Overview of Research Methodology

Chapter 1 Introduction

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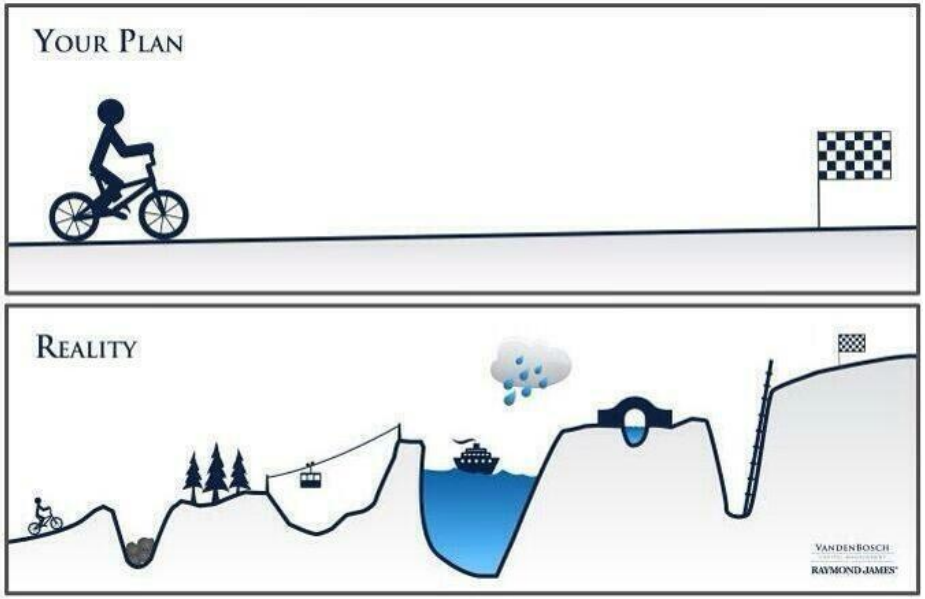
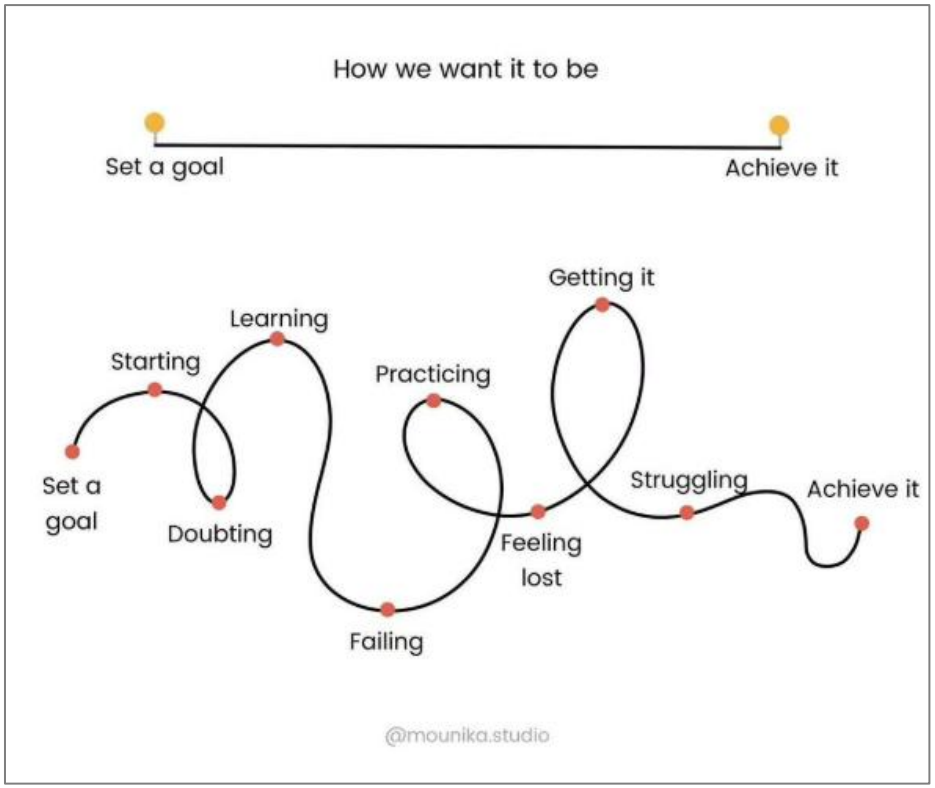

YOUR PLAN
REALITY
VANDENBOSCH
RAYMOND JAMES


How we want it to be
Set a goal
Achieve it
Set a goal
Starting
Learning
Doubting
Failing
Practicing
Getting it
Feeling lost
Struggling
Achieve it
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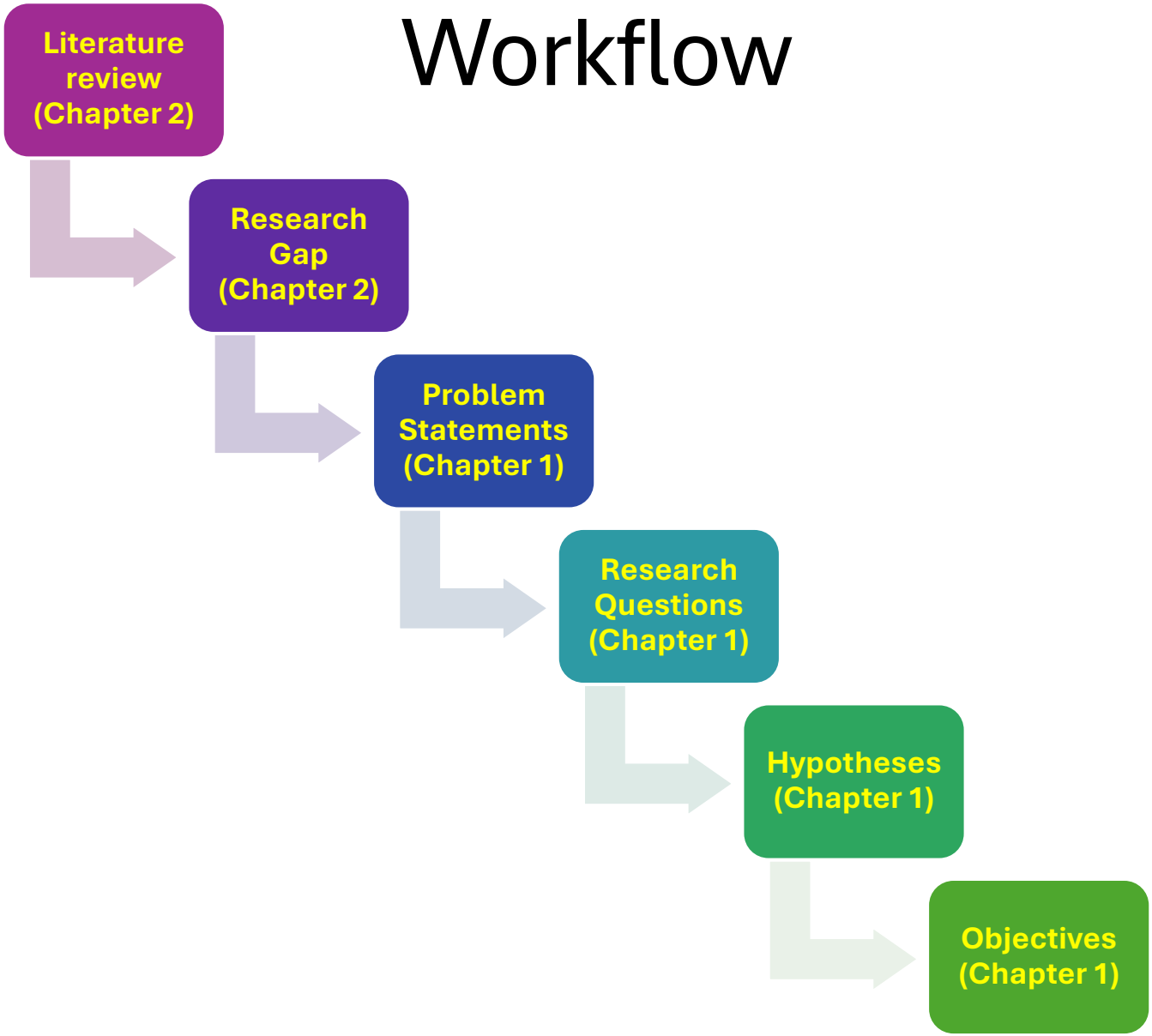
Chapter 1: Introduction

1.1 Background of Study
1.2 Problem Statement
1.3 Research Questions
1.4 Hypotheses
1.5 Objectives of Study
1.6 Scope of Study
1.7 Significance of Study
1.8 Organization of Study

Typical structure

UNIMAS New Thesis Template for Masters and PhD

Workflow


Literature review (Chapter 2)
Research Gap (Chapter 2)
Problem Statements (Chapter 1)
Research Questions (Chapter 1)
Hypotheses (Chapter 1)
Objectives (Chapter 1)

Problem Statement

- Describes an important issue, real-world limitation or challenge
- Explains why the problem matters, who is affected and what the consequences are if the problem remains unsolved
- Sets the motivation for the research

Problem Statement vs Research Gap

Thesis title	Problem Statement in Chapter 1	Research Gap in Chapter 2
	A real-world limitation or challenge	A specific lack of scientific knowledge or methodological capability in the existing literature
Mechanical Behaviour and Reinforcement Mechanisms of Durian Skin Fiber–Reinforced Concrete	There is a growing interest in natural fiber–reinforced concrete for sustainable construction. In Malaysia, durian skin waste represents a largely untapped resource with potential value in cementitious composites. However, the performance of such materials is highly variable due to inconsistent fiber properties and limited understanding of fiber–matrix interactions.	There are limited studies reported in the literature that provide insight into the controlled design of durian skin fiber–reinforced concrete, the relationship between its microstructure and mechanical performance, and the fundamental reinforcing mechanisms involved. These knowledge gaps hinder the optimization and wider adoption of this material, thereby motivating the present study.

Problem Statement vs Research Gap

Thesis title	Problem Statement in Chapter 1	Research Gap in Chapter 2
	A real-world limitation or challenge	A specific lack of scientific knowledge or methodological capability in the existing literature
Laser-Based Soil Spectroscopy and Machine Learning for Optimizing Fertilizer Application in Paddy Cultivation	Despite the importance of accurate soil nutrient assessment for sustainable paddy cultivation, current laboratory-based soil analysis methods are time-consuming and unsuitable for rapid field-level decision-making.	There is a lack of field-deployable systems for the rapid determination of soil nutrients in paddy fields. Furthermore, the quantitative validity of such systems relative to conventional analytical techniques has not been sufficiently established. In addition, the integration of laser-based soil sensing data with machine learning models for predicting optimal fertilizer application rates remains underexplored. Addressing these gaps is essential for enabling precision nutrient management in paddy cultivation.

Research Questions (RQs)

- What you want to find out to achieve the objectives
- Preferably, research questions are directly mapped one-to-one with the objectives
- Clear, specific, and investigable

Hypotheses

- Testable predictions answering the RQs
- Required mainly for quantitative / experimental studies
- Not always needed for exploratory or design-focused research
- Must be statistically testable

Hypotheses

Example 1

- H_0: There is no significant correlation between light intensity and metal concentration.
- H_1: There is a significant correlation between light intensity and metal concentration.

Example 2 (commonly used in engineering)

- It is hypothesised that light intensity exhibits a statistically significant correlation with metal concentration.

Example 3

- This study hypothesises that the light intensity is significantly correlated with metal concentration.

Sample PhD 1

RQs - Hypotheses - Objectives

Research questions	Hypothesis	Objectives
1. Can laser-based soil analysis techniques be used to generate a spatially resolved soil fertility map for paddy fields?	1. Laser-based soil analysis can successfully capture spatial variations in soil fertility parameters, enabling the development of a high-resolution soil fertility map for paddy fields.	1. To develop a novel laser-based soil fertility map for paddy fields
2. How accurately does the laser-based soil fertility map represent soil fertility parameters when compared with conventional laboratory-based soil analysis methods?	2. The laser-based soil fertility map shows strong agreement with conventional soil analysis techniques, with no statistically significant differences in key fertility parameters.	2. To validate the developed soil fertility map with the conventional techniques
3. Can machine learning models trained on laser-based soil fertility data accurately predict optimum fertilizer application rates for paddy cultivation?	3. Machine learning models using laser-derived soil fertility parameters can accurately predict optimum fertilizer application rates comparable to conventional rule-based fertilizer recommendation approaches.	3. To predict the optimum fertilizer application rates using machine learning

Sample PhD 2

RQs - Hypotheses - Objectives

Research questions	Hypothesis	Objectives
1. How do different 2D passive micromixer geometries influence liquid mixing efficiency in point-of-care (PoC) applications?	1. 2D-structured passive micromixers with enhanced geometric features can achieve significantly higher mixing efficiency compared to simple straight microchannels.	1. To investigate the liquid mixing performance of 2D-structured passive micromixers for utilization in PoC
2. What is the achievable and stable flow rate range of passive micropumps for PoC applications?	2. Passive micropumps can deliver stable and repeatable flow rates with performance influenced by microchannel geometry and pressure-driven conditions.	2. To investigate the flow rate performance of passive micropumps for utilization in PoC
3. How the integrated passive micromixer and passive micropump in the form of PoC can be optimized for enhanced fluid mixing?	3. Enhanced mixing performance of the integrated passive micromixer-micropump can be achieved by determining the optimum gauge pressure.	3. To optimize the gauge pressure via CFD simulation for enhanced mixing performance in the proposed PoC unit

Sample MSc 1

RQs - Hypotheses - Objectives

Research questions	Hypothesis	Objectives
1. How smartphone and laser can be combined to measure glucose levels in urine?	1. A smartphone and laser, combined with optical-based refractometry, can be designed to measure the refractive index in urine.	1. To design and fabricate a smartphone-based laser refractometer for non-intrusive measurement of glucose in urine.
2. What is the effects of volume variation, turbidity and shelf-life of urines on measurement results?	2. Volume variation, turbidity and shelf-life of urines have no effect on the measurement results.	2. To calibrate the developed glucometer, accounting for variations in urine volume, turbidity and shelf-life.
3. How accurately does the developed laser-based glucometer measure glucose concentration in urine compared to standard laboratory analysis?	3. The developed laser glucometer can measure urinary glucose concentrations with accuracy comparable to standard laboratory method and demonstrates a strong correlation.	3. To assess the efficacy of the developed laser glucometer for glucose measurement in urine and compare with laboratory results.

Sample MSc 2

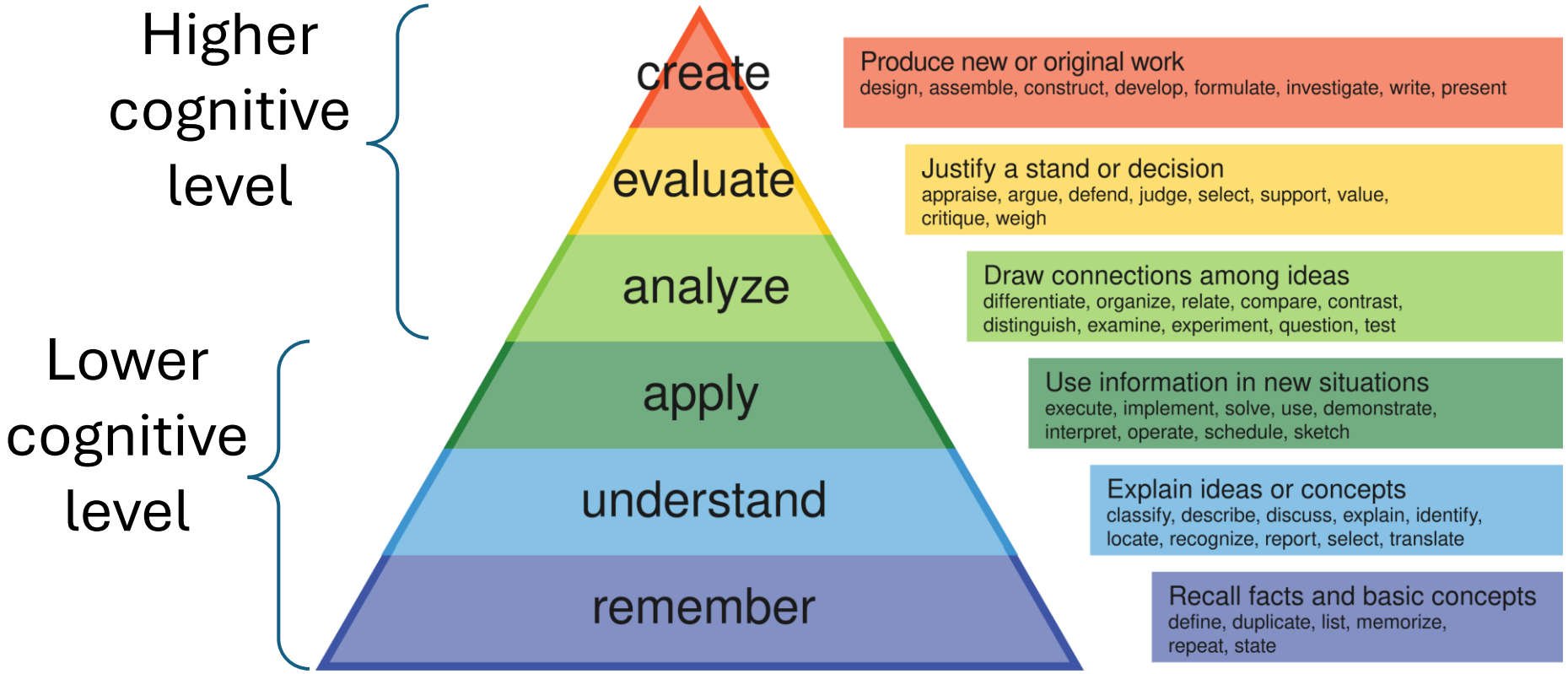
RQs - Hypotheses - Objectives

Research questions	Hypothesis	Objectives
1. What are the optimum laser parameters for drying black pepper berry to achieve the optimum drying characteristics?	1. An optimum drying speed with suitable laser power and number of laser passes would produce excellent drying characteristics of black pepper berry.	1. To experimentally investigate the optimum parameters in laser drying process of pepper berries by response surface methodology.
3. How to design an effective set of experiments and optimize the laser drying parameters with respect to drying characteristics?	2. RSM optimization paired with Box–Behnken design (BBD) can be employed to achieve the optimum drying quality of black pepper berry by laser drying.	
3. How does laser processing affect the physico-chemical properties and thermal characteristics of berries compared to untreated berries?	3. High laser power and low drying speed would result in ablation and burning of black pepper berry.	2. To evaluate the physico-chemical and thermal characteristics of the laser-processed berries.

Research Objectives

- What you intend to achieve
- Derived from the problem statement
- Guide the entire study
- Some thesis examiners emphasise appropriate **Bloom's taxonomy** verbs in research objectives
- Some thesis examiners emphasise on **SMART** (Specific, Measurable, Achievable/Attainable, Relevant/Realistic, and Time-bound)

Bloom's taxonomy



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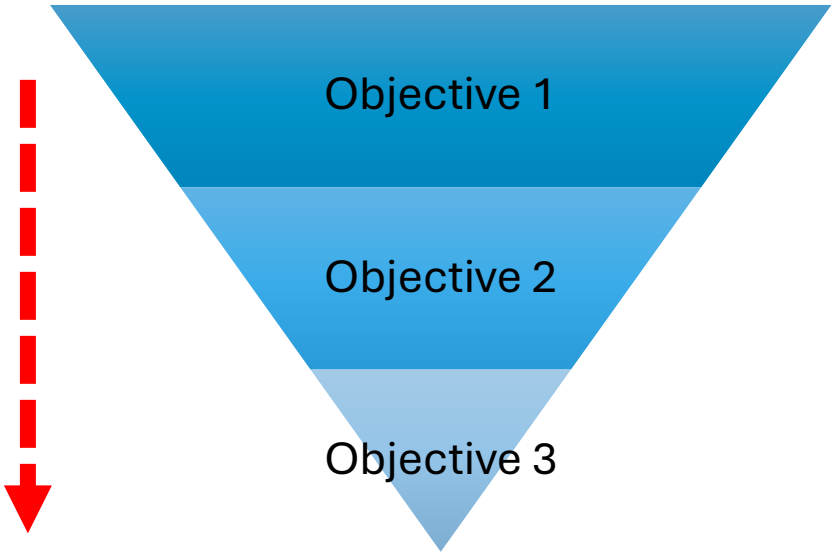
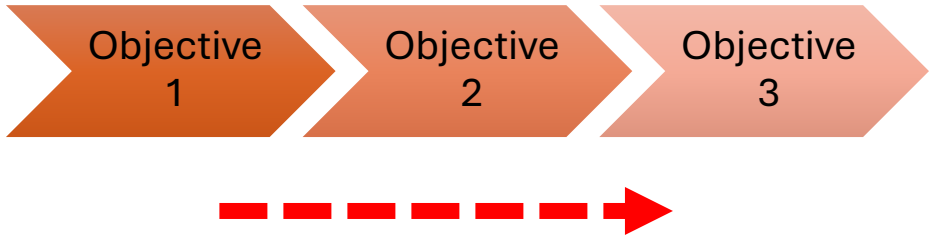
Research Objectives



- ✓ All objectives are related and demonstrate continuity
- ✓ The study progresses in depth from Objective 1 to Objective 3
- ✓ The focus is progressively narrowed



- ✓ All objectives are related and show continuity
- × However, the study does NOT progress in depth from Objective 1 to Objective 3.
- × This may result in a major correction for the PhD

Research Objectives

Example A	PhD	Masters
Objective 1	• To design and fabricate a novel durian skin fiber–reinforced concrete with controlled material composition and processing parameters	• To create a novel fiber composite using durian skin
Objective 2	• To investigate the structure–property relationships governing the mechanical performance of durian skin fiber–reinforced concrete	• To characterize the mechanical and structural properties of the novel fiber composite
Objective 3	• To elucidate the reinforcing mechanisms of durian skin fibers within the concrete matrix	

PhD expectations
- ✓ Original material and controlled design
- ✓ New knowledge (structure–property relationship)
- ✓ Mechanistic understanding (core PhD contribution)

Acceptable for Masters
- ✓ Material fabrication
- ✓ Standard characterization

Research Objectives

Example B	Good	Not-so-good
Objective 1	• To develop a novel laser-based soil spectrometer for paddy fields	• To design, build and calibrate a novel laser-based soil spectrometer for paddy fields in Sarawak
Objective 2	• To validate the developed laser-based soil spectrometer with the conventional techniques	• To investigate the nutrient content of soil using conventional techniques
Objective 3	• To predict the optimum fertilizer application rates using machine learning	• To assess the accuracy and reliability of the developed laser-based soil spectrometer for soil nutrient analysis

✓ Acceptable for PhD
✓ New knowledge on relationship between light, nutrient deficiency and fertilizer requirement

✓ Acceptable for Masters
× Shallow for PhD since Objectives 1 and 2 can be combined
✓ No new knowledge

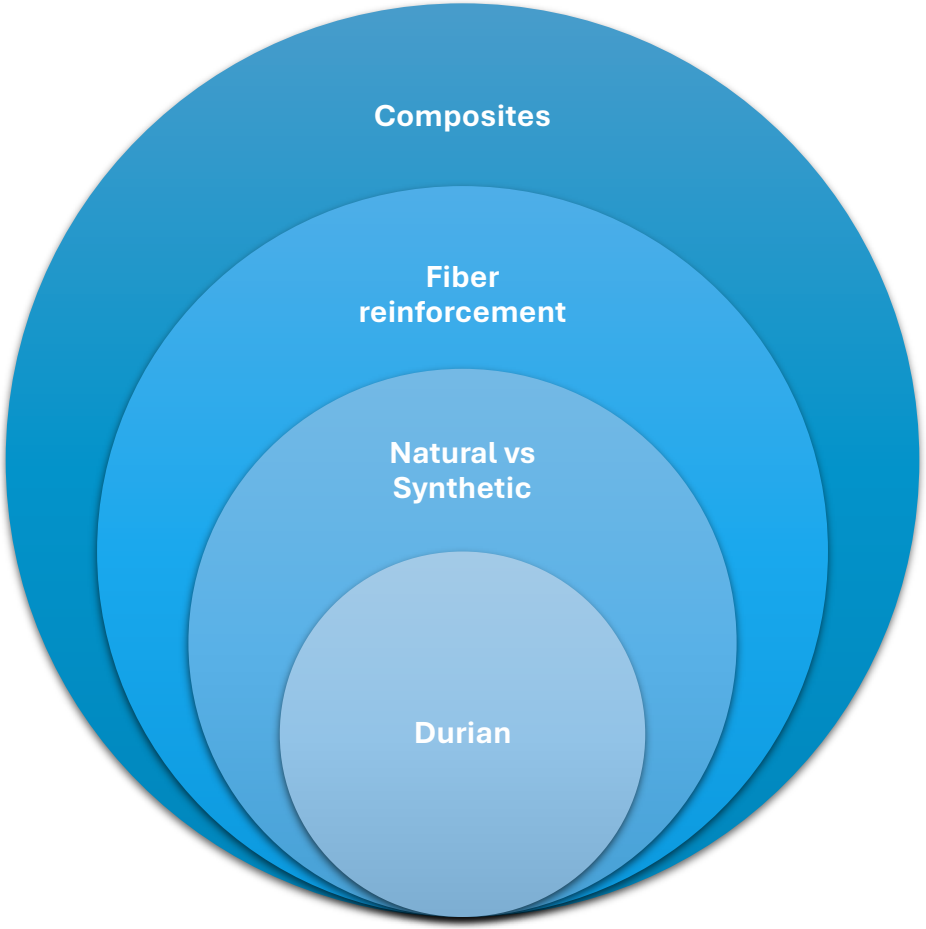
Research Objectives

Example C	Good	Not-so-good
Objective 1	• To investigate the liquid mixing performance of 2D-structure passive micromixers for utilization in point-of-care (PoC)	• To experimentally characterize two distinct novel micromixers for non-conductive and conductive liquids
Objective 2	• To investigate the flow rate performance of passive micropumps for utilization in PoC	• To experimentally characterize two different novel passive micropumps operating at sub-atmospheric and atmospheric pressures
Objective 3	• To optimize the gauge pressure via CFD simulation for enhanced mixing performance in the proposed PoC unit	• To compare the performances of the developed micromixers and micropumps with the literature

× Objective 3 does not add any new knowledge for PhD

Scope of Study

- Determines your research boundary
- Parameters selection
- Range of parameters
- Sample type
- Sample size
- Duration
- Location



Thank You