Course: Research Method in Software Engineering

WEEK 4 – Setting Research Questions, Objectives, and Hypotheses

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Week 4- Setting Research Questions, Objectives, and Hypotheses

Contents

Learning Outcome

- Understand types of research questions and key elements of good research questions
- Understand the possible sources and the process of identifying research questions.
- Identify the steps to develop research questions.
- Understand research objectives and how to develop
- Understand research hypotheses and differentiate its type
- Understand hypothesis testing methods

1. Research Questions

What is Research Question?

- The critical first step in any research endeavor is the formulation of a research question, a task that requires a deep understanding of both the topic at hand and the existing scholarly landscape surrounding it.
- Research is a knowledge-gathering exercise rather than verification. So we asks a series of questions, gets many answers and looks for patterns.
- The research question serves as the inspiration that guides the trajectory of the investigation, providing a focal point that centers the research activities and objectives.

[1]. ServiceScape, How Does a Hypothesis Differ From a Research Question?, David Costello, 2023. https://www.servicescape.com/blog/how-does-a-hypothesis-differ-from-a-research-question

1. Research Questions …Cont'd

Types of research questions

- There are **three types of research questions**, each of which reflect the type of research study.

1. Descriptive research questions

- These questions generally look at descriptions of a particular issue or situation aiming to provide a detailed and accurate description of a phenomenon, event, or subject.
- These questions seek to describe the current state of affairs without trying to determine cause-and-effect relationships.

➢ **Example :-** What are the most commonly used programming languages in software development today?

[1]. ServiceScape, How Does a Hypothesis Differ From a Research Question?, David Costello, 2023. https://www.servicescape.com/blog/how-does-a-hypothesis-differ-from-a-research-question

1. Research Questions …Cont'd

Types of research questions ….Cont'd

2. Exploratory Research questions

- These questions explore (discover) a particular issue or phenomenon aim to investigate that are not well understood or to generate insights that can guide further research.
- These questions often focus on discovering patterns, behaviors, and relationships rather than testing specific hypotheses.
- **Example:-** How is the Internet of Things (IoT) changing the landscape of software development?

1. Research Questions …Cont'd

Types of research questions ….Cont'd

3. Explanatory Research questions:

- These questions seek to establish causal effects between two or more variables.
- It often follow exploratory research and are designed to test hypotheses based on existing theories or findings.
- **Example:** How does the implementation of Agile methodologies impact project delivery times compared to traditional development methods?

[2]. The Writing Center, George Mason University, How to Write a Research Question, August 8, 2018. https://writingcenter.gmu.edu/writing-resources/research-based-writing

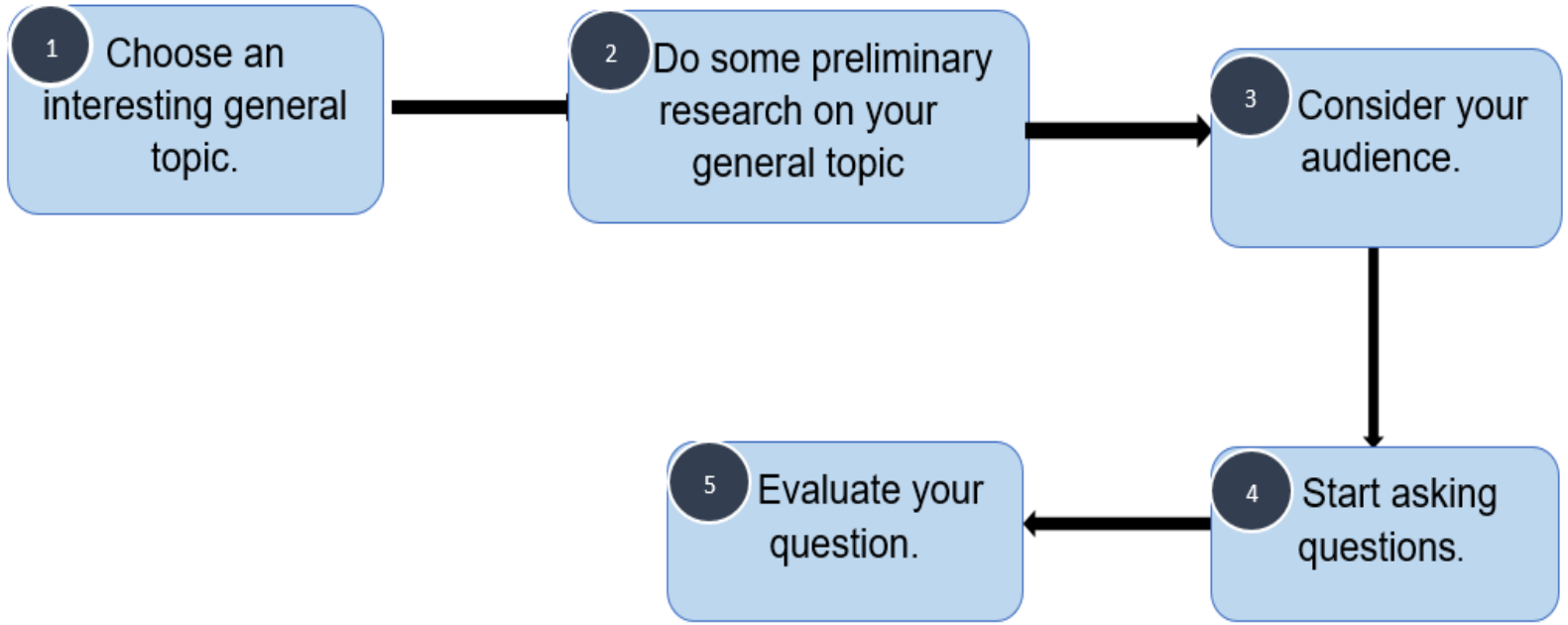
1. Research Questions …Cont'd

Elements of good research questions

- **Clear**: provides enough specifics that one's audience can easily understand its purpose without needing additional explanation.
- **Focused**: narrow enough that it can be answered carefully
- **Concise**: expressed in the fewest possible words.
- **Complex**: not answerable with a simple "yes" or "no," but rather requires synthesis and analysis of ideas and sources prior to composition of an answer.
- **Arguable**: its potential answers are open to debate rather than accepted facts.

1. Research Questions …Cont'd

Steps to develop a research question:



Example: Research Question in software Engineering :-

- What factors contribute to software quality challenges in open source projects?

1. Research Questions ….Cont'd

Questions

1. What is wrong with this research question?

"What are the effects of not exercising on the health of people?"

A. Too narrow

B. Too Short

C. Not interesting

D. Too Broad

Ans. D .

- This research question does not specify the population of people that will participate in this study and the frequency of exercising.
- A more correct way to state this research question is *"What are the effects of not exercising daily on the health of women over the age of 65?"*

1. Research Questions ….Cont'd

2. What is wrong with this research question?

"Does exercising daily have an effect on the health of women over the age of 65?"

A. This research question is too complex

B. This researcher should investigate something more relevant

C. This research question is too simple

D. This research question is unethical

Ans. C .

- Because. This research question can have a **yes/no** answer, and a proper research question should not have a yes/no answer.
- A more correct way to state this research question is "What effects does exercising daily have on the health of women over the age of 65?"

2. Research Objectives

- Objective is the goal intended to be attained (and which is believed to be attainable)
- It outlines what the researcher intends to accomplish and what they hope to learn or discover through their research.
- It is crucial for guiding the research process and ensuring that the study stays focused and on track

https://www.marketing91.com/wp-content/uploads/2023/09/Research-Objectives.jpg

[3]. IdeaScale, What is a Research Objective? Definition, Types, Examples and Best Practices, Nick Jain, Sep. 8, 2023 https://ideascale.com/blog/what-is-research-objective

2. Research Objectives …Cont'd

Why develop Research Objectives?

- To Focus the study
- To avoid the collection of data which are not strictly necessary for understanding and solving the problem we have identified.
- To Organize the study in clearly defined parts or phases.
- Properly formulated, specific objectives will facilitate the development of our research methodology and will help to orient the collection, analysis, interpretation and utilization of data. Helps to minimizes wastage of resources like time, money, and energy

- **Remember** : the objectives of a research summarize what is to be achieved by the study and they should be closely related to the statement of the problem.

2. Research Objectives …Cont'd

SMART objectives

SMATR stands for specific, measurable, achievable, relevant, and time-bound.

- **S**pecific: states clear about the what, why, when, and how , exactly what you need to achieve
- **M**easurable: identifies the main variables of the study and quantifies the targets
- **A**chievable: attainable using the available time and resources
- **R**ealistic/Relevant: can be challenging but must be achievable and accurately addresses the scope of the problem
- **T**imebound: identifies the time in which each step will be completed

[5]. Atlassian, How to write SMART goals (with examples), Kat Boogaard, December 26, 2023. https://www.atlassian.com/blog/productivity/how-to-write-smart-goals

2. Research Objectives …Cont'd

- Research objectives can be broadly classified into **general** and **specific objectives**.

General objectives Vs specific objectives

- General objectives state what the research expects to achieve overall while specific objectives break this down into smaller, logically connected parts, each of which addresses various parts of the research problem.
    - General objectives are the main goals of the study and are usually fewer in number while specific objectives are more in number because they address several aspects of the research problem.

[4]. Researcher.Life, What Are Research Objectives and How to Write Them (with Examples), Divya Sreekumar, July 14, 2023. https://researcher.life/blog/article/what-are-research-objectives-how-to-write-them-with-examples/

2. Research Objectives …Cont'd

Example. Research Objective in software engineering part

General Objective

- To investigate the challenges, strategies, and best practices in software maintenance to enhance the sustainability, quality, and efficiency of software systems over their lifecycle.

Specific Objectives

- To identify and categorize the most common challenges faced by software maintenance teams in various types of software projects.
- To assess the impact of documentation quality and practices on the efficiency of software maintenance tasks.
- To develop metrics for measuring the performance of software maintenance processes and assess their impact on overall software quality.

2. Research Objectives …Cont'd

Classification of research objectives

- It can be grouped into several categories depending on the research problem, as given in the following Table.

Type of research objective	Definition
Exploratory	Explores a previously unstudied topic, issue, or phenomenon; aims to generate ideas.
Descriptive	Describes the characteristics and features of a particular population or group
Explanatory	Explains the relationships between variables; seeks to identify cause-and-effect relationships
Predictive	Predicts future outcomes or events based on existing data samples or trends
Comparative	Compares two or more groups or phenomena to identify similarities and differences

2. Research Objectives …Cont'd

Research objectives Vs. Research aims

- **Research aims :** Statements that reflect the broad goal(s) of the study and outline the general direction of the research. They are not specific but clearly define the focus of the study.
  - Example: *This research aims to explore employee experiences of digital transformation in retail HR.*
- **Research objectives:** Focus on the action to be taken to achieve the aims-→make the aims more practical and should be specific and actionable.
  - **Example:** To observe the retail Human Recourse (HR) employees throughout the digital transformation

[6]. Research methods: The basics, Walliman, N., Routledge, 2021. Page-48

3. Research Hypotheses

What is Hypotheses? Why we use Hypotheses? Types of Hypotheses?

What is Hypotheses?

- A hypothesis is a well-reasoned proposition in response to a research question that we will test to confirm or disprove in our research. Not all research has a hypothesis.
- It is an assumption about the relationships between two variables
- A hypotheses is not just a guess –it should be based on existing **theories and knowledge**.
- If we want to test a relationship between two or more things , we need to write hypotheses before we start our experiment or data collection

[6]. Research methods: The basics, Walliman, N., Routledge, 2021, Page-35

3. Research Hypotheses …Cont'd

Types of Hypotheses

1. Simple hypotheses

- It shows a relationship between one dependent variable and a single independent variable.

Example:- It you eat more vegetables , you will lose weight faster

- Independent variable = eating more vegetables
- Dependent variable = losing weight

2. Complex hypotheses

- It shows the relationship between two or more dependent variables and two or more independent variables.
- E.g. Eating more vegetables and fruits leads to weight loss, glowing skin, reduces the risk of many diseases such as heart diseases, high blood pressure and some cancers.

3. Research Hypotheses …Cont'd

Types of Hypotheses ….Cont'd

3. Directional Hypothesis

- Additionally indicates both the direction of the relationship or difference

  E.g. The more horsepower a car has, the higher the consumption

- This shows the effect and direction of effects
- The relationships between the variables can also predict its nature

[7]. BYJU'S, What is Hypothesis - Characteristics, Source, Types, Examples and Functions, https://byjus.com/physics/hypothesis/

3. Research Hypotheses …Cont'd

Types of Hypotheses ….Cont'd

4. Non- directional hypotheses

- Askes whether there is a difference or correlation regardless of the direction of the correlation or difference. E.g. There is a correlation between height and weight, but it doesn't matter if the correlation is positive or negative.→ Just to test if there is a correlation.
    - It is a statements that a relationship exists between two variables, without predicting the exact nature of the relationship

5. Null- Hypothesis

- It provides a statement which is contrary to the hypothesis. It's a negative statement, and there is no relationship between independent and dependent variables. The symbol is denoted by "HO".

4. Formulation of Hypotheses

Hypothesis testing Process Steps

1. State the hypothesis.

2. Formulate the analysis plan→ outlines how the data will be evaluated.

3. Carry out the plan and analyze the sample data.

4. Analyze the results and either reject the null hypothesis, or state that the null hypothesis is reasonable, given the data.

Example: Hypothesis:- Man earn more than women in Ethiopia –>

Goal – Test this hypotheses (whether to retain or reject the hypothesis)

Data collection - we need survey data e.g.. 1000 employed people in Ethiopia

Data analysis – with the help of Hypothesis test (e.g. a t-test)

4. Formulation of Hypotheses …Cont'd

Variables in Hypotheses

- **Variable** : a property of an object or event that can take on different values
  - E.g. . Eye is an object with different values such as **brown, back and blue**
- Hypotheses propose a relationship between two or more variables
  - **Independent Variables***:- something the researcher changes or control*
  - **Dependent variable** *: - something the researcher observes and measure*
- **Example** : Research Variables in software engineering
  - Software Quality , Agile model , Waterfall model, System Performance…

[8]. Pracfical research: Planning and design, Leedy, P. D., & Ormrod, J. E. , Global edition, 2015, Page-60

4. Formulation of Hypotheses …Cont'd

Two **hypotheses** are always formulated that assert the opposite. These are called **null** and **alternative hypotheses.**

- **Null hypothesis : -**assumes that there is no difference between two or more variables

  Example :- salary of women and men does not differ in Ethiopia

- **Alternative hypothesis :-** assumes that there is a difference

  Example: the salary of women and men dose differ in Ethiopia

Note:-

- It is always the null hypothesis that is tested with hypothesis test.
- Thus, the null hypothesis is always either rejected of not rejected

4. Formulation of Hypotheses …Cont'd

Hypothesis testing

- Provides a way to verify whether the results of an experiment are valid.
- A null hypothesis and an alternative hypothesis are set up before performing the hypothesis testing.

a) The Null hypothesis

- A concise mathematical statement that is used to indicate that there is no difference between two possibilities→ there is no difference between certain characteristics of data.
- This hypothesis assumes that the outcomes of an experiment are based on **chance alone,** and denoted as H0.
- Hypothesis testing is used to conclude if the null hypothesis can be rejected or not.

4. Formulation of Hypotheses …Cont'd

b) Alternative Hypothesis

- An alternative to the null hypothesis.
- It indicates that there is a statistical significance between two possible outcomes and can be denoted as **H1** or **Ha**.

Example :

Suppose an experiment is conducted to check if girls are shorter than boys at the age of 5.

- **Null hypothesis (H0)** -→ girls and boys are the same height.
- **Alternative hypothesis(H1)** → girls are shorter than boys at the age of 5.

[9]. Cuemath, Hypothesis Testing - Definition, Examples, Formula, Types.
https://www.cuemath.com/data/hypothesis-testing/

Summary

- The research question serves as the inspiration that guides the route of the investigation, providing a focal point that centers the research activities and objectives
- There are three types of research questions – descriptive, exploratory and explanatory.
- Research questions need to be clear, focused, concise. complex, arguable.
- Research Objectives outlines what the researcher intends to accomplish and what they hope to learn or discover through their research.
- A hypothesis is derived from theory and it is a statement that explains the relationship between two or more variables.
- A hypothesis usually indicates the direction of the association of the independent and dependent variable.
- A null hypothesis and an alternative hypothesis are set up before performing the hypothesis testing.

References

1. ServiceScape, How Does a Hypothesis Differ From a Research Question?, David Costello, 2023. https://www.servicescape.com/blog/how-does-a-hypothesis-differ-from-a-research-question

2. The Writing Center, George Mason University, How to Write a Research Question, August 8, 2018. https://writingcenter.gmu.edu/writing-resources/research-based-writing

3. IdeaScale, What is a Research Objective? Definition, Types, Examples and Best Practices, Nick Jain, Sep. 8, 2023 https://ideascale.com/blog/what-is-research-objective

4. Researcher.Life, What Are Research Objectives and How to Write Them (with Examples), Divya Sreekumar, July 14, 2023. https://researcher.life/blog/article/what-are-research-objectives-how-to-write-them-with-examples/

5. Atlassian, How to write SMART goals (with examples), Kat Boogaard, December 26, 2023. https://www.atlassian.com/blog/productivity/how-to-write-smart-goals

6. Research methods: The basics, Walliman, N., Routledge, 2021, Page-35.

7. BYJU'S, What is Hypothesis - Characteristics, Source, Types, Examples and Functions, https://byjus.com/physics/hypothesis/

8. Pracfical research: Planning and design, Leedy, P. D., & Ormrod, J. E. , Global edition, 2015, Page-60

9. Cuemath, Hypothesis Testing - Definition, Examples, Formula, Types. https://www.cuemath.com/data/hypothesis-testing/

Thank You !