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Research Methods & Professional Development

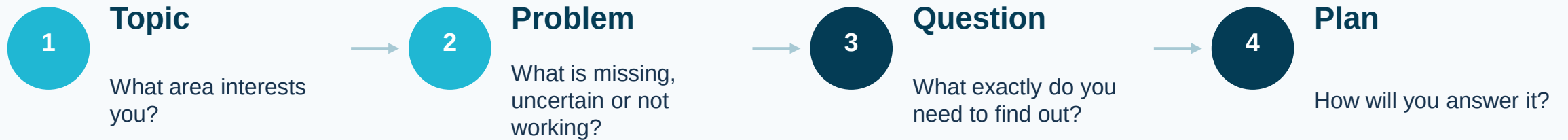
Lecture 2 – Research Questions, Aims, Objectives and Hypotheses

Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives



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From choosing a topic to designing a study



Key idea

A research proposal connects a worthwhile problem to a focused question and a feasible method. The strongest proposals make the logic easy for a reader to follow.

By the end of this lecture, you should be able to...

Explain

the purpose and core sections of a research proposal.

Formulate

a focused, feasible research question from a research problem.

Distinguish

between a research aim and research objectives.

Construct

appropriate null and alternative hypotheses when a study requires them.

Align

problem, question, aim, objectives, hypothesis and method.

01 Proposal foundations

What a research proposal is, why it matters, and how a broad topic becomes a researchable problem.

A research proposal is a structured argument and a practical plan

It tells a reader what you intend to study, why the study is worth doing, and how you will conduct it.

WHAT?

The topic, problem, research question, aim and objectives.

WHY?

The gap, relevance, significance and expected contribution.

HOW?

The design, data, participants or sources, analysis, ethics and timeline.

A proposal is not the final answer. It is a justified plan for obtaining a credible answer.

A strong proposal reduces uncertainty before the research begins

Focus

Clarifies the problem and prevents the project from becoming too broad.

Feasibility

Tests whether the study can be completed with available time, data and resources.

Quality

Forces early decisions about evidence, methods, ethics and analysis.

Communication

Allows supervisors, reviewers or funders to judge and improve the plan.

Think of the proposal as a design review before you invest in the full project.

Typical components

The exact format varies by discipline, project type and assessment brief.



The proposal should read as one connected story, not eight unrelated boxes.

Research becomes manageable as the focus narrows

Broad topic: Artificial intelligence in education

Context: Generative AI use in undergraduate programming modules

Issue: Students use AI tools, but effects on debugging skill are unclear

Research problem: There is insufficient evidence on whether guided AI use improves independent debugging performance

The research problem is not just a topic. It identifies a specific knowledge gap, practical difficulty or unresolved issue.

Decide first. Then explain why.

2–3 MINUTES

1 I want to investigate how first-year students use ChatGPT when debugging Python assignments.

☐

2 Artificial intelligence is changing the world.

☐

3 This study will assess whether gamified coding exercises improve motivation in introductory programming.

☐

4 Computers are useful in education.

☐

A useful problem statement answers three questions

1. Context

What situation or domain are we examining?

2. Gap or problem

What is unknown, inadequate, inconsistent or underperforming?

3. Consequence

Why does this gap matter? What happens if it remains unresolved?

Research Problem Statement

A good problem statement can be one paragraph. It should not simply say that a topic is important.

The problem statement adds evidence and purpose to a topic

Too broad

“AI tools are increasingly used by programming students.”



Research problem

“Although generative AI tools are widely used in programming education, there is limited evidence on whether guided use improves students’ independent debugging performance. Without this evidence, educators cannot judge how to integrate such tools without weakening core problem-solving skills.”

Specific context + evidence gap + consequence = a research problem

02 Research questions, aims & objectives

Turn the problem into a precise question, an overall purpose and a sequence of achievable research tasks.

The research question defines exactly what the study needs to find out

A strong research question is...

- Focused
- Answerable with evidence
- Feasible within the project
- Ethically researchable
- Analytical, not merely opinion-based

Worked example

Problem: It is unclear whether guided generative AI use improves independent debugging performance.

Research question: “To what extent does guided use of generative AI affect debugging performance among first-year undergraduate programming students?”

A good question creates boundaries: what, who, where, and sometimes when.

Question wording often signals the kind of evidence required

Descriptive

What is happening?

How do students currently use AI tools during debugging?

Comparative

How do groups or approaches differ?

Do students using guided AI prompts outperform students using standard support?

Relational

Are variables associated?

What is the relationship between AI reliance and debugging self-efficacy?

Explanatory / causal

Does X influence Y?

Does guided AI use improve debugging accuracy?

Design / evaluation

How well does a solution work?

How effective is an AI feedback tool for reducing common debugging errors?

Make the question focused, answerable and feasible

PAIR TASK

Weak question

“Does technology improve learning?”



Your task

- Specify the technology
- Specify the learning outcome
- Specify the group / context
- Choose appropriate question wording

Write one improved research question in 60–90 seconds.

The aim states what the study intends to accomplish overall

Good aim

To investigate the effect of guided generative AI use on independent debugging performance among first-year undergraduate programming students.

Useful verbs

Investigate
Evaluate
Examine
Assess
Compare
Develop and evaluate

Avoid

“To learn about...”
“To understand everything about...”
Multiple unrelated aims
An aim that promises the result in advance

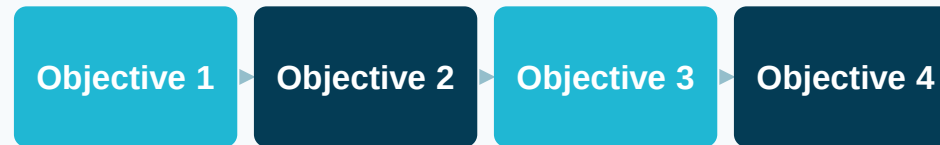
Aim = one broad purpose, written as a clear action statement.

Objectives break the aim into specific, achievable research tasks

- 1 Review** relevant literature on generative AI and programming skill development.
- 2 Design** a guided AI intervention and a comparison condition.
- 3 Measure** debugging performance using a defined task and scoring approach.
- 4 Compare** performance between groups using an appropriate analysis.
- 5 Interpret** the findings and identify implications for programming education.

A useful test: if all objectives are completed, should the aim be achieved?

Aim = destination. Objectives = route.



Aim: To investigate the effect of guided AI use on independent debugging performance.

Objectives specify the evidence-producing tasks needed to achieve that aim.

ONE overall purpose

SEVERAL specific steps

03 Hypotheses & variables

Know when a hypothesis is appropriate, how it differs from a research question, and how null and alternative hypotheses are written.

A hypothesis is a testable prediction about an expected relationship or difference

Research question

“Does guided use of generative AI affect independent debugging performance?”



Hypothesis

“Students who use guided generative AI support will achieve higher independent debugging scores than students who use standard support.”

Question asks. Hypothesis predicts.

Not every research project needs a hypothesis

Usually appropriate

Quantitative studies that test:

- differences between groups or conditions
- relationships between measurable variables
- predicted effects or associations
- model performance against a benchmark

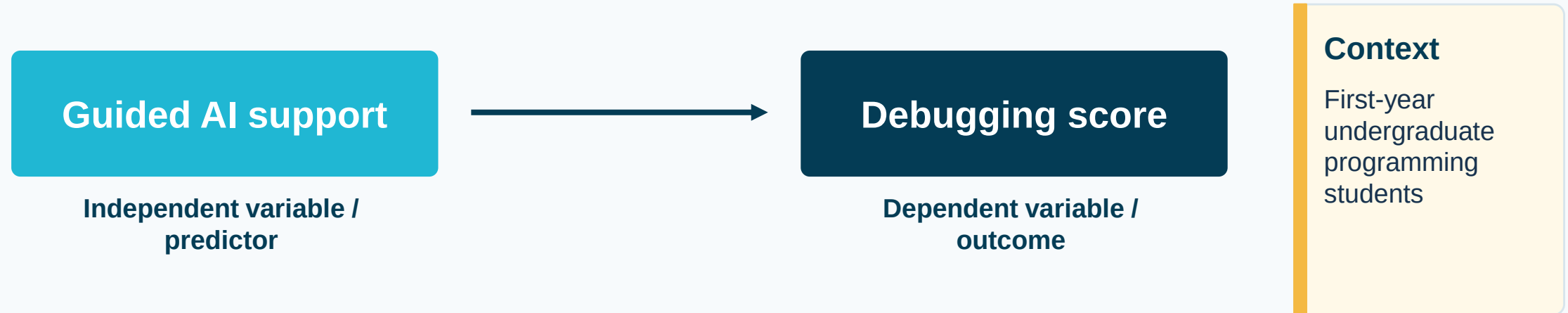
Often not necessary

Exploratory or qualitative studies that aim to:

- understand experiences or perceptions
- explore an under-researched phenomenon
- develop themes or theory inductively
- discover how or why a process occurs

Use the research design to decide whether hypotheses add value.

A testable hypothesis identifies measurable concepts



Operationalise key concepts: define exactly how each variable will be represented or measured.

Hypothesis testing commonly starts with two competing statements

H_0 : Null hypothesis

There is no statistically significant difference in independent debugging performance between students using guided generative AI support and students using standard support.

H_1 : Alternative hypothesis

Students using guided generative AI support will demonstrate significantly higher independent debugging performance than students using standard support.

H_0 represents “no effect / no difference / no association”. H_1 represents the effect or relationship being tested.

The wording depends on what prior evidence allows you to predict

Directional

Predicts the direction of the effect.

Example: “Students using guided AI will achieve higher debugging scores than students using standard support.”

Non-directional

Predicts a difference or relationship, but not its direction.

Example: “Debugging scores will differ between students using guided AI and students using standard support.”

Do not force a directional prediction when the literature is mixed or insufficient.

Write an alternative hypothesis and a null hypothesis

2 MINUTES

Research question

“Does using a gamified coding platform affect programming motivation among first-year computer science students?”

H_1 :

H_0 :



Write an alternative hypothesis and a null hypothesis

2 MINUTES

Research question

“Does using a gamified coding platform affect programming motivation among first-year computer science students?”

H_1 :

Students using a gamified coding platform will report higher programming motivation than students using a non-gamified platform

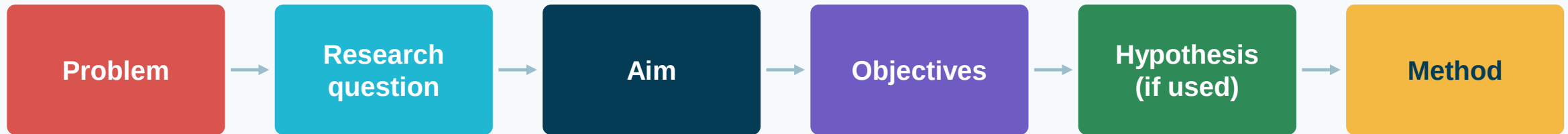
H_0 :

There will be no significant difference in programming motivation between the two groups

04 Alignment: make the proposal coherent

The problem, question, aim, objectives, hypothesis and method should form one logical chain.

Every element should answer the one before it



Alignment test

Can you point to each objective and explain which part of the question it helps answer? Can you explain why the chosen method generates the evidence needed for the question and hypothesis?

One coherent line of reasoning

Problem

Insufficient evidence on whether guided AI improves independent debugging.

Question

To what extent does guided AI affect debugging performance?

Aim

To investigate the effect of guided AI on independent debugging performance.

Objectives

Review evidence; design intervention; measure performance; compare groups; interpret findings.

Hypothesis

Guided AI users will achieve higher independent debugging scores.

Method

Comparative quantitative design using a debugging task and between-group analysis.

Which element does not fit? What would you change?

THINK • PAIR • SHARE

Question

How does pair programming affect code quality among novice developers?

Aim

To understand students' perceptions of pair programming.

Objective

To compare defect rates between pair-programming and individual-programming groups.

Hypothesis

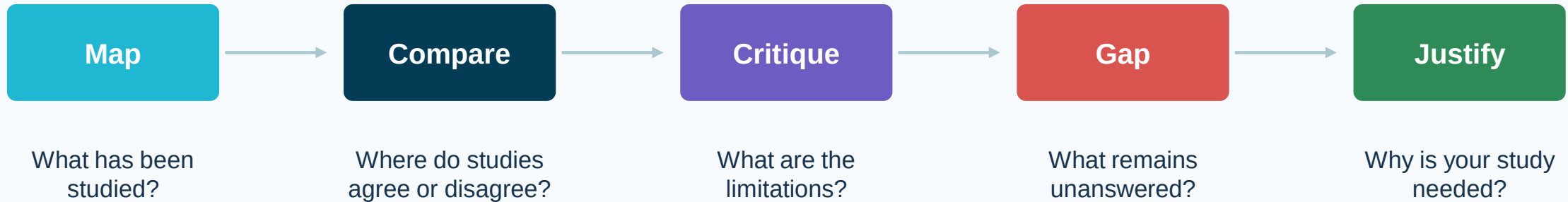
Pair-programming teams will produce fewer defects than individual programmers.

There may be more than one valid repair, but the final chain must be internally consistent.

05 Building the rest of the proposal

Use the aligned core to decide what literature, methodology, evidence, ethics, timeline and contribution the proposal needs.

The literature review explains what is known, debated and missing



Avoid the “laundry list”

Organise sources around ideas, patterns, disagreements and limitations. End by making the gap explicit and showing how it leads to your research question.

Methodology translates the question into an evidence plan

Design

Experiment, survey, case study, interviews, dataset analysis, design science...

Data / sample

What or who provides evidence? How will cases, participants or datasets be selected?

Measures / instruments

What will be observed, measured or asked? How are key concepts operationalised?

Analysis

How will the evidence be analysed to answer the question or test the hypothesis?

Ethics

Consent, privacy, data security, bias, risk and responsible use of AI or data.

Be clear about what the study may contribute without pretending you already know the result

Possible outputs

- Dataset
- Evaluation results
- Prototype or model
- Framework or guidelines
- Evidence about a relationship
- Design recommendations

Contribution

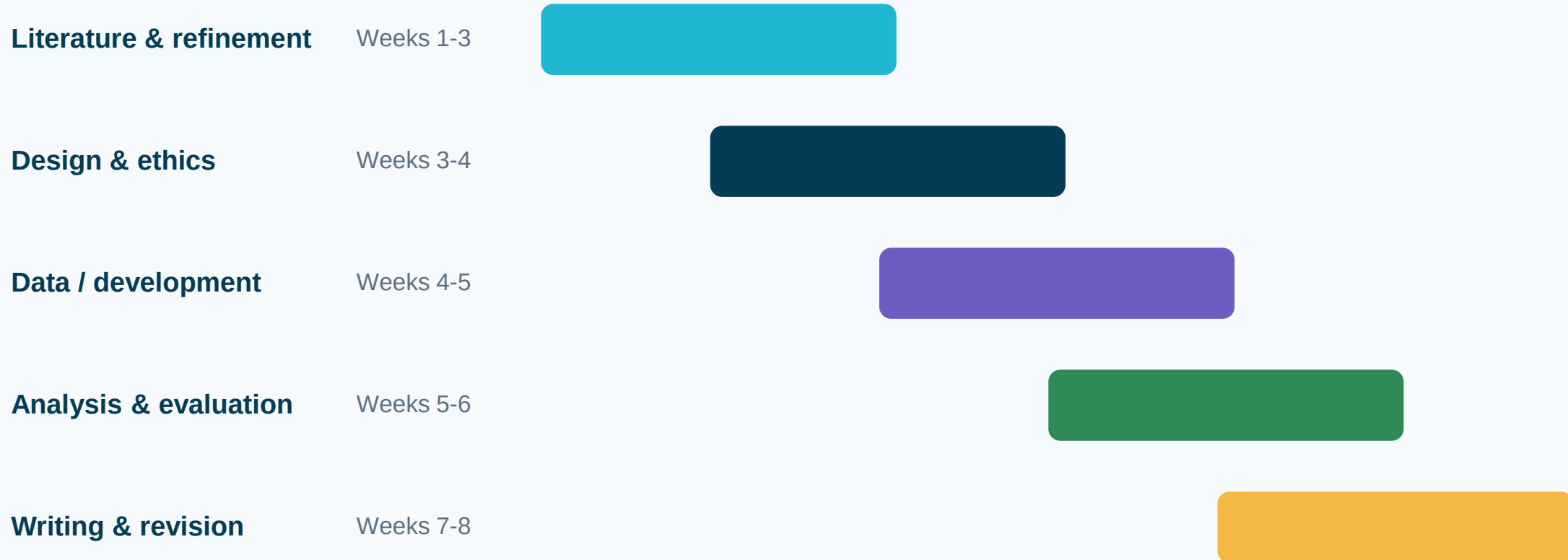
What new knowledge, evidence, tool or practical insight could the study add?

Avoid overclaiming

Do not write: “The model will improve accuracy by 15%” unless that result is already established.

Prefer: “The study will evaluate whether the model improves accuracy.”

A proposal must be doable, not just interesting



Feasibility check: time • access to data/participants • tools/skills • ethics approval • computing resources

Show where ideas and evidence come from

Cite

Prior findings
Definitions or frameworks
Datasets and software where required
Figures or adapted material

Reference consistently

Use the required style, such as IEEE. Ensure every in-text citation has a matching reference entry.

Use sources critically

Prefer relevant peer-reviewed research and authoritative sources. Do not cite material simply because it appears first in a search.

Good referencing supports credibility, reproducibility and academic integrity.

Before submission, can the reader answer “yes” to these questions?

- ✓ Is the problem specific and supported by a clear rationale?
- ✓ Is the research question focused, feasible and answerable with evidence?
- ✓ Does the aim match the question?
- ✓ Do the objectives collectively deliver the aim?
- ✓ If a hypothesis is used, is it testable and linked to measurable variables?
- ✓ Does the methodology generate the evidence needed to answer the question?
- ✓ Are contribution, ethics, feasibility, timeline and references addressed?

06 Check your understanding

Short retrieval practice before the final workshop.

Choose the best answer

1 Which is the best research question?

A. Is AI good? B. How does guided AI use affect debugging performance among first-year programming students? C. Technology and education.

2 Which statement best describes an aim?

A. A list of tasks B. A statistical prediction C. The overall purpose of the study D. A literature gap

3 Which is an objective?

A. To improve education worldwide B. To compare debugging scores between two study groups C. AI will improve scores

4 What does H_0 usually state?

A. The predicted positive effect B. The research aim C. No effect, difference or association D. The method

5 True or false: Every research proposal must include a hypothesis.

True / False

What should you remember?

1 B

Specific question, defined population and measurable outcome.

2 C

The aim is the overall purpose, not the task list.

3 B

Objectives are concrete research actions that help achieve the aim.

4 C

The null hypothesis represents no effect, difference or association.

5 FALSE

Hypotheses are useful for many quantitative testing studies, but not every design requires them.

07 Workshop: build a proposal chain

Apply the lecture to a realistic computer science scenario and produce a coherent mini-proposal.

Smart-city systems collect data, but turning it into timely decisions remains difficult

Scenario

Cities use IoT sensors for traffic, waste management and energy consumption. However, fragmented systems and slow analysis can prevent decision-makers from responding effectively to real-time conditions.

As a computer science researcher, propose a study using machine learning, cloud computing or edge computing to improve decision-making.

Your goal

Move from the broad scenario to:

1. problem statement
2. research question
3. aim
4. 3-5 objectives
5. hypothesis, if appropriate
6. matching method

Complete each line so that the next line follows logically

Problem

Research question

Aim

Objectives

Hypothesis?

Method

Final check: Does the method provide the evidence needed to answer the research question?

Recommended structure

- 1 Title
- 2 Introduction / background
- 3 Literature review
- 4 Problem statement
- 5 Research question
- 6 Aim & objectives
- 7 Hypothesis, if appropriate
- 8 Methodology & ethics
- 9 Expected contribution & timeline
- 10 References

Quality rule

Do not write each section independently. Keep checking the alignment chain as the proposal develops.

Pitch the logic of the study, not every detail

1 Title & context

2 Problem / gap

3 Research question

4 Aim & objectives

5 Hypothesis, if used

6 Methodology & ethics

7 Expected contribution

8 Timeline

9 References

A reviewer should be able to understand the whole study in a few minutes.

Five distinctions to remember

Proposal

the justified plan for the study

Research question

what the study needs to find out

Aim

the overall purpose of the study

Objectives

the specific research steps that deliver the aim

Hypothesis

a testable prediction, used when appropriate

The quality of the proposal depends on alignment between all five.

Developing the proposal further

Introduction

Building a clear rationale from context to problem and research purpose.

Literature review

Searching, organising and critically synthesising relevant academic sources.

Refinement

Using feedback to tighten the research question, aim, objectives and study scope.

Bring your draft topic or research problem to the next session.

Useful research-methods sources

Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., & FitzGerald, W. T. (2016). *The Craft of Research* (4th ed.). University of Chicago Press.

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE.

Saunders, M., Lewis, P., & Thornhill, A. (2023). *Research Methods for Business Students* (9th ed.). Pearson.

Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., & Wesslén, A. (2012). *Experimentation in Software Engineering*. Springer.

Also follow the module handbook and assessment brief for the required proposal structure and referencing style.

Questions?

Before you leave: write one research question for your own topic.

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