Course: Research Method in Software Engineering

WEEK 1 - Introduction to Research Basics

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Course Description

- The course emphasis will be on offering an exploration of a research, its process and applications within the dynamic field of software engineering.
- Concerned to allow students to deepen their understanding of various research paradigms, such as quantitative, empirical, qualitative approaches, etc. and how they can be strategically employed to a ddress the unique challenges and opportunities present in software development.
- Concerned learners to develop their proficiency in research design, equipping them with the skills to formulate research questions, construct robust methodologies, and select appropriate data collection and analysis techniques.
- Focuses on helping students navigate the complexities of software engineering research, where the integration of human factors, technological advancements, and organizational dynamics play a crucial role on the performance of software product.

Unit 1. Introduction to Research Basics

Contents

Lecture Learning Outcome

- Define what research is and its significance.
- Understand characteristics of research
- Understand the overview of software engineering its development Life Cycle
- Describe the steps involved in research process
- Distinguish between different types of research
- Understand why doing research in software engineering
- Identify key research areas of software engineering.

1. Introduction to Research

What is Research?

- A systematic process of collecting, analyzing, and interpreting information—data—in order to increase our understanding of a phenomenon about which we are interested or concerned.
- Established methods to investigate a problem or question in detail with the aim of generating new knowledge for a targeted domain area of studies.

Example

- How the COVID-19 disease has impacted the Economy?
- How social media impact in hate speech?

[1] Leedy, P. D. and Ormrod, J. (2009) Practical Research: Planning and Design (ninth edition). Harlow: Pearson. Page-19

1. Introduction to Research ….Cont'd…

What a research is Not?

- Research is not simply gathering information from resources such as books or magazines.
- Simply transporting facts from one source to another doesn't constitute a research
- Research is not simply learning about something
  - Because, gathering information to know more about a certain area is different form looking at a body of data and decide how it contributes to the solution of a problem.
- Research problems do not simply result in ‘’Yes’’ or a ‘’No’’ answer

[1] Leedy, P. D. and Ormrod, J. (2009) Practical Research: Planning and Design (ninth edition). Harlow: Pearson.page-19

2. Importance of Research

Why to conduct research?

- To contribute something new to what is already known in the field of study.
- To find answers about something that we are not sure of.
- Expands our knowledge base
- To prove lies and support truths
- Gives us the latest information
- Helps to know about our competitors
- Builds our credibility
- Helps with problem-solving
- Encourages curiosity, etc..

3. Basic Characteristics of research

- Originate with a question or problem
- Requires a clear articulation of a goal or objective
- Requires a specific plan or procedure
- Often divide main problem into sub-problems
- Accepts certain critical assumptions
- Requires collection and interpretation of data
- Cyclical (Helical) in nature

4. Research in Software Engineering

How can we use research to gain new knowledge?--->See some of the ways.

a. Categorizing: - involves organizing data into groups based on shared characteristics.

- Useful in explaining which ‘things’ belong together and how.
- Allow to systematically analyze and interpret data in the research.

b. Descriptive – Use to describe characteristics of a population or phenomenon being studied to answer the ‘What‘ question.

- Helps researchers gain a deeper understanding of a specific issue and provides valuable insights that can inform future studies by observing and collecting data on a given topic.

Example :- ‘’What are the eating habits of teenagers in urban areas?"

- A researcher can conduct this descriptive research in the following situations:
  - To better understand a particular population or phenomenon
  - To describe the relationships between variables
  - To describe patterns and trends, etc.

[2]. *Nicholas, W. (2018) . Research Methods The Basics’ (Second edition). Page-8.*

4.Research in Software Engineering ….Cont'd..

c. Comparison – involves examining two or more contrasting cases to highlight differences and similarities between them, leading to a better understanding of phenomena.

d. Correlation – involves investigating the relationships between two phenomena to see whether and they influence each other. The relationship might be just a loose link at one extreme or a direct link when one phenomenon causes another.

Example: - In a pharmaceutical study to determine the effectiveness of a new drug on the treatment of migraines

[2] *Nicholas, W. (2018) . Research Methods The Basics' (Second edition).Page-8.*

4. Research in Software Engineering ….Cont'd…

e. Prediction – it is a process of using data to forecast future outcomes, using data analysis, machine learning, artificial intelligence, and statistical models to find patterns that might predict future behavior

Example :- 'If temperatures are increased, then the rate of reaction will increase'--→if and then are used to articulate the prediction.

f. Control (Experimental) :- a scientific methodology of understanding relationships between two or more variables (independent and dependent variables) which are experimentally tested to prove or disprove a cause-and-effect relationship between two variables.

Example : a simple experiment looking at the effectiveness of new medication

[*2]. Nicholas, W. (2018) . Research Methods The Basics' (Second edition).Page-8.*

4. Research in Software Engineering ...Cont'd ...

An Overview

- **Software** :- is a sequence of instructions that enabling users to interact with a computer hardware.
- **Software Engineering?**
  - It is an engineering branch associated with development of software product using well-defined scientific principles, methods and procedures with efficient and reliable software product.
  - Commonly involves the planning, design, and continued development and maintenance of a software application.

4. Research in Software Engineering ...Cont'd ..

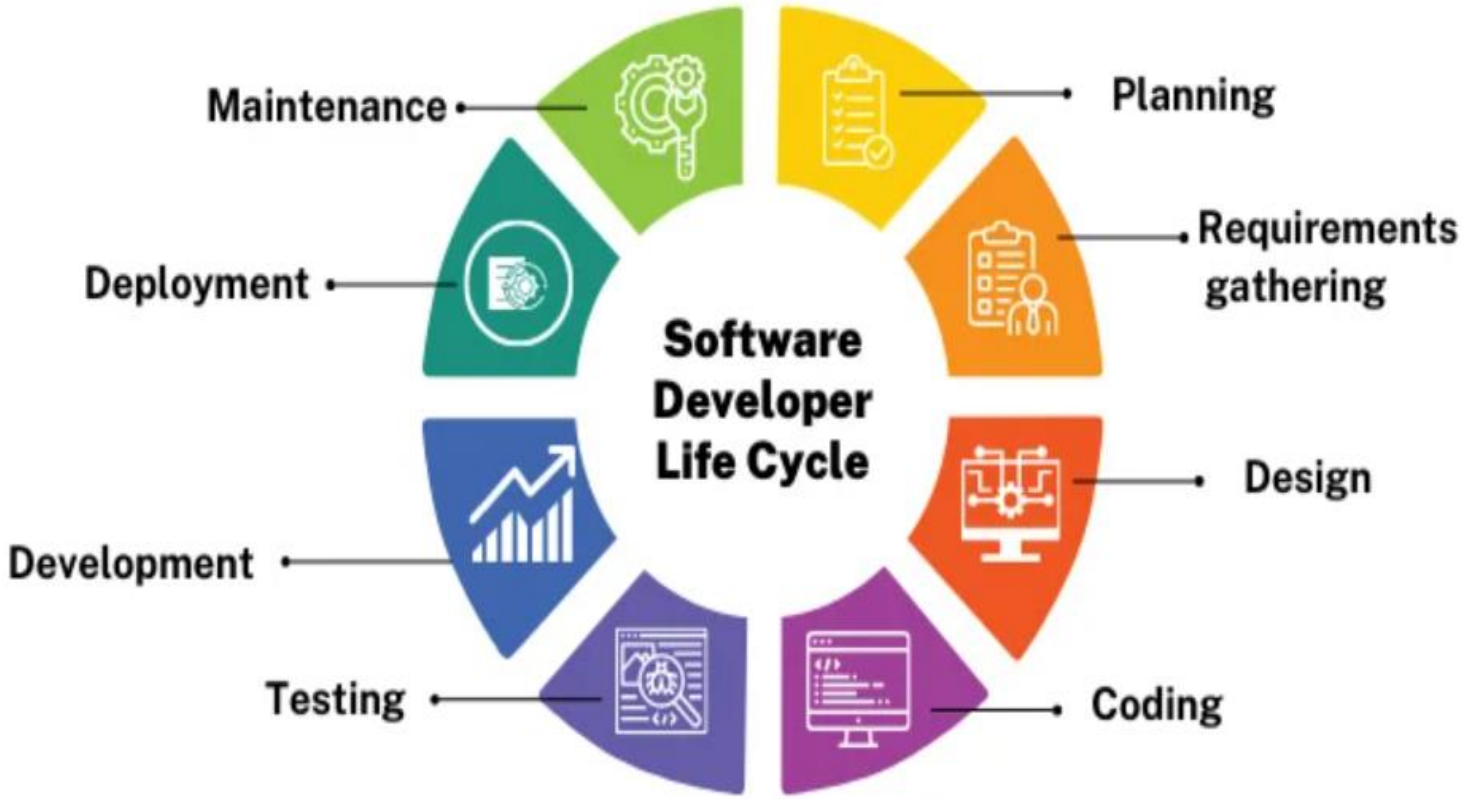
Why research in Software Engineering (SW) ?

- It is becoming ever more important to our daily lives as well as every sector of industry, and organizations. However, as software systems increase in capability, its complexity resulting in delays, defects, and vulnerabilities.
- Thus, it is significant to do research in Software Engineering to study how we build a software that repairs itself, intelligently adapts to a changing world, and is trustworthy in a world full of dangerous situations and adversaries.

4. Research in Software Engineering ....Cont'd ..

Overview of Software Development Life Cycle(SDLC)

- A well-defined, structured sequence of stages to develop the intended software product.



[3] https://technogeekscs.com/software-developer-lifecycle/

4. Research in Software Engineering ...Cont'd ...

- **Some of Research areas in software Engineering**

  a) **Software development Methodologies** --- a series of processes used in software development such as ***Waterfall, Agile, Spiral Model , Rapid Application Development (RAD), etc.***

  - Depends on the size and complexity of the project, available resources, timeline, and the specific needs and requirements of the final product.

  ➢ However, no one methodology is best for all situations. Thus choosing an appropriate management structure can help achieve a successful end result in terms of cost, meeting deadlines, client happiness, robustness of software, or minimizing expenditures on failed projects.

[4] https://www.geeksforgeeks.org/software-development-methodologies

4. Research in Software Engineering ..Cont'd...

b) Software Quality Assurance→ consists of processes aimed at ensuring the quality of application development at each stage of the life cycle (i.e., testing software for error, and checking if customer satisfaction is meet)

- Quality Assurance (QA): defined in ISO 9000 as a part of quality management that focuses on ensuring that defect elimination requirements should met.
- A research has to conducted on how to ensure that a software product will meet customer requirements .

[5] Ushakova, I., Yu, S., & Shcherbakov, A. (2022). Methods of quality assurance of software development based on a systems approach

4. Research in Software Engineering ..Cont'd....

c) Software Maintenance and Evolution-→critical phases in the software development lifecycle, ensuring that software remains relevant, reliable, and efficient over time [6] .

- **Challenges**: Organizational factors: - budget constraints and resource availability
  - Technological advancements:- the rise of cloud computing and mobile technology, have a significant impact on software maintenance and evolution.
  - Complex and poorly documented legacy code often making it difficult to understand and modify. The dynamic trends highlight the nature of software maintenance and evolution. Thus, it is significant to address the challenges to manage software systems and ensure their long-term success.

5. Research Process

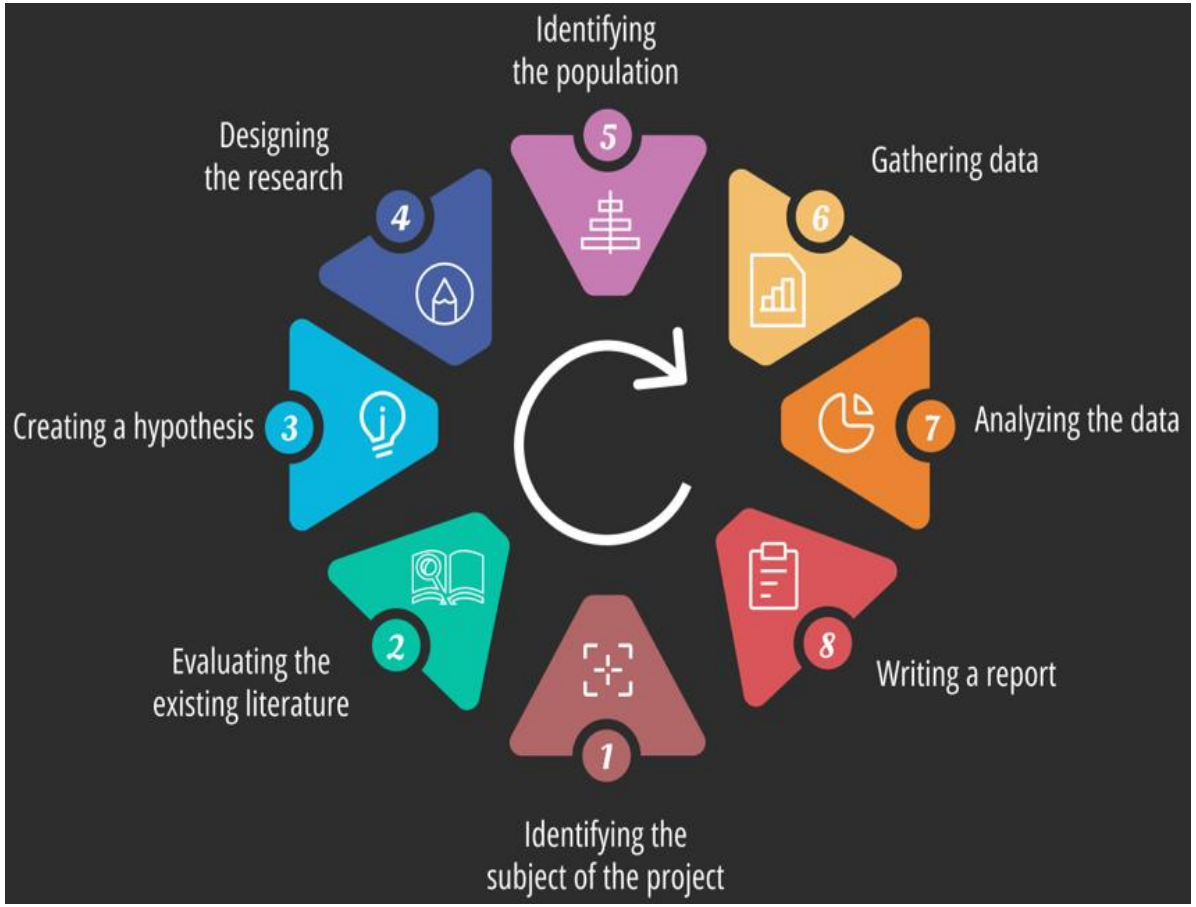
Important questions support the framework of any research project:-

- What are you going to do?
  - *The subject of our research*.
- Why are you going to do it?
  - *The reason for this research being necessary or interesting.*
- How are you going to do it?
  - *The research methods that we will use to carry out the project.*
- When are you going to do it?
  - *The programme of work.*

5. Research Process ...Cont'd...

1. Identifying a Research Problem: Define specific challenges or gaps in the current knowledge.

2. Evaluating Literature Review: Survey existing research to understand the state of the art and identify gaps



[7] https://forms.app/en/blog/research-process-steps

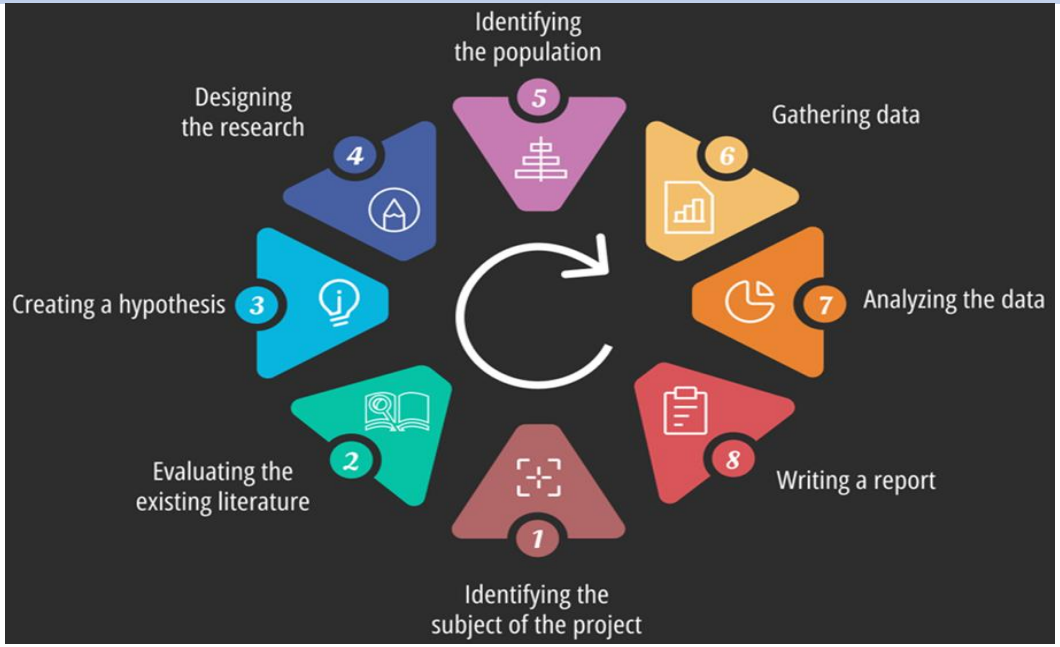
5. Research Process ..Cont'd...

3. Formulating Research Questions and Hypotheses:

Develop focused questions that guide the research.

4. Research Designing: Choose appropriate methodologies , such as experimental, observational, or case studies.

5. Identify the population :population refers to the group participating in the study. Your project may focus on many things, such as a specific group of people, programs,

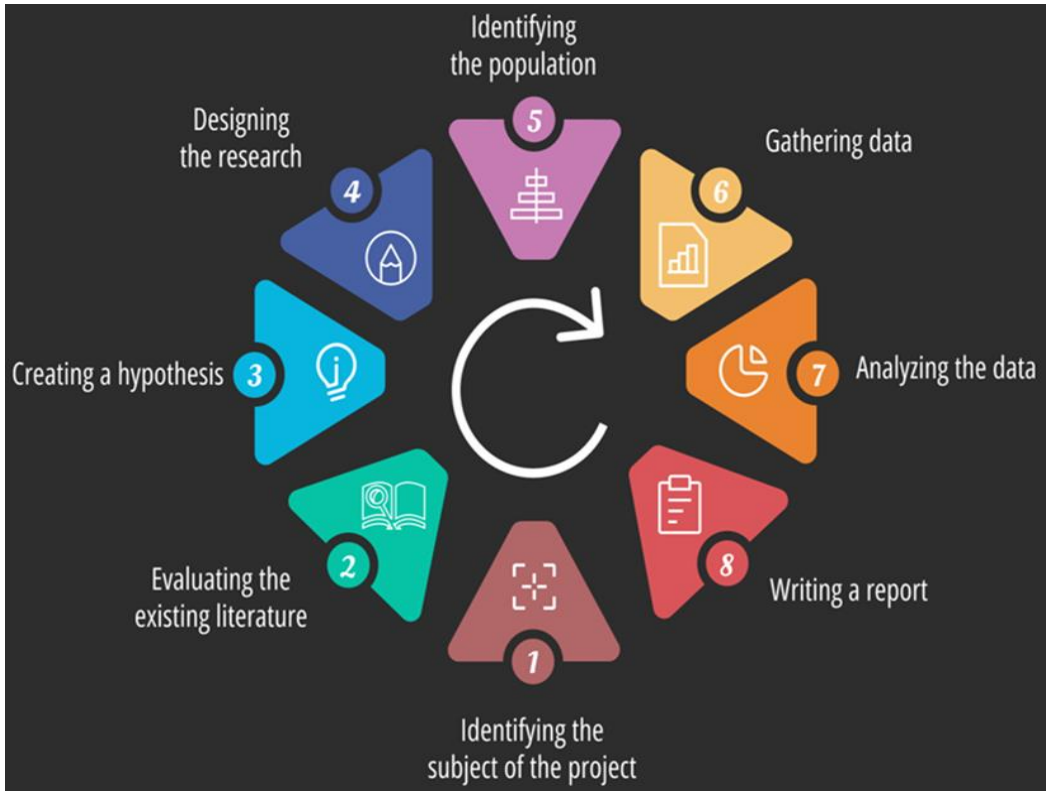


5. Research Process ...Cont'd...

6. Data Collection: Gather data through surveys, experiments, interviews, or automated analysis.

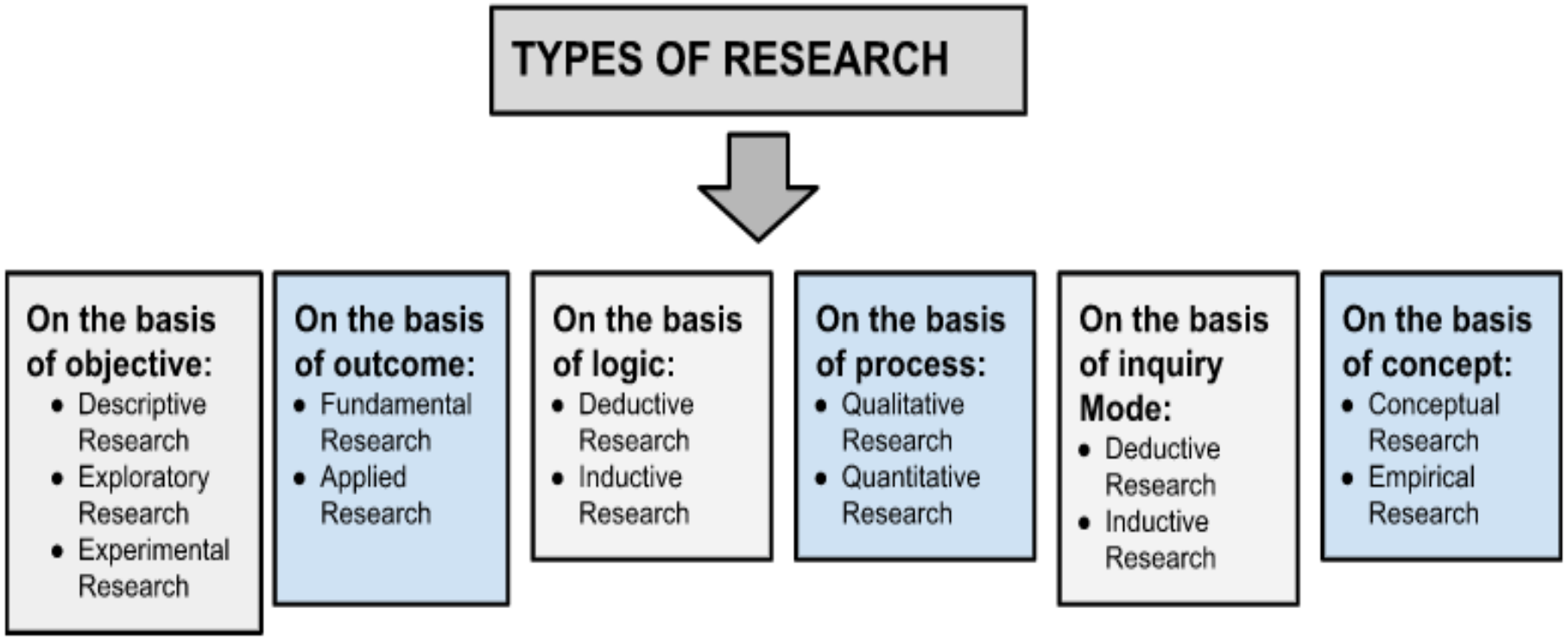
7. Data Analysis: Analyze collected data using statistical or qualitative methods.

8. Writing Report findings: Present results in a structured format, detailing methodology, findings, and implications.



6. Types of Research:- Overview

- Types of research depending upon several factors: - *objective, outcome and process* etc.



[8] https://www.adda247.com/teaching-jobs-exam/research-methodology/

6. Types of Research:- An Overview ...Cont'd..

➢ **Empirical Research:** it is based on the collection and analysis of data involves the observation and measurement of real-world phenomena, and the use of statistical methods to analyze the data.

- This empirical evidence can be gathered using quantitative and qualitative research methods**.**
- The term ***empirical*** means :- it is guided by scientific experimentation or evidence.
- A study is empirical when it uses real-world evidence in investigating its assertions.

[9]. Hasselbring, W., & Giesecke, S. (2006). Research methods in software engineering. Page 13.

6. Types of Research:- Overview …Cont'd..

➢ **Applied Research: -** Used to answer a specific question, determine why something failed or succeeded, and solve a specific, pragmatic problem.

- Researchers and stakeholders working together to identify problems, develop interventions, and assess their effectiveness.
- It often involves cycles of planning, action, reflection, and adjustment

Example : Teachers collaborating with researchers to improve classroom teaching methods and student outcomes by implementing and refining innovative teaching strategies.

[10] https://www.appinio.com/en/blog/market-research/applied-research

6. Types of Research:- An Overview ...Cont'd..

➢Descriptive Research:

- It is mainly used to describe the behavior of a sample population. The major objectives of descriptive research are to describe, explain and validate the finding.
- This descriptive methodology focuses on the "**what"** of the research problem.
- The primary methods used in descriptive research include observations, surveys, and case studies

Examples :-

- What are the consequences of living in a house with domestic abuse?
- Discuss the types of services provided by an organization.

6. Types of Research:- An Overview …Cont'd..

Experimental research

- Attempts to determine *how* and *why* something happens
- Tests the way in which an **independent variable→** (the fa ctor that the scientist manipulates) affects a **dependent variable-→** (the factor that the scientist observes)
- At its simplest, changes are made to an independent variable and the effects are observed on a dependent variable – i.e. cause and effect.
- Might be completed in a controlled environment.

https://www.indeed.com/career-advice/career-development/experimental-research

Example : - drug trials, psychology experiments.

Summary

- Understanding the fundamentals of research, its importance, characteristics, and the specific context of software engineering is essential for advancing knowledge and improving practices.
- By following a structured research process and recognizing the different types of research, we can effectively address complex challenges and contribute to the field.
- Research in software engineering focuses on understanding and improving software development processes and practices . It encompasses various aspects, including software design, testing, maintenance, and software quality.
- By investigating, researchers should address the challenges in software quality, software evolution and maintenance, software development mereologies, etc. for the contribution of effective software products that meet user needs.

References

1. Leedy, P. D. and Ormrod, J. (2009) Practical Research: Planning and Design (ninth edition). Harlow: Pearson.
2. Nicholas, W. (2018) . Research Methods The Basics' (Second edition).
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10. https://www.appinio.com/en/blog/market-research/applied-research

Thank You !