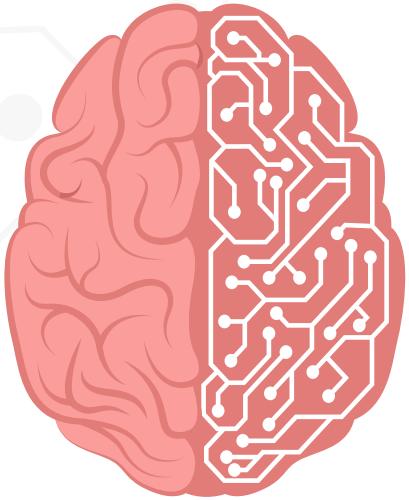


How to define a problem statement

By Guillaume GUERARD

Why do you need this course?

In all engineering work, you will have to confront issues related to research.

For an industrial project:

- Understand the context in the world
- Understand the scientific context
- Identify existing work
- Identify scientific obstacles
- Find a solution to these locks
- Produce and analyze results
- Discuss the method and the results (critical thinking)
- Write the different renderings

For scientific and technological monitoring:

- Understand the context in the world
- Understand the scientific context
- Identify existing work
- Organizing the state of the art
- Discuss the state of the art
- Identify scientific obstacles
- Identify scientific challenges
- Identify technological constraints
- Suggest ways to improve
- Write the different renderings

Whatever your project, the research methodologies will be useful to you!

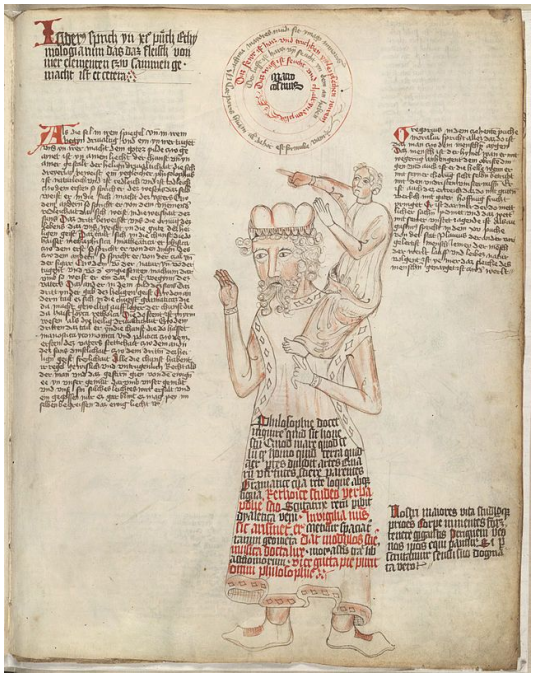
Why do you need this course?

Get some new skills!

A research course equips engineering students with essential research skills, including **conducting a literature review**, **defining a research problem**, **creating a mind map**, and **formulating research questions**.

Research work encourages engineering students to **think critically and analytically**. They learn to **identify gaps** in existing knowledge, explore potential solutions, and develop problem-solving abilities.

It allows to **explore** new ideas, **challenge** existing theories, and **propose** novel solutions to real-world problems. You will ain a deep understanding of the research process, from **conceptualization** to data analysis and **interpretation**.



Whatever your project, the research methodologies will be useful to you!

Starting the research process

A problem statement is a clear and concise description of an issue or challenge that needs to be addressed through research or problem-solving. It defines the context and scope of the problem and outlines the objectives of the study or project. A well-written problem statement is crucial as it sets the direction for the entire research or problem-solving process.

Starting the research process

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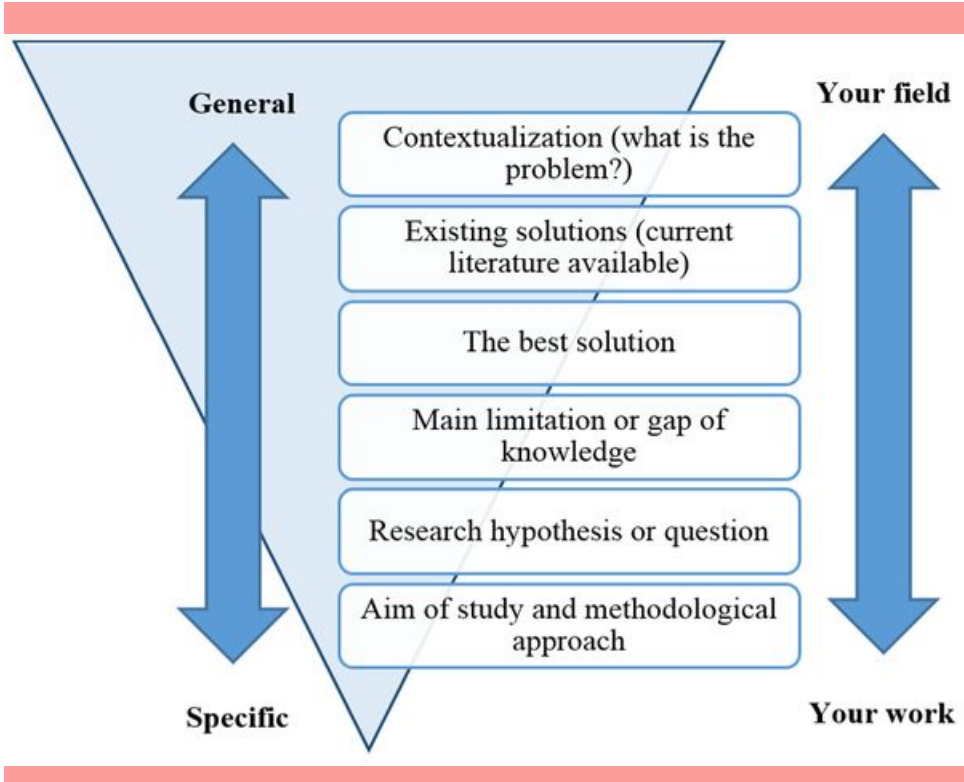

Step 1: Understand your topic

First, it is essential to understand your subject (title and presentation). For that it will be necessary to study it without touching anything else for the moment!

Analyze the title

- Remember the keywords and their relationship (like W2V or TF-IDF in NLP methods)
- Go deeper into each keyword
- Iterate until you have an idea of what you should know on each keyword

Let's see a quick brainstorming about a title! Of course, you have to go deeper in your thoughts when analyzing the Title of your topic.

Smart Grid Modeling by Multi-agent System in a Zero-Carbon Policies

Smart Grid? what is that, its definition? Its context (generally, and within the project)?

→**Modeling**? Definition in your context? Applied to Smart Grid? You need to find in the future some works in this topic.

MAS? Definition? Applied to Modeling? Applied to Smart Grid? Any other kind of paradigm? What are the pros and cons?

Etc.

Return to Smart Grid to add questions and links to other key words.

Step 2: Understand the context

Since you have a better idea of the key points of your topic. You have to understand its context (socio-economic context as scientists said).

You have to answer to various questions:

- Societal relevance → see the example
- Industry impact
- Potential benefits (industry, global)
- Potential drawbacks if the project is not done (industry, global)
- Policy implications
- Current state of the ongoing topic (stay general)

Use the key points in step 1 to enhance your understanding of the context.

“Dragonpox is one of the most problematic infectious diseases today. It is the most common disease in children under the age of 12 and about 2 in 5 people contract it in their lifetime. Dragonpox causes green and purple rashes and sparks that come out of the nostrils when the patient sneezes.

These symptoms can worsen, leading to serious complications (pneumonia, encephalitis, etc.) and significant sequelae (respiratory failure, mottled skin). In addition, in 8.4% of cases, the infection leads to the death of the patient. In 2021, the deadly consequences and high prevalence of dragon pox prompted the Wizzard Health Organization (WHO) to declare it the priority public health problem for the next decade.

Etc.

Step 3: Understand the scientific context

At this point, focus only on scientific context (since you have the keywords and the general context). The scientific context also depends on the scope of your project.

Taking Dragonpox, the scientific context can be on:

- Its diagnosis,
- Its treatment,
- Its mechanism of contagion,
- The increased vulnerability of some people to this disease,
- The genetic code of the virus,
- The proteins that make up the membrane of the virus,
- Its evolutionary origins...

Take your keywords and question to narrow the topic!

“Dragon pox is mainly treated with anti-herpetic agents. Indeed, the disease results from a primary infection due to the varicella-monster virus (VMV), which belongs to the family of human herpesviruses. Recent studies suggest that oral aclocyvir is the most effective method against VMV. Aclocyvir is a nuke that mimics guasonine....”

etc.

Step 4: Identify a problem

So you've settled on a topic and found a niche – but what exactly will your research investigate, and why does it matter? To give your project focus and purpose, you have to define a research problem.

The problem might be a practical issue – for example, a process or practice that isn't working well, an area of concern in an organization's performance, or a difficulty faced by a specific group of people in society.

Alternatively, you might choose to investigate a theoretical problem – for example, an underexplored phenomenon or relationship, a contradiction between different models or theories, or an unresolved debate among scholars.

To put the problem in context and set your objectives, you can write a problem statement. This describes who the problem affects, why research is needed, and how your research project will contribute to solving it.

Step 5: Write a problem statement

Contextualize the problem

The problem statement should frame your research problem in its particular context and give some background on what is already known about it.

Practical research problems

For practical research, focus on the concrete details of the situation:

- Where and when does the problem arise?
- Who does the problem affect?
- What attempts have been made to solve the problem?

Theoretical research problems

For theoretical research, think about the scientific, social, geographical and/or historical background:

- What is already known about the problem?
- Is the problem limited to a certain time period or geographical area?
- How has the problem been defined and debated in the scholarly literature?

Take a break: Write the problem statement

Show why it matters

The problem statement should also address the relevance of the research: why is it important that the problem is solved?

This doesn't mean you have to do something groundbreaking or world-changing. It's more important that the problem is researchable, feasible, and clearly addresses a relevant issue in your field.

Practical problems (context)

Practical research is directly relevant to a specific problem that affects an organization, institution, social group, or society more broadly. To make it clear why your research problem matters, you can ask yourself:

- What will happen if the problem is not solved?
- Who will feel the consequences?
- Does the problem have wider relevance (e.g. are similar issues found in other contexts)?

Theoretical research problems (scientific context)

Sometimes theoretical issues have clear practical consequences, but sometimes their relevance is less immediately obvious. To identify why the problem matters, ask:

- How will resolving the problem advance understanding of the topic?
- What benefits will it have for future research?
- Does the problem have direct or indirect consequences for society?

Take a break: Write a problem statement

Set your aims and objectives (topic analysis)

Finally, the problem statement should frame how you intend to address the problem. Your goal should not be to find a conclusive solution, but to seek out the reasons behind the problem and propose more effective approaches to tackling or understanding it.

The aim is the overall purpose of your research. It is generally written in the infinitive form:

- The aim of this study is to **determine**...
- This project aims to **explore**...
- I aim to **investigate**...

The objectives are the concrete steps you will take to achieve the aim:

- Qualitative methods will be used to **identify**...
- I will use surveys to **collect**...
- Using statistical analysis, the research will **measure**...

Step 6: Find delimitations and limitations

Delimitations refer to the boundaries of the research study, based on the researcher's decision of what to include and what to exclude. They narrow your study to make it more manageable and relevant to what you are trying to prove.

Limitations relate to the validity and reliability of the study. They are characteristics of the research design or methodology that are out of your control but influence your research findings. Because of this, they determine the internal and external validity of your study and are considered potential weaknesses.

In other words, limitations are what the researcher cannot do (elements outside of their control) and delimitations are what the researcher will not do (elements outside of the boundaries they have set). Both are important because they help to put the research findings into context, and although they explain how the study is limited, they increase the credibility and validity of a research project.

Step 7: Formulate questions

Next, based on the problem statement, you need to write one or more research questions. These target exactly what you want to find out. They might focus on describing, comparing, evaluating, or explaining the research problem.

A strong research question should be specific enough that you can answer it thoroughly using appropriate qualitative or quantitative research methods. It should also be complex enough to require in-depth investigation, analysis, and argument. Questions that can be answered with “yes/no” or with easily available facts are not complex enough for a thesis or dissertation.

How to write a question

The process of developing your research question follows several steps:

- Choose a broad topic
- Do some preliminary reading to find out about topical debates and issues
- Narrow down a specific niche that you want to focus on
- Identify a practical or theoretical research problem that you will address

When you have a clearly-defined problem, you need to formulate one or more questions. Think about exactly what you want to know and how it will contribute to resolving the problem.

Example research problem	Example research question(s)
The teachers at school X do not have the skills to recognize or properly guide gifted children in the classroom.	What practical techniques can teachers at school X use to better identify and guide gifted children?
Under-30s increasingly engage in the "gig economy" instead of traditional full-time employment, but there is little research into young people's experiences of this type of work.	What are the main factors that influence young people's decisions to engage in the gig economy? What do workers perceive as its advantages and disadvantages? Do age and education level have an effect on how people experience this type of work?

How to write a question

Both qualitative and quantitative research require research questions. The kind of question you use depends on what you want to find out about and the type of research you want to do. It will shape your research design.

The table below shows some of the most common types of research questions. Bear in mind that many academic research questions will be more complex than these examples, often combining two or more types.

Research question type	Formulation
Descriptive research	*What are the characteristics of X?*
Comparative research	*What are the differences and similarities between X and Y?*
Correlational research	*What is the relationship between variable X and variable Y?*
Exploratory research	*What are the main factors in X? What is the role of Y in Z?*
Explanatory research	*Does X have an effect on Y? What is the impact of Y on Z? What are the causes of X?*
Evaluation research	*What are the advantages and disadvantages of X? How well does Y work? How effective or desirable is Z?*
Action research	*How can X be achieved? What are the most effective strategies to improve Y?*

How to write a question

Focused and researchable

Criteria	Explanation
Focuses on a single topic and problem	Your central research question should follow from your research problem to keep your work focused. If you have multiple questions, they should all clearly relate to this central aim.
Answerable using primary or secondary data	You must be able to find an answer by collecting quantitative and/or qualitative data, or by reading scholarly sources on the topic to develop an argument. If such data is impossible to access, you will have to rethink your question and ask something more concrete.
Does not ask for a subjective value judgement	Avoid subjective words like *good*, *bad*, *better* and *worse*, as these do not give clear criteria for answering the question. If your question is evaluating something, use terms with more measurable definitions. ✖ Is X or Y a better policy? ✔ How effective are X and Y policies at reducing rates of Z?
Does not ask *why*	*Why* questions are usually too open to serve as good research questions. There are often so many possible causes that a research project cannot give a thorough answer. Try asking *what* or *how* questions instead. ✖ Why does X occur? ✔ What are the main factors contributing to X? ✔ How is X influenced by Y?

How to write a question

Feasible and specific

Criteria	Explanation
Answerable within practical constraints	Make sure you have enough time and resources to do the research required to answer the question. If you think you might struggle to gain access to enough data, consider narrowing down the question to be more specific.
Uses specific, well-defined concepts	All the terms you use in the research question should have clear meanings. Avoid vague language and broad ideas, and be clear about *what*, *who*, *where* and *when* your question addresses. ✖ What effect does social media have on people's minds? ✔ What effect does daily use of Twitter have on the attention span of under-16s?
Does not ask for a conclusive solution, policy, or course of action	Research is about informing, not instructing. Even if your project is focused on a practical problem, it should aim to improve understanding and suggest possibilities rather than asking for a ready-made solution. ✖ What should the government do about low voter turnout? ✔ What are the most effective communication strategies for increasing voter turnout among under-30s?

How to write a question

Complex and arguable

Criteria	Explanation
Cannot be answered with *yes* or *no*	Closed *yes*/*no* questions are too simple to work as good research questions — they don't provide enough scope for investigation and discussion. ✖ Has there been an increase in homelessness in the UK in the past ten years? ✔ How have economic and political factors affected patterns of homelessness in the UK over the past ten years?
Cannot be answered with easily found facts and figures	If you can answer the question through a Google search or by reading a single book or article, it is probably not complex enough. A good research question requires original data, synthesis of multiple sources, interpretation and/or argument to provide an answer.
Provides scope for debate and deliberation	The answer to the question should not just be a simple statement of fact: there needs to be space for you to discuss and interpret what you found. This is especially important in an essay or research paper, where the answer to your question often takes the form of an argumentative thesis statement.

How to write a question

Relevant and original

Criteria	Explanation
Addresses a problem relevant to your field or discipline	The research question should be developed based on initial reading around your topic, and it should focus on addressing a problem or gap in the existing knowledge.
Contributes to a topical social or academic debate	The question should aim to contribute to an existing debate — ideally one that is current in your field or in society at large. It should produce knowledge that future researchers or practitioners can build on.
Has not already been answered	You don't have to ask something groundbreaking that nobody has ever thought of before, but the question should have some aspect of originality (for example, by focusing on a specific location or taking a new angle on a long-running debate).

Step 8: Understand your research design

The research design is a practical framework for answering your research questions. It involves making decisions about the type of data you need, the methods you'll use to collect and analyze it, and the location and timescale of your research.

There are often many possible paths you can take to answering your questions. The decisions you make will partly be based on your priorities. For example, do you want to determine causes and effects, draw generalizable conclusions, or understand the details of a specific context?

You need to decide whether you will use primary or secondary data and qualitative or quantitative methods. You also need to determine the specific tools, procedures, and materials you'll use to collect and analyze your data, as well as your criteria for selecting participants or sources.

Component of a research design

The research design is a framework for planning your research and answering your research questions. Creating a research design means making decisions about:

- The type of data you need
- The location and timescale of the research
- The participants and sources
- The variables and hypotheses (if relevant)
- The methods for collecting and analyzing data

The research design sets the parameters of your project: it determines exactly what will and will not be included. It also defines the criteria by which you will evaluate your results and draw your conclusions. The reliability and validity of your study depends on how you collect, measure, analyze, and interpret your data.

Determine your data

Primary vs secondary data

Primary data	Secondary data
You will directly collect original data (e.g. through surveys, interviews, or experiments) and then analyze it.	You will analyze data that someone else already collected (e.g. in national statistics, official records archives, publications, and previous studies).
This makes your research more original, but it requires more time and effort, and relies on participants being available and accessible.	This saves time and can expand the scope of your research, but it means you don't have control over the content or reliability of the data.

Qualitative vs quantitative data

Qualitative data	Quantitative data
If your objectives involve describing subjective experiences, interpreting meanings, and understanding concepts, you will need to do qualitative research.	If your objectives involve measuring variables, finding frequencies or correlations, and testing hypotheses, you will need to do quantitative research.
Qualitative research designs tend to be more flexible, allowing you to adjust your approach based on what you find throughout the research process.	Quantitative research designs tend to be more fixed, with variables and methods determined in advance of data collection.

Determine your data

Method	What to consider
Surveys	• How many respondents do you need and what sampling method will you use (e.g. simple random or stratified sampling)? • How will you distribute the survey (e.g. in person, by post, online)? • How will you design the questionnaire (e.g. open or closed questions)?
Interviews	• How will you select participants? • Where and when will the interviews take place? • Will the interviews be structured, semi-structured or unstructured?
Experiments	• Will you conduct the experiment in a laboratory setting or in the field? • How will you measure and control the variables? • How will you design the experiment (e.g. between-subjects, within-subjects, double blinding)?
Secondary data	• Where will you get your sources from (e.g. online or a physical archive)? • What criteria will you use to select sources (e.g. date range, content)?

Step 9: Write a research proposal

Finally, after completing these steps, you are ready to complete a research proposal. The proposal outlines the context, relevance, purpose, and plan of your research.

As well as outlining the background, problem statement, and research questions, the proposal should also include a literature review that shows how your project will fit into existing work on the topic. The research design section describes your approach and explains exactly what you will do.

You might have to get the proposal approved by your supervisor before you get started, and it will guide the process of writing your thesis or dissertation.

Guidelines

- Why – the general aims and objectives (purpose) of the project.
- What – the subject to be investigated, and the included variables.
- Where – the location or setting of the study, i.e. where the data will be gathered and to which entity the data will belong.
- When – the timeframe within which the data is to be collected.
- Who – the subject matter of the study and the population from which they will be selected. This population needs to be large enough to be able to make generalisations.
- How – how the research is to be conducted, including a description of the research design (e.g. whether it is experimental research, qualitative research or a case study), methodology, research tools and analysis techniques.