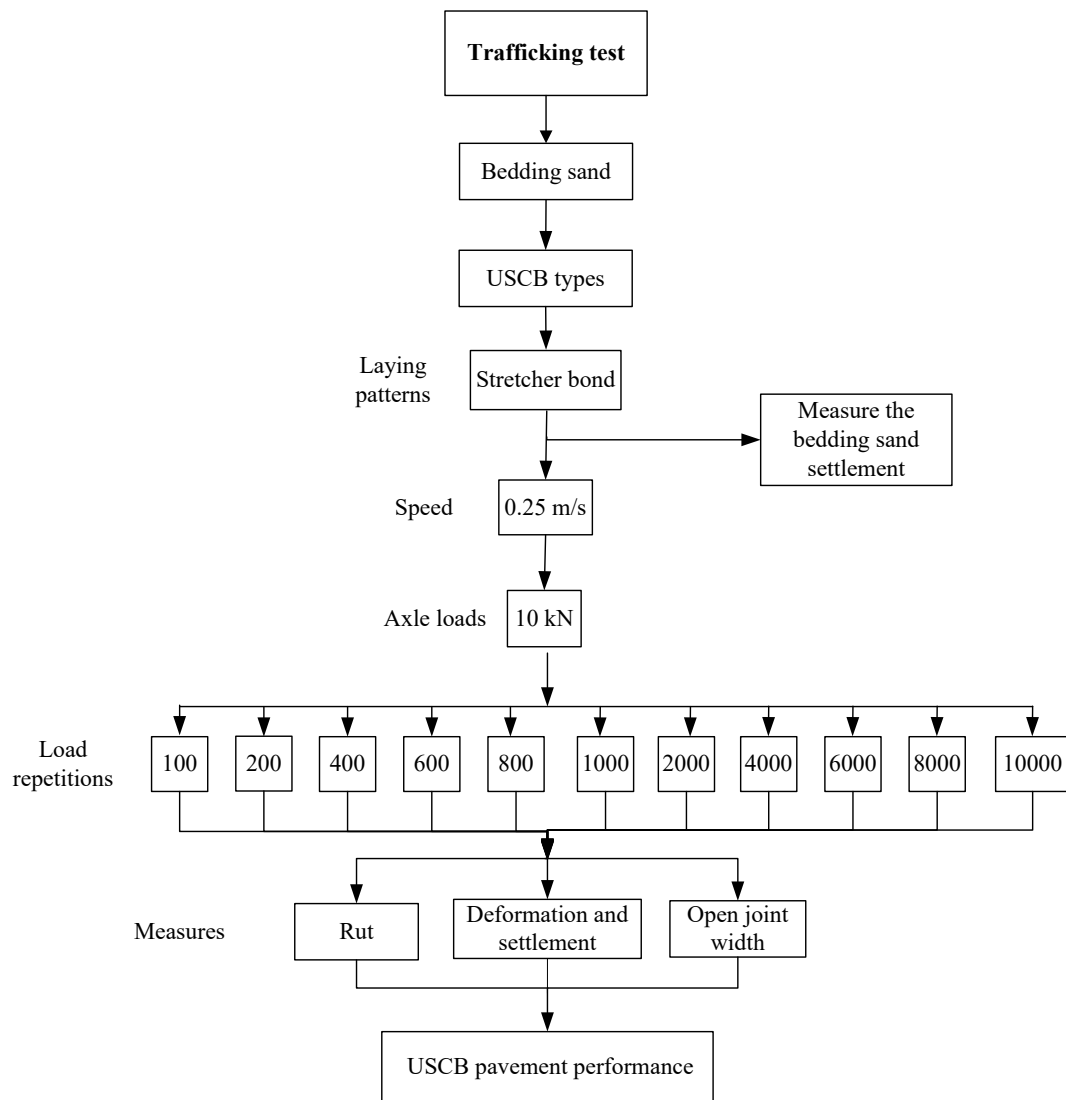


Figure 7.1 Trafficking test flowchart

7.2.1 Trend Analysis

Trend Analysis is a statistical technique that tries to determine future movements of a given variable by analyzing historical trends (Figure 7.2 – 7.6). In other words, it is a method of predicting future behaviors by examining the past events.

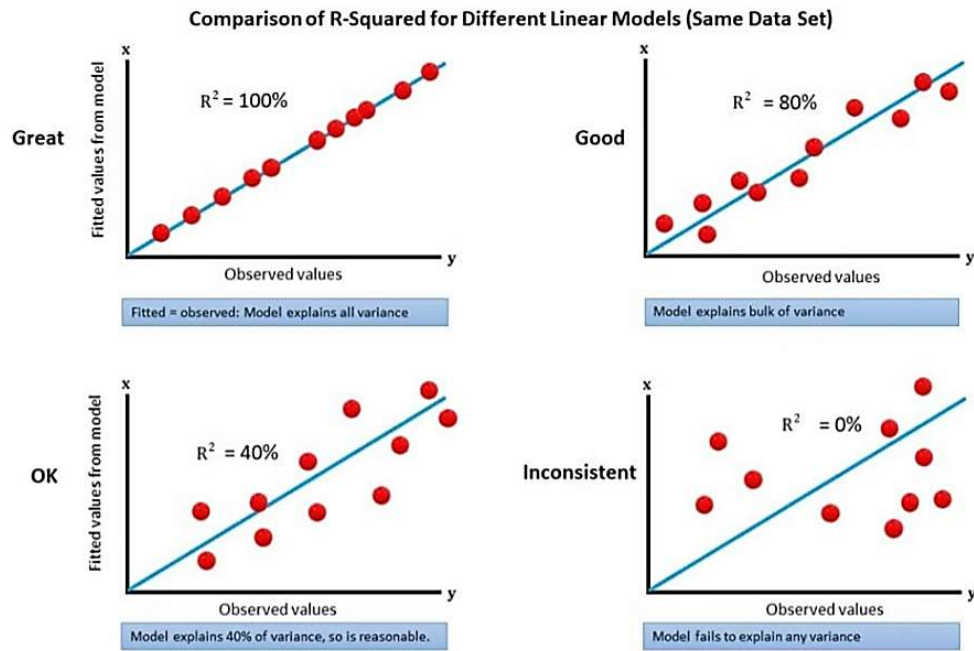


Figure 7.2 Different liner model graph

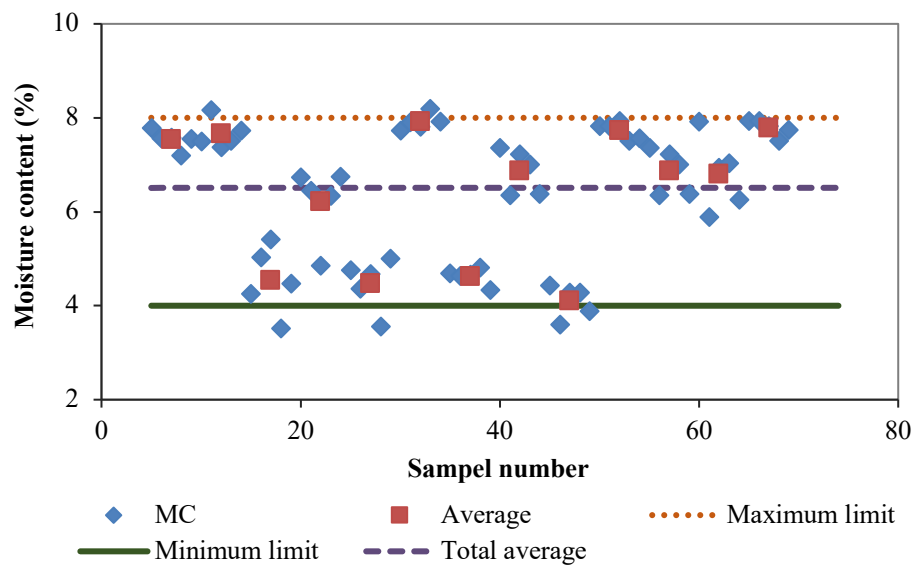


Figure 7.3 Range of data in the limit boundary

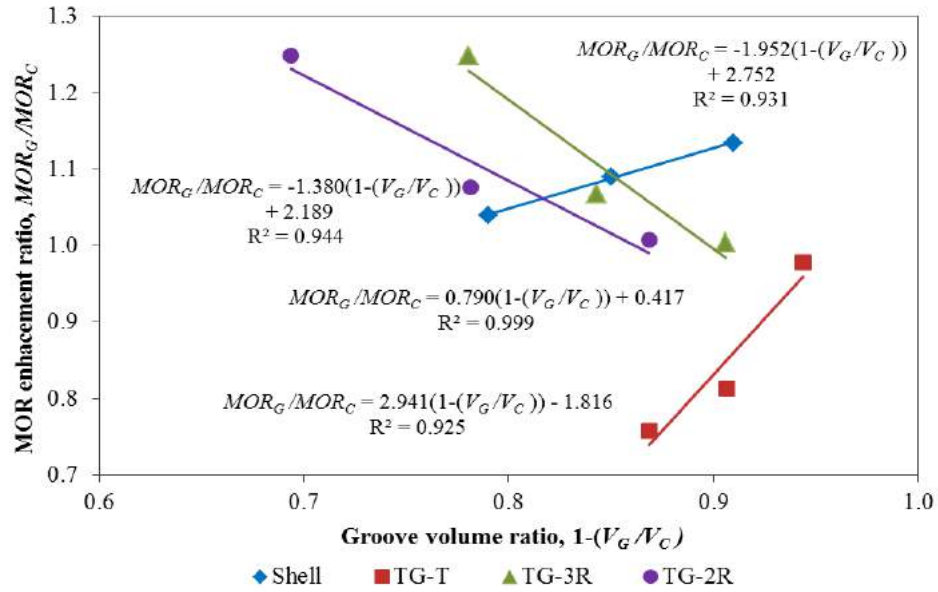


Figure 7.4 The relationship between the parameters

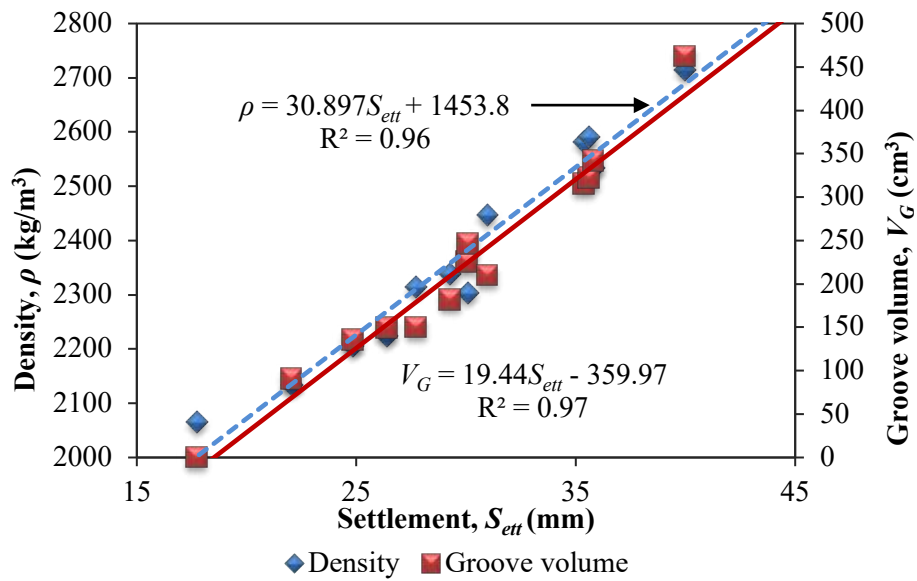


Figure 7.5 Correlation between the parameters

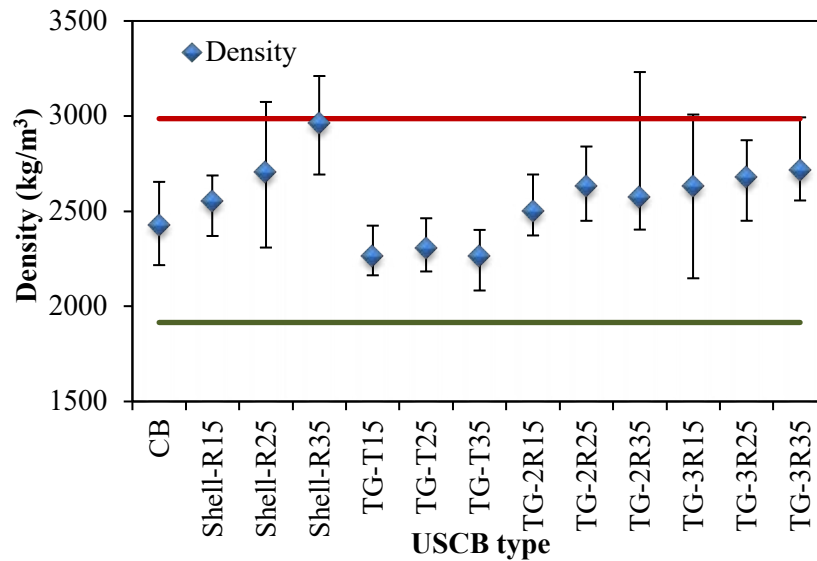


Figure 7.6 Range of data in the boundary limit and consistency of each data

7.2.2 Box Plot

In descriptive statistics, data are sometimes represented using the representations of their quartiles. Such plot is known as box plot (or boxplot). Boxplots represent a given data using a five-number summary of the main points of the data and these are the minimum value, the first quartile (Q1), median, third quartile (Q3) and the maximum value (Galarnyk, 2018).

Figures 7.7 and 7.8 show examples of boxplots, each for a distribution data and range of data in a limit boundary. Outside the upper and lower quartiles, variability is indicated in boxplots by extended vertical lines from the boxes (whiskers) at both ends, hence, the terms box-and-whisker plot and box-and-whisker diagram, as they are sometimes called. Outliers in such data and their values can be determined and are indicated as individual points on the chart. They are also used to determine the symmetry of a given data or how tightly the data is grouped as well as the skewness. Boxplots are either drawn vertically or horizontally. Figure 7.8 shows boxplots in vertical arrangement.

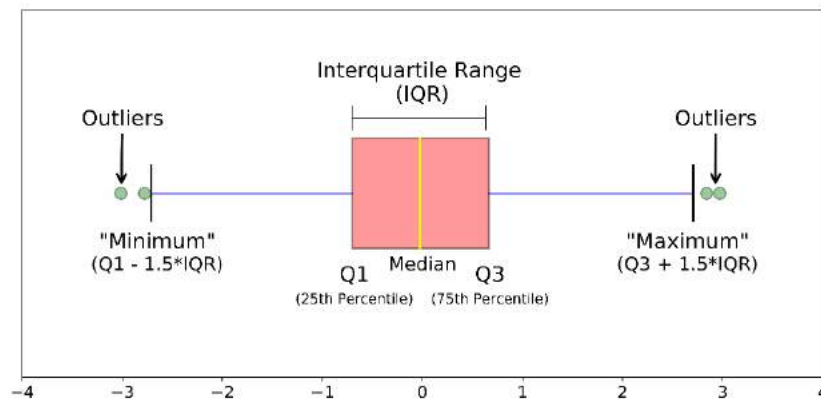


Figure 7.7 Boxplot distribution

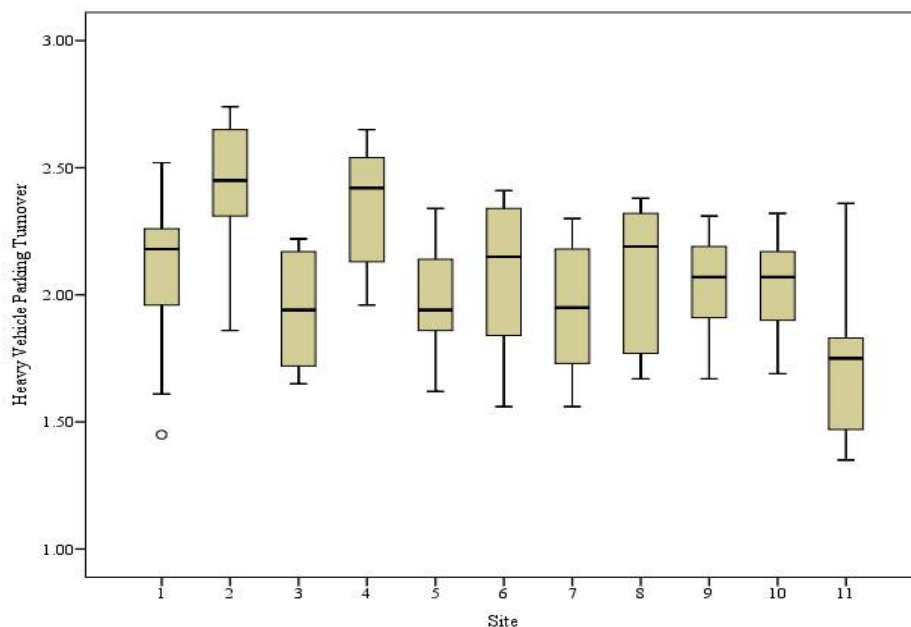


Figure 7.8 Range of data in the limit boundary

7.2.3 Error Bar

Error bars are used to reveal the uncertainty of a data points. A short error bar shows that values are concentrated, signaling that the plotted average value is more likely, while a long Error Bar would indicate that the values are more spread out and less reliable (Figure 7.9 – 7.10).

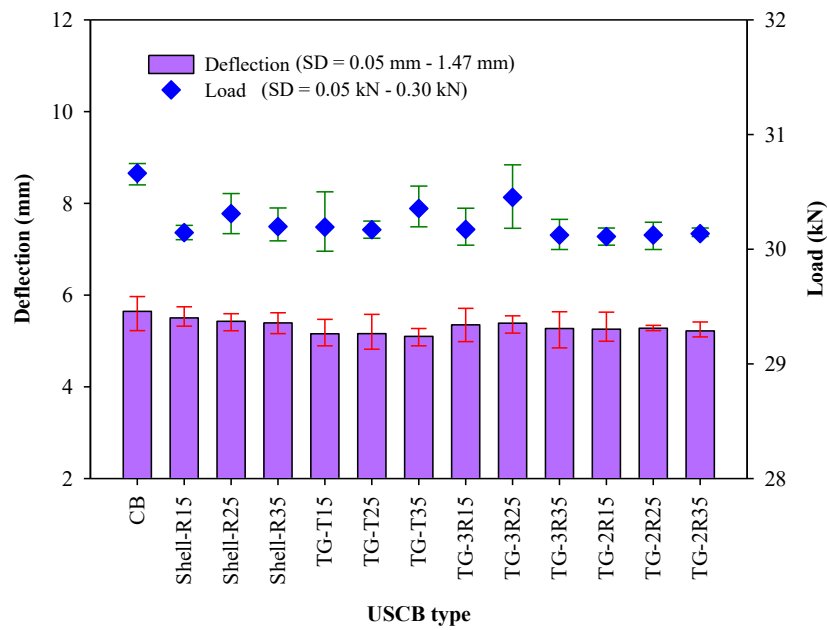


Figure 7.9 Uncertainty of a data point

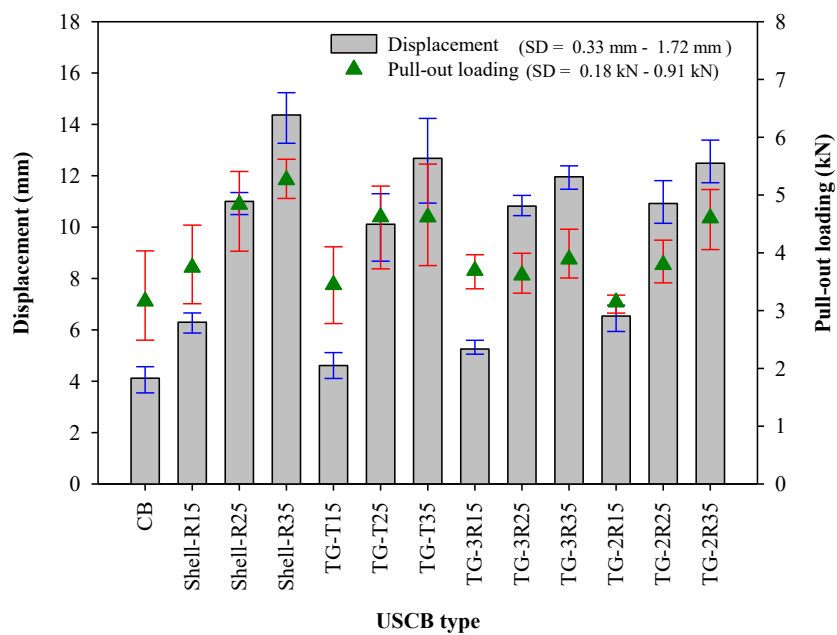


Figure 7.10 Error Bar shows that values are concentrated

7.2.4 Spider graphs

The spider graphs (Figure 7.11) is used to compare two or more items under various functions of typical metrics. Also known as radar charts, they are used for visualizing multivariate data, used in plotting one of more group of given set of values represented on axes starting from the same point. They help in presenting a simpler overview of complex data in a spatial and/or coloured organized chat in the form of a spider web, hence, the term, spider graph or diagram.

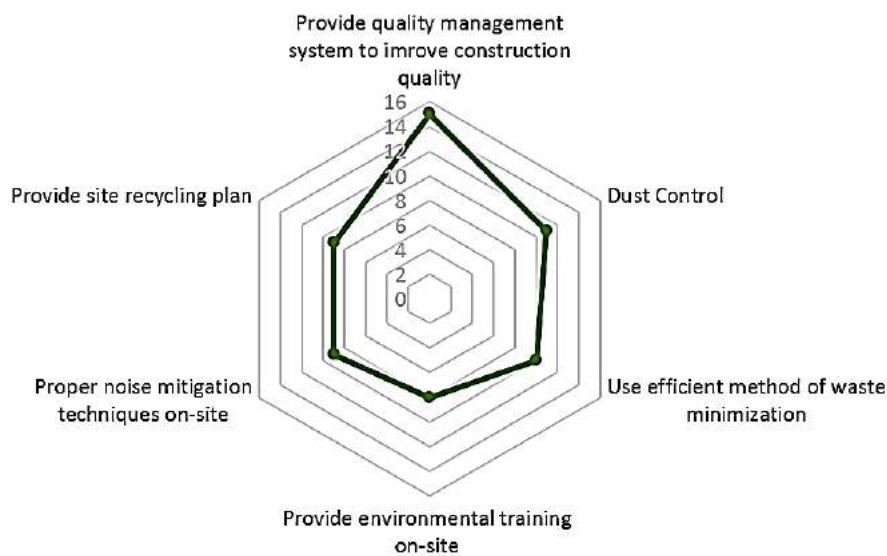


Figure 7.11 Comparison of the data

7.2.5 Contour Plots

Contour plots are used to depict a three-dimensional surface on a two-dimensional plane. Also called Level Plots, they present graphs of two predictor variables of X, Y coordinates on the y-axis and a response variable Z as the corresponding values where X and Y occur. These contours are sometimes called z-slices or iso-response values. Contour plots are broadly used cartography with contour lines used to illustrate elevations on a topological map. They are well applicable in many fields such as meteorology, astrology, physics etc. Contour lines are also commonly used to illustrate altitudes, but could also be used to show brightness, density or electric potential depending on applications (Figure 7.12 – 7.13).

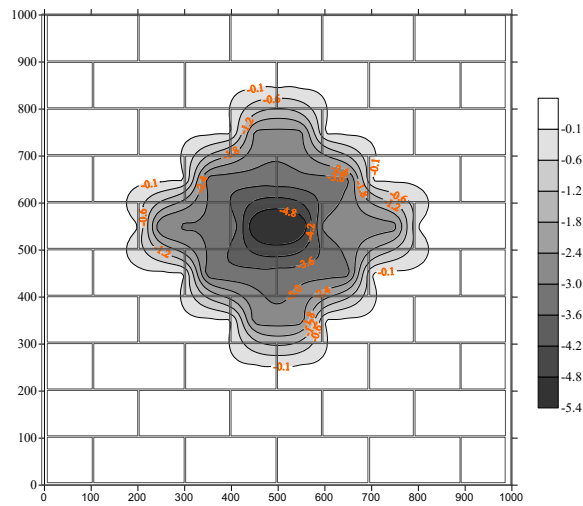
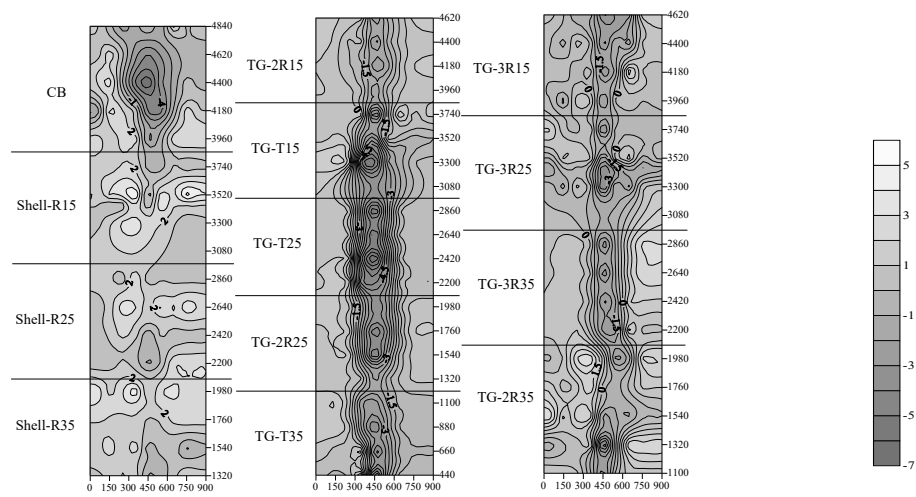
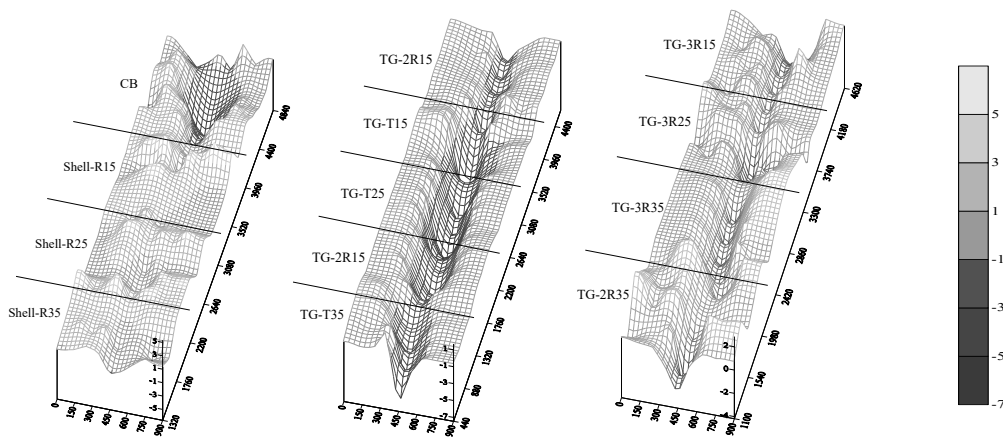


Figure 7.12 Show on a two-dimensional plane



(a) 2D view



(b) 3D view

Figure 7.13 (a) 2D view,(b) 3D view of 100 load repetitions on the USCB pavement

7.3 TABLES

A table is a named relational database data set that is organized by rows and columns. The relational table is a fundamental relational database concept because tables are the primary form of data storage (example Table 7.1 – 7.2).

Table 7.1 Comparison of concrete block density between USCB and previous study

| Type of concrete block | Density (kg/m ³) |
|--|------------------------------|
| USCB manual- made (in this study) | 2133 to 2258 |
| *RCPB manual- made (Ling, 2012) | 1740 to 1930 |
| *RCPB plant- made (Ling, 2012) | 1917 to 2138 |
| **NCA manual- made (Poon and Lam, 2008) | 2329 to 2371 |
| Control Block manual- made (Chan and Poon, 2010) | 2221 to 2278 |

* Rubberized Concrete Paving Block

** Natural Crushed Aggregate

7.4 IMAGES AND MAP

Elaboration of findings should have evidence or justification. In images or photos or map, the notation or caption to focus in the mentioned discussion should be indicated. It is better to visualize for better understanding of such as such findings. Figure 7.14 -7.16 show the examples of illustration from photos and map.



Figure 7.14 Development of rut after several repeated load for USCB and control block (CB)

Table 7.2 Proposed guideline and potential application of USCB

| Type of concrete block | Effective thickness, h_e (mm) | Average block weight (kg) | SSD (kg/m^3) | Compressive strength, σ_c (MPa) | Horizontal resistance (kN) | *Rutting (mm) | Performance | Proposed application | Remark |
|------------------------|---------------------------------|---------------------------|-------------------------|--|----------------------------|---------------|--------------|--------------------------|--|
| CB | 80 | 3.56 | 2303 - 2370 | 52 | 4.28 | 13.53 | Good | **Heavy duty engineering | Normal block |
| Shell-R15 | 65 | 3.17 | | 41 | 5.82 | 8.76 | Excellent | **Heavy duty engineering | Spike action, durable and better interaction |
| Shell-R25 | 55 | 2.94 | | 38 | 5.18 | 6.33 | Excellent | *** Normal | Spike action, durable and better interaction |
| Shell-R35 | 45 | 2.75 | | 26 | 5.42 | 6.07 | Successful | *** Normal | Spike action, durable and better interaction |
| TG-T15 | 65 | 3.39 | | 66 | 5.82 | 15.76 | Good | *** Normal | Notch consideration and better interaction |
| TG-T25 | 55 | 3.27 | | 65 | 5.87 | 15.24 | Satisfactory | **** Light duty | Notch consideration and better interaction |
| TG-T35 | 45 | 3.17 | | 57 | 3.98 | 13.91 | Satisfactory | **** Light duty | Notch consideration |
| TG-3R15 | 65 | 3.03 | | 54 | 5.30 | 11.38 | Successful | **Heavy duty engineering | Spike action, durable and better interaction |
| TG-3R25 | 55 | 2.97 | | 41 | 4.33 | 8.96 | Successful | *** Normal | Spike action and durable |
| TG-3R35 | 45 | 2.73 | | 34 | 3.83 | 6.81 | Good | **** Light duty | Spike action |
| TG-2R15 | 65 | 3.14 | | 37 | 4.23 | 10.37 | Good | **Heavy duty engineering | Spike action, durable and better interaction |
| TG-2R25 | 55 | 2.91 | | 30 | 3.93 | 11.46 | Satisfactory | **** Light duty | Spike action and durable |
| TG-2R35 | 45 | 2.65 | | 22 | 3.13 | 10.63 | Satisfactory | **** Light duty | Spike action |

Notation: CB – Control block

Shell-R15,25 and 35 – Shell rectangular groove with groove depth of 15 mm, 25 mm and 35 mm.

TG-T15, 25 and 35 – Trench triangular groove with groove depth of 15 mm, 25 mm and 35 mm.

TG-3R15, 25 and 35 – Trench three rectangular groove with groove depth of 15 mm, 25 mm and 35 mm.

TG-2R15, 25 and 35 – Trench two rectangular groove with groove depth of 15 mm, 25 mm and 35 mm.

* After 10,000 load repetitions subjected to 10 kN axle load (about stress of 318 kN/m^2)

** Container yards and port, City road, Bus and lorry terminal, Intersections

Industrial storage yards, Bridge abutment slopes, Petrol pump stations, Heavy traffic road

*** Driveways to residential area, Carpark, Residential road, Buggy tracks

Pedestrian crossing, Road shoulders, Medium traffic road,

**** Sidewalk and footpaths, Jogging track, Bicycle paths, Playgrounds, Pool deck, Light traffic road

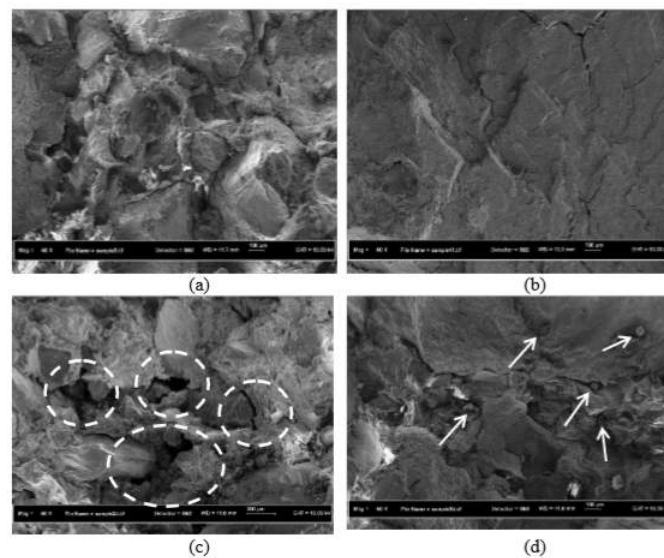


Figure 5.50 PC incorporating fine micro-filler (a) PC-GPOFA (b) PC- CaCO_3 PC with coarse filler (c) PC-UPOFA (d) PC-Sand.

Figure 7.15 Something to show in the photo



Figure 7.16 Jalan Utama Kg Bukit Dagang (PD 1001)

7.5 COMMON MISTAKES

There are many common mistakes made in writing styles and consistency which are equally very important in reportage of research findings. To avoid the common mistakes, the beginning of writing style must be consistent and all the writing

discipline must be well understood. Table 7.3 shows some of the common mistakes in writing and reportage of research findings.

Table 7.3 Common mistakes in writing

| Don'ts | Dos |
|--|--|
| Unexplained or referred Figures and Tables | All figures and tables must be referred and explained in the paragraph text clearly. |
| Unclear or blur Chart and Figures are not | All charts or figures or photos must be clear and easy to understood. Lines and selection of colour line width or thick must equally be appropriate. |
| Non-indication of notation in the Figures or photos | The descriptions or notations used must be indicated and be well explained as used in the figures or photos. |
| Non indication of abbreviation legends after Figures or Tables | The detailed description of abbreviation must be clearly indicated and stated. |
| Inconsistency of appropriate Font type and size | Selection of font type and size must be appropriate by following the standard writing format and such selection must be consistent throughout the writing . |
| Attempt to include all your data in the report | Only most relevant information to the research question should be presented in the manuscript. Note that there is no space for too many reports of data, hence, the need for reporting only the most relevant. |
| Use of text to describe everything | Visualization in form of figures or tables helps in the understanding of most data and must be explored as much as possible. Capturing the essence of presented data by clear illustrations make the work more precise and clearer. Use of texts to describe results make the writing uninteresting. |

Table 7.3 Common mistakes in writing (continue)

| Don'ts | Dos |
|--|--|
| Repetition of reported data already included in figures, tables and legends. | Both texts and graphical presentations must complement each other. Therefore, it is imperative to avoid repeating information already contained in the illustrations except only where is necessary for the purpose of explanation. Information not captured well in the figure legends should be included in the result section. |
| Unorganized manner of data presentation and discussion. | Chronological order of data presentation based on the methodology must be followed and in the order of relevance to the research questions. The most important information must be presented first regardless of the arrangement of the overall structure of the Results. |
| Writing of long explanations | All descriptions and statements must be kept concise. While phrases of passive voice structure may be used in methodology, they are not acceptable in result presentations. The important contributions of the research are better communicated with the use of active voice and choice of strong verbs. |
| Use of meaningless exact numbers out of context | The significance of presented information is better understood by using percentages or other relevant comparison-oriented numbers. This must be considered where appropriate as it helps to highlight important trends with better clarity for readers to easily digest. Use of factors, percentages or other comparison oriented numbers are more memorable than series of random digits. |

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CHAPTER 8

Managing Research Project and Well-Being

8.1 INTRODUCTION

Student needs to appropriately manage his/her research project, well-being and happiness. The management of scientific research project is important as it is one of factor contributes to the successful completion of planning objectives. There are many factors contribute to the efficient management of scientific research project. Scientists naturally acquire variety of skills over time due to experiences with failed experiments, planning a research question, and writing manuscripts. The internal politics, including the resources of their institution and the skills and motivation of the team members affect the research team. Therefore, management techniques are needed to overcome the constraining factors. While being a skilled and creative scientist they must also manage projects carefully. A successful research project basically requires the management on the data, resources, time and relationship (Brown and Atkins, 2002).

When managing a research project, there are several concerns that an investigator might have. Various important considerations when conducting science team meetings include preparation, participation, conduct, and follow-up. Moreover, information flow should be carefully upheld to provide sufficient information so that all team members comprehend the process and the project.

8.2 SMART PARTNERSHIP

An appropriate matching of student and supervisor is a key catalyst for the progress of research students. The initial consultation between a student and prospective supervisor is an important stage. Begin exploring each others's on research interests and gain early impressions of each other especially when the student and supervisor

have not met before. Supervisors may play a leading role in selecting research topic for funded research project (James and Baldwin, 1999). The students may also suggest their own because independence in choosing research topic has advantage. Normally students are more likely to flourish when they have a strong personal desire to pursue research questions of their own especially closely relevant to their career advancement. Students need to be fully aware of staff research interests and any possible limits to their involvement. Students normally prefer to choose their own supervisor and they are encouraged to ask and know themselves about their prospective supervisors. Principal supervisor has overall responsibility for the project and the quality of supervision. Joint and panel supervision is favourable if the research area requires interdisciplinary. Co-supervision may overcome some of the shortcomings enriching the project with specialized knowledge. There are probably few perfect matches between research students and their supervisors and to be ideal is unrealistic.

8.3 BALANCING EXPECTATION

Supervisors are responsible on assessments of student needs especially in the early stages. Allow supervisors to know student what knowledge and skills students bring to research project that need assistance. As an initial assessment the supervisors should be informed on the student theoretical base, option, technical and computing skills. Students familiarize themselves with research essentials and policy related issue. Get to know on research data records, research ethics, intellectual property and occupational health and safety.

The success of relationship depends on sensitivity and tact. Most helpful approach a supervisor acknowledge by talking with a student that both are going through a process of learning and adjustment, which requires mutual respect and support, this is normal and take time. Sensitive issues are best addressed in face-to-face meetings rather than email or telephone. This way the supervisor can clarify misunderstandings on the spot and provide emotional support if necessary (James and Baldwin, 1999). Articulating and sharing ideas and work in progress can help to

build student's confidence. Student should alert to any cultural difference with more suitable behaviour for balancing the cultural diversity.

The progress of a student is greatly affected by the nature of relationship either informal relationship, comradeship or formal relationship. The new student may not realize that it requires more independent and much certainty about knowledge. Sometimes message are misinterpreted, the student becomes confused and resentful and about not knowing what supervisor really wants. It could be a mismatch of expectations about the appropriate degree of direction. So avoid the supervisor become disappointed with the student's work and attitude. The supervisor has more experience on the nature of research needs a sharing of perspective and views continually throughout the candidature. The supervisor may have very clear view about what is desirable but will also need to take into account the student circumstances and preferred habit of works. It is important the students to get opportunity for an exchange of views of about how the research is going to work. It is good to establish reasonable and agreed expectations. Relevant information about the availability, cost and provisions for purchase of new equipment and consumables. Get information about the facilities available to them, such as study space and photocopying entitlement. These expectations and requirements evolve overtime, they need to be discussed more than once (James and Baldwin, 1999).

Students should be responsible on how frequently they should submit something in writings, how often meeting should be held. The submission of written works such as progress report, literature reviews and article for presentation and publication. Essential for students and supervisor to plan a schedule and check regularly the progress against the schedule. The progress-to-plan need not be rigidly adhered to because most research tends to be unpredictable. Avoid over-lengthy completion times but should not be allowed to interfere with the quality.

8.4 STRONG RESEARCH PLAN










Students need to work with supervisor to establish a strong conceptual structure and research plan (Brown and Atkins, 2002). The proposal might include:

1. A statement of the problems and issues and why they are worth investigating
2. A description of the study in relation to the previous research
3. Clear research questions and objectives
4. A methodology that can investigate these, including where relevant, the specification of equipment, and facilities requirements
5. A feasible timeline with measurable target

The proposal needs to be robust enough to consider the scale of the project appropriate to the level of the degree, feasible, manageable, adequate resources, enough data and plausible time frame.

Graduate students can encounter difficulties and problems in all aspects of their research as well their personal lives. The reason for late completion or late completion of a graduate program typically lay in a combination of challenges or difficulties rather than a single factor. Common factors that interfere with a student's completion are poor planning and management of the project, methodological difficulties, writing, isolation, personal problems and inadequate or negligent supervision

Educationalists and mentors list the sign of a student who may be at risk (Swanson and Watt, 2011). The students should aware and avoid of the following manners:

- | | | | |
|---|---|---|--------------------------------------|
|  | Postponing supervision meetings |  | Resisting advice or criticism |
|  | Making excuses for unfinished work |  | Procrastination and delay |
|  | Focusing next stage rather than the current task |  | Intellectualizing practical problems |
|  | Uncertainty or frequent changes in research topic or method |  | Blaming others for shortcomings |
|  | Spending time on things other than graduate work |  | Failing to integrate early work |

8.5 EFFECTIVE COMMUNICATION

Effective communication contributes to successful supervision. Communication and feedback can be both oral and written. Communicate with supervisors and acquire support at every stage: formulation of research project, establishing methodologies, presentation of results, publication of dissertation and research (Swanson and Watt, 2011). Develop understanding and judgments as that will explore knowledge further. This may need to be thoroughly revised or discarded by regular meeting with supervisors. Once the project is underway in laboratory or field early writing can help polishing research notes/records and methodological detail for publication and thesis. Writing should be undertaken from an early stage of the project: literature review, conceptual framework, report of the results that are the basis for conference papers or articles.

Feedback is important and students should initiate timely feedback from supervisors in maintaining the momentum of the project and helping it stay on course. Some students and supervisors favour daily, weekly, fortnightly or monthly. Others prefer to meet when desirable and the need arises. Feedback is confirmation of success, unambiguous identification of problem areas, and suggestion on how to

tackle them. Informal oral feedback in laboratory and formal consultation with supervisors need written notes or comments. Frequent and regular contact is the single most important in successful supervision .

8.6 MENTAL MANAGEMENT

Student' experience of conducting research are greatly enhanced and enriched if they feel part of the academic community. Academic and social isolation are widely recognized problems for postgraduate research students. Students need the supervisors and departments to avoid negative experiences of this kind. Join the vibrant postgraduate learning communities, discussion and gathering will provide inspiration and support if going gets tough. Student should work for opportunities in communicating their ideas through seminars, conferences and symposium. Students may engage in scholarly discussion and debate.

The most impressive inspiring power in postgraduate research is a conviction that the task is significant. Supervisors have a key task to carry out in assisting with invigorating and keep up understudy inspiration. For the most part postgraduate understudies start with a powerful urge to direct research, yet their managers can insist and bolster this craving, and help to support it. The students must take the initiative in drawing attention to the problem.

Research students may have problem with their research project: laboratory test, equipment, data, methods and others. The reasons for non-completion of Ph.D., that external factors are generally more significant than academic factors (personal, family, financial, women's lives, culture, loneliness). Supervisor has a responsibility to work with the student to find the best solution. Students get help from supervisor if academic and personal crises crop up. Serious problems require expert help, and the university offers a good deal of this.

The potential supervisor roles and associate attitudes are:



If a student receives the potential supervisor ideally own all the above qualities, then he/she would be very lucky (James and Baldwin, 1999).

8.7 SUMMARY

The guidelines for managing the research project and well-being are summarized in the following Table 8.1.

Table 8.1 Summary of guidelines for managing research project and well-being

| Task | Guidelines |
|-----------------------|--|
| Smart Partnership | <ul style="list-style-type: none"> • Ensure the partnership is reasonably right for the project • Appropriate matching of student and supervisor • To be ideal is unrealistic and needs compromise • Aware of expertise, interests and limitation • Interdisciplinary needs panel supervision |
| Balancing Expectation | <ul style="list-style-type: none"> • Students know their needs and expectation • Needs initial assessment from supervisor • Establish reasonable, agreed expectations • Balancing the culturally diversity • Understand research essentials and policy |
| Strong Research Plan | <ul style="list-style-type: none"> • Students aware warning sign of may be at risk • Know common factors that interfere with completion • Work with supervisor to establish a strong research plan |

Table 8.1 Summary of guidelines for managing research project and well-being (continue)

| Task | Guidelines |
|-------------------------|--|
| Effective Communication | <ul style="list-style-type: none"> • Acquire support from supervisor at every stage • Students engage to write early and often • Initiate regular contact with high quality feedback • Best feedback will motivate |
| Mental Management | <ul style="list-style-type: none"> • Engage activities that will inspire and motivate • Get help from supervisor if crises crop up • Be responsible for final production of the research |

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eISBN 978-967-2401-31-5



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