

RESEARCH METHODOLOGY

Introduction to research



PLAN:

- Introduction to research
- Research project
- Finding of a _good_ research question
- Working with literature
- Choosing your research method
- Research methods ...
- Validation of research
- Writing about research

ASSIGNMENT

- **Team of 3, presentation 10-15 min**
- **Choose one of the research methodologies proposed**
- **Download and read the main references that describe this methodology**
 - Search for your own sources to complement..
- **Present the methodology in class based on the articles focusing on the following:**
 - When this methodology should be applied?
 - What kind of research problems/questions can be addressed by this methodology?
 - When this methodology should NOT be applied?
 - Feasibility constraints (e.g., sample size is too small)
 - What sort of data is used? (e.g., quantitative, numerical, textual, etc..) How is it collected?
 - How the data is analysed? What methods?
 - The research protocol (present the steps)
 - How the results are validated? What are the main threats to validity?
- **Propose an illustrative example:**
 - Use some research article that implements this methodology
 - What is the research question?
 - What data was collected? How?
 - What analysis was made?
 - What are the results?
 - Are they validated?
- **Summary:**
 - What is good about this methodology?
 - What are challenges that make the implementation fail?

RESEARCH METHODS IN INFORMATION SYSTEMS AND SOFTWARE ENGINEERING

- Controlled Experiment
- Proof of Concept (POC)
- Case study
- Action research
- Design Science Research
- Interview
- Survey
- Literature review
 - Systematic literature review (SLR)
 - Systematic mapping study (SMS)
 - Multivocal literature review (MLR)

Research and its types

- Why do we care?
- Basic vs. Applied
- Empirical vs. Analytical
- Qualitative vs. Quantitative
- Research in IS and SE

Problems

- Research goals
- Practical vs. Research problems
- RQ

Project

- What is Research Method?
- How to conduct a research project?

Methodologies

- Methods for Data collection and Data analysis in IS and SE
- How to choose?
- How to follow?

Quality

- Research validity
- Threats to validity
- Mitigation strategies

Communication of research

- Write a scientific document
- Publish your research
- Present your results

Tools for research

- Research hypothesis
- Conceptual framework
- Working with literature
- Ethics in research

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WHAT IS RESEARCH?

- Originated from French “Recherche” → first mentioning about 1577
- OECD: "Any creative systematic activity undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications." [1]
- Merriam-Webster Online Dictionary: "studious inquiry or examination *especially* : **investigation or experimentation aimed** at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws"[2]

1. [*"OECD Glossary of Statistical Terms – Research and development UNESCO Definition"*](#). stats.oecd.org. Archived from [*the original*](#) on 19 February 2007. Retrieved 20 May 2018.
2. *Merriam-Webster.com*. Merriam-Webster, Inc. Retrieved 31 July 2021.

EMPIRICAL VS. THEORETICAL RESEARCH

- **Empirical research**
 - Based on experience, observation
- **Non-empirical (theoretical) research**
 - Involves the development of theory as opposed to using observation and experimentation
 - Seeks solutions to problems using existing knowledge as its source
 - Mathematics
 - Theoretical physics
 - Cosmology
- **In Software Engineering and Information Systems:**
 - Socio-technical context
 - Organisational issues
 - **EMPIRICAL METHODS**

RESEARCH IN INFORMATION SYSTEMS AND SOFTWARE ENGINEERING:

“Engineering means, among other things, that we should be able to understand, plan, monitor, control, estimate, predict and improve the way we engineer our products.
“(Claes et al., 2003)

“A learning organisation is an organisation skilled at creating, acquiring, and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights” (Garvin, 1998)

- relying on scientific methods rather than guesswork
- using scientific methods for systematic improvement (*of products, platforms, processes, services, solutions etc.*)

RESEARCH IN INFORMATION SYSTEMS AND SOFTWARE ENGINEERING:

- Multi-disciplinary field
- Socio-technical context
- Organisational issues
- Human-intensive



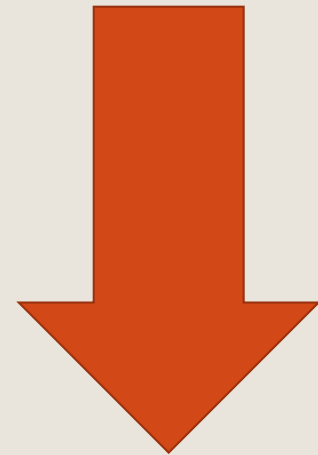
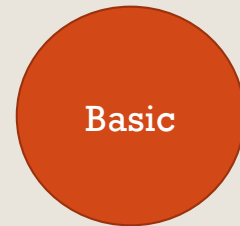
Empirical Research

- To compare .. (technologies, solutions, strategies, processes, models, decisions, algorithms ..)
- To predict .. (errors, reliability, performance, ..)
- To design .. (solutions, processes, ..)

*"To understand how software engineers construct and maintain complex, evolving software systems, we need to investigate not just the tools and processes they use, but also the social and cognitive processes surrounding them."
(Eastbrook et al., 2008)*

BASIC VS. APPLIED RESEARCH

- **Basic research** (fundamental or pure research) aims at improving scientific theories for better *understanding* and prediction of natural or other phenomena.
- **Applied research** uses scientific theories to develop technology or techniques to *alter* natural or other phenomena.



BASIC RESEARCH

- Source of most new scientific ideas and ways of thinking about the world
 - Often driven by pure curiosity, desire to know
 - Exploratory, descriptive, explanatory
 - Produces new ideas, principles, theories → discovery
 - Empirical and analytical methods (can happen “in the mind”)
- ~ 76% of fundamental research is conducted by universities
- Does not have immediate commercial objectives
 - 20-30 years between theoretical discovery and its application (innovation)

<https://www.youtube.com/watch?v=6gnsQjPCC78>

APPLIED RESEARCH

- Practical application of science
 - Driven by practical problems currently experienced in an organisation
 - Has specific (commercial) objectives related to products, procedures, services [1]
 - Leads to Innovation
 - Empirical methodology (based on experiment, observation..)
- **Issues:**
 - Formal research protocols are not always applicable
 - No transparency of methodology
 - Sensitive to interpretation
 - Reproducibility

1. "Basic vs. Applied Research". www.utep.edu. Retrieved 2020-10-31.

SUMMARY: BASIC VS. APPLIED

Basic (fundamental)

- Driven by curiosity
- Aims to expand knowledge
- Results in theories and ideas that may not be directly commercialised
 - (20-30 years delay)
- Conducted mostly in the universities

Applied

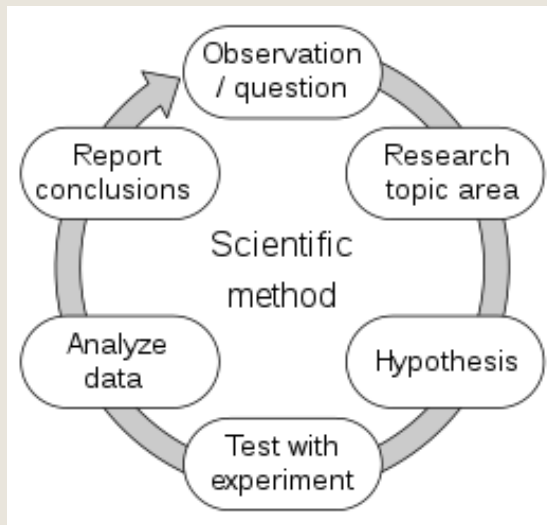
- Driven by a specific problem
- Has specific (commercial) objectives
- Results in (innovative) solutions with a direct added value
- Conducted by the R&D and specific research institutions/labds

SCIENTIFIC RESEARCH

- Funded by public authorities, charitable organisations, companies ..
 - Example: European commission
- Is communicated via Scientific (peer-reviewed) publications, conferences, workshops etc.
- Follows a structured process – “**scientific method**”

ELEMENTS OF SCIENTIFIC METHOD

- The scientific method is an iterative, cyclical process through which information is continually revised (Godfrey-Smith 2009) (Crawford, Stucki 1990)



1. Define a question
2. Gather information and resources (observe)
3. Form an explanatory hypothesis
4. Test the hypothesis by performing an experiment and collecting data in a reproducible manner
5. Analyse the data
6. Interpret the data and draw conclusions
 - Go to 3.: Revisit hypothesis, form new hypothesis
7. Communicate (Publish) results
8. Retest (frequently done by other scientists)

METHODS IN EMPIRICAL RESEARCH

- **Quantitative research** - focuses on quantifying the collection and analysis of data.
 - Formed from a deductive approach - testing of theory
 - **Goal:** Measure, test, predict and describe using statistics
 - Validating a theory
 - **Methods:** Experiments, Surveys, Structured interviews, large datasets → Statistical analysis involved
- **Qualitative research** – focuses on explanation of a phenomenon, relies on data obtained by the researcher from first-hand observation
 - Naturalistic and interpretive : **more than a single interpretation of a phenomenon exists!**
 - **Goal:** Describe, explore and explain (instead of measuring and quantification)
 - Generating (and validating) a hypothesis
 - **Methods:** Field research, Action research, Case studies, Open-ended interviews

- **Mixed approach**

<https://www.youtube.com/watch?v=RZcfmA116cE>

Scribbr: <https://www.youtube.com/watch?v=a-XtVF7Bofg>

IN SOFTWARE ENGINEERING AND IS:

- **Mixed approach**

- **Scenario 1:**

- Quantitative – to identify an issue
 - Qualitative – to understand its causes and consequences;

- **Scenario 2:**

- Qualitative – to propose a new solution (process, technique, etc.)
 - Quantitative – to validate this new solution and prove its effectiveness compared to the old one

EXERCISE

- **Check out the following Examples:**

- To identify the impact of lockdown on student performance, the (Qualitative or Quantitative?) research can be conducted
- To understand the causes of performance drop, the (Qualitative or Quantitative?) research can be conducted
- To compare the new ERP solution with the previous one, the (Qualitative or Quantitative?) research can be conducted
- To evaluate the quality of new ERP system in the company , the (Qualitative or Quantitative?) research can be conducted
- To design a new process for student admission in the university, the (Qualitative or Quantitative?) research can be conducted
- To evaluate the process for student admission in the university, the (Qualitative or Quantitative?) research can be conducted

FORMS OF RESEARCH

- **Primary research** (also Original research) - to produce new knowledge
 - Produce new results, create new theories, artefacts.
 - *Primary study*. (In the context of evidence) An empirical study investigating a specific research question.
- **Secondary research** - to present the existing knowledge in a new form (e.g., summarized or classified).
 - *Secondary study*. A study that reviews all the primary studies relating to a specific research question with the aim of integrating/synthesising evidence related to a specific research question.

Source: „Guidelines for performing Systematic Literature Reviews in SE“, Kitchenham et al., 2007

See also on Primary vs. Secondary research Sources: <https://www.youtube.com/watch?v=CPQ95B95bWE>