

# Chapter 2: Research Problem

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## LEARNING OBJECTIVES

By the end of this chapter, you should be able to:

1. Discuss what a research problem is.
2. Select an appropriate research problem.
3. Explain the necessity of defining a problem.
4. Describe the techniques involved in defining a research problem.
5. Illustrate typical research problems with real-world examples.

## 2.1 WHAT IS A RESEARCH PROBLEM?<sup>1</sup>

A **research problem** is a statement about an area of concern, a gap in existing knowledge, or an unresolved issue that prompts the need for research. It serves as the foundation for a study, providing focus and guiding the researcher in formulating questions and hypotheses.

### Key Features of a Research Problem

- **Focus:** Directs the research towards a specific area of investigation.
- **Purpose:** Helps bridge knowledge gaps or solve practical issues.
- **Clarity:** Clearly defines what the research seeks to address.

A well-defined research problem in engineering often focuses on addressing real-world technical challenges, such as improving efficiency, reducing costs, or solving environmental issues.

### Example

In renewable energy, a research problem could be stated as:

- "Current photovoltaic cells experience a 30% reduction in efficiency during low-light conditions. This research will investigate methods to enhance performance under these conditions."

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<sup>1</sup> A research problem is not simply a question but must identify something specific and researchable, linking to measurable objectives.

## 2.2 SELECTING A RESEARCH PROBLEM<sup>2</sup>

Choosing the right research problem is important to the success of a project. It should be relevant to your field of study, feasible given your resources, and meaningful to the broader community.

### Criteria for Selecting a Research Problem

1. **Relevance:** The problem should address real-world needs or academic gaps.
2. **Practicality:** Consider the resources, time, and tools available for solving the problem.
3. **Significance:** Ensure the research contributes to your field or solves a pressing issue.
4. **Personal Interest:** Choose a problem you are passionate about for better engagement and quality.
5. **Novelty:** Ensure your problem offers new insights or solutions, extending beyond existing research.

### Example

Rather than investigating "energy storage systems" broadly, a more specific problem might be:

- "How can we improve the longevity and efficiency of lithium-ion batteries in solar energy systems?"

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<sup>2</sup> When selecting a research problem, evaluating the potential impact is crucial, as projects should balance theoretical interest with practical applications to ensure relevance and feasibility.

## 2.3 THE NECESSITY OF DEFINING THE RESEARCH PROBLEM<sup>3</sup>

Defining the research problem is a critical step that ensures clarity and focus throughout the research process. A well-defined problem leads to precise research questions and objectives, setting the stage for your investigation.

### Why Define the Research Problem?

- **Provides Direction:** Establishes the purpose of the study and keeps the research on track.
- **Ensures Focus:** Avoids unnecessary broadness or ambiguity in the research.
- **Clarifies Objectives:** Helps formulate research questions and hypotheses that directly address the problem.

### Example

Instead of broadly studying "urban energy use," a well-defined problem might be:

- "What building design changes can reduce energy consumption in urban areas during summer heatwaves?"

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<sup>3</sup> A well-defined research problem is crucial for forming valid and specific research hypotheses, leading to reliable and actionable results.

## 2.4 TECHNIQUES FOR DEFINING A RESEARCH PROBLEM<sup>4</sup>

Defining a research problem involves several steps that guide you from a general topic to a specific, researchable issue. Below are key techniques to help refine your problem:

### 1. Conduct a Literature Review

The **literature review** helps you identify what has already been studied and uncovers gaps in existing research. By reviewing relevant articles, books, and reports, you can understand what issues have not been fully explored.

#### Example

If you're researching photovoltaic cells, a literature review may show that while much work has been done on efficiency in sunny climates, there's a gap in studies focused on cold weather conditions.

### 2. Consult Stakeholders<sup>5</sup>

Engage with industry experts, customers, or communities affected by the problem. These consultations help ensure the problem is not only academically interesting but also practically important.

#### Example

Discussions with energy companies may reveal that integrating renewable energy into existing power grids is a significant concern that requires further research.

### 3. Develop a Problem Statement<sup>6</sup>

A **problem statement** summarizes the core issue and defines the focus of your research. It should be concise, specific, and researchable.

#### Example:

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<sup>4</sup> A comprehensive literature review helps not only in identifying gaps but also in refining research questions by avoiding duplication of existing research.

<sup>5</sup> Stakeholders can provide insights into practical needs, making the research problem more applicable and ensuring that it addresses existing gaps.

<sup>6</sup> A well-crafted problem statement should succinctly capture the core issue while being clear and researchable.

"The wear and tear of wind turbine blades in extreme weather reduces their efficiency by 20%. This research will explore the development of durable materials for these blades."

#### 4. Set Clear Objectives<sup>7</sup>

Once the problem is defined, the next step is to develop **SMART (Specific, Measurable, Achievable, Relevant, Time-bound)** objectives that will guide your research. Objectives should be closely aligned with the research problem.

##### Example

"To evaluate the durability of new composite materials under harsh wind conditions."

#### 5. Conduct Feasibility Analysis<sup>8</sup>

Ensure that your problem is feasible to research, given the available resources, time, and technology. A feasibility analysis helps narrow down overly ambitious or resource-intensive problems.

##### Example:

If studying a global energy solution is too broad, refine your focus to a manageable scope, such as "energy efficiency improvements in a specific region."

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<sup>7</sup> Clear objectives are essential for guiding the research process and ensuring the focus remains aligned with the problem throughout the study.

<sup>8</sup> Feasibility checks prevent resource wastage and increase the likelihood of successful project completion by ensuring that the problem is manageable.

## 2.5 ILLUSTRATIONS OF TYPICAL RESEARCH PROBLEMS<sup>9</sup>

Research problems in engineering often derive from practical challenges. Below are examples from various fields of engineering:

### 1. Mechanical Engineering

**Problem:** Current 3D printing techniques result in weak structural integrity in metal parts.

- **Research Focus:** Investigating new materials or techniques to improve the strength of 3D-printed metals.

### 2. Civil Engineering

**Problem:** Coastal erosion is damaging the foundations of bridges.

- **Research Focus:** Developing erosion-resistant materials to protect coastal infrastructure.

### 3. Electrical Engineering

**Problem:** Significant energy loss occurs in power transmission over long distances.

- **Research Focus:** Exploring superconducting materials to minimize energy loss in power grids.

### 4. Computer Engineering

**Problem:** Autonomous vehicles struggle with real-time object recognition.

- **Research Focus:** Developing faster, more accurate algorithms for real-time object detection in self-driving cars.

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<sup>9</sup> In engineering fields, a well-structured research problem typically emerges from observed performance limitations in existing technologies or processes.

### **1. Problem: Inefficient Waste Management in Urban Areas**

#### **Problem Statement**

Uganda's rapid urbanization, particularly in Kampala, has led to increased solid waste production, yet current waste management systems are inefficient, resulting in environmental degradation and public health risks. This research seeks to develop an optimized waste-to-energy conversion system using anaerobic digestion technologies for urban waste management.

### **2. Problem: Energy Loss in National Power Grid**

#### **Problem Statement**

Uganda experiences significant energy losses in its national grid due to outdated infrastructure and long-distance transmission, contributing to high energy costs and unreliable power supply. This study aims to investigate the potential for superconducting materials to reduce energy loss and improve transmission efficiency in Uganda's power grid.

### **3. Problem: Limited Access to Clean Water in Rural Areas**

#### **Problem Statement**

Many rural communities in Uganda face challenges accessing clean and safe drinking water, leading to health problems and inefficiencies in water retrieval. This research will explore the application of solar-powered water purification systems using low-cost, locally available materials to provide sustainable access to clean water.

### **4. Problem: Inadequate Renewable Energy Integration**

#### **Problem Statement**

Uganda's heavy reliance on hydroelectric power presents challenges during dry seasons, necessitating diversification in renewable energy sources. This research will develop and assess hybrid renewable energy systems, combining solar, wind, and bioenergy to ensure a stable energy supply throughout the year.

## **5. Problem: High Rate of Road Traffic Accidents**

### **Problem Statement**

Uganda records a high rate of road traffic accidents due to inadequate infrastructure and lack of real-time traffic management systems. This study aims to design and implement a smart traffic control system using sensors and machine learning algorithms to reduce traffic congestion and enhance road safety.

## **6. Problem: Post-Harvest Losses in Agriculture**

### **Problem Statement**

Uganda's agriculture sector suffers significant post-harvest losses due to inadequate storage facilities and inefficient supply chains. This research will explore the design and development of solar-powered cold storage units using phase-change materials (PCMs) to reduce post-harvest losses and improve food security.

## **7. Problem: Low Penetration of Electric Vehicles**

### **Problem Statement:**

Electric vehicle (EV) adoption in Uganda remains low due to high upfront costs, limited charging infrastructure, and lack of awareness. This research seeks to develop an affordable electric vehicle charging infrastructure using renewable energy sources, focusing on rural and urban areas, to promote wider adoption of EVs.

## **8. Problem: Unreliable Internet Connectivity in Rural Areas**

### **Problem Statement**

Limited access to reliable internet connectivity in rural Uganda hampers technological and educational advancements. This research will investigate the use of innovative mesh networks powered by solar energy to provide reliable, affordable, and sustainable internet connectivity in rural communities.

## **9. Problem: Flood Management in Kampala**

### **Problem Statement**

Kampala faces recurrent flooding during the rainy season due to inadequate drainage systems, causing property damage and disrupting economic activities. This study proposes to design a smart flood monitoring and alert system using IoT technologies to predict, mitigate, and manage flood risks in the city.

## **10. Problem: Inefficient Transportation Systems**

### **Problem Statement**

Uganda's transportation system suffers from inefficiencies, leading to long travel times and high fuel consumption. This research aims to design and develop an intelligent transportation system (ITS) using real-time data analytics and artificial intelligence to optimize traffic flow, reduce congestion, and minimize environmental impact.

## **11. Problem: Deforestation and Charcoal Dependency**

### **Problem Statement**

Uganda's heavy reliance on charcoal as a primary energy source for cooking is contributing to widespread deforestation. This research will explore the potential of alternative biofuel technologies, such as briquettes made from agricultural waste, as a sustainable energy source to reduce charcoal dependency and mitigate environmental degradation.

## **12. Problem: Low Agricultural Mechanization**

### **Problem Statement**

Ugandan farmers face challenges related to low mechanization, which reduces productivity and efficiency, especially among smallholder farmers. This study will investigate the design and development of low-cost, solar-powered agricultural machinery tailored to smallholder farmers' needs to enhance agricultural productivity and sustainability.

## **13. Problem: Lack of Efficient Urban Housing**

### **Problem Statement**

The growing population in Uganda's urban centers has outpaced the development of affordable and sustainable housing, leading to overcrowded slums. This research will explore innovative building techniques using sustainable materials like compressed earth blocks and solar power to design affordable, energy-efficient housing models.

## **14. Problem: Water Management in Agricultural Irrigation**

### **Problem Statement**

Uganda's agriculture is heavily reliant on rainfall, making it vulnerable to climate variability. This research aims to design an automated, sensor-based drip irrigation system that uses minimal water and maximizes crop yields, particularly during dry spells, to promote sustainable agricultural practices.

## **15. Problem: Limited Access to Healthcare in Remote Areas**

### **Problem Statement**

Remote areas in Uganda suffer from limited access to healthcare services, often requiring residents to travel long distances for treatment. This study will investigate the development of mobile health (mHealth) solutions using telemedicine technologies powered by solar energy, enabling remote diagnosis and treatment, and improving healthcare delivery in underserved regions.

### **Summary of Research Problem Themes**

- 1. Energy:** Exploring sustainable energy solutions, such as renewable energy systems, grid efficiency, and electric vehicles.
- 2. Water:** Addressing clean water access and water management for irrigation.
- 3. Agriculture:** Focusing on post-harvest losses, mechanization, and smart farming technologies.
- 4. Transport and Urban Planning:** Traffic management, smart city solutions, and affordable housing.
- 5. Health:** Utilizing telemedicine and mHealth technologies to expand healthcare access.
- 6. Environmental Sustainability:** Renewable energy, flood management, and deforestation mitigation strategies.

These research problems and statements are designed to contribute to Uganda's technological, engineering, and innovation sectors, addressing critical local challenges while promoting sustainable development.

## SUMMARY

In this chapter, we explored the concept of a research problem, how to select and define it, and techniques for refining the problem. Understanding how to define a clear and actionable research problem is fundamental to any successful research project, especially in engineering, where practical challenges often drive investigation.

### Key Takeaways

1. A research problem guides the direction of the entire study.
2. Selecting a relevant, feasible, and novel problem is crucial.
3. Techniques such as literature reviews and consultations help refine the problem.
4. Typical engineering problems often involve practical, real-world challenges that require innovative solutions.

## END OF CHAPTER 2 REVIEW QUESTIONS

1. Evaluate the importance of selecting a relevant research problem in engineering. How can choosing an irrelevant or impractical problem impact the outcome of a study?
2. Analyze a research problem you have encountered (in class or real life) and explain how the techniques discussed in this chapter could have helped define the problem more clearly.
3. Compare two research problems in the same field (e.g., renewable energy) and assess which problem would be more practical to investigate, providing reasons for your choice.
4. Propose a novel research problem in your field of study. Outline the steps you would take to ensure that the problem is well-defined and feasible to research.
5. Critique the role of stakeholders in refining a research problem. What are the potential risks and benefits of involving external experts in this process?
6. Design a research problem that integrates both academic interest and practical significance. Explain how you would validate its relevance to both academia and industry.