FACHBEREICH INFORMATIK

# Lecture
# Empirical Model Building and Methods
## (Empirische Modellbildung und Methoden)

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**SS 2017**

## Chapter 3 – Empirical Process

Fraunhofer IESE

AG·SE

# Chapter objectives

## At the end of this chapter (3), you should

- Understand the relevance of empirical studies for SE research and practice
- Know the empirical process and how it relates to QIP
- Be able to plan and design an empirical study
- Understand how to implement, execute, analyze and package an empirical study
- Understand the ethical issues concerning empirical studies
- **Be able to assess an empirical study**

# Outline

3.1 Introduction
3.2 Definition
3.3 Design
3.4 Implementation
3.5 Execution
3.6 Data analysis
3.7 Packaging

# Subchapter objectives


Introduction
3.2 Definition
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## At the end of this chapter (3.1), you should

- Know the definitions of the terms
  - empirical study, hypothesis, and theory
- Understand the limitations of empirical studies
- Have an overview of the steps of the empirical process and their purposes
- Understand how the QIP matches to empirical process

# Outline


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3.4 Implementation
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3.6 Data analysis
3.7 Packaging


## 3.1.1 Empiricism
## 3.1.2 Hypotheses and theories
## 3.1.3 Limits of empiricism
## 3.1.3 Research paradigms
## 3.1.4 Empirical process

# Empiricism


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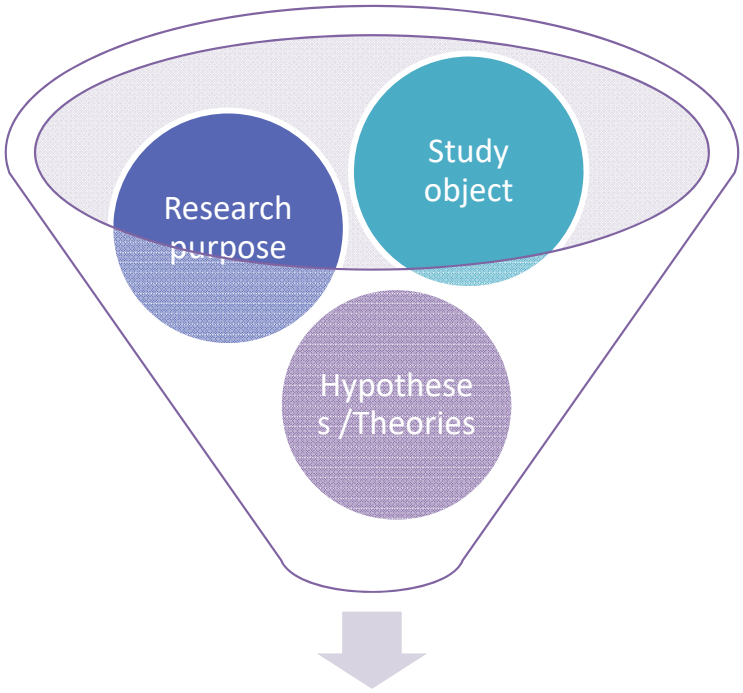


(tested) Hypotheses/Theories

## Empirical research

- Research based on observation and experimentation

## Empirical study

- planned and systematic investigation for colleting and analyzing data on an object with the purpose of building/testing hypothesis and theories

Concepts and definitions

# Theory and Hypothesis


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## Theory

- Subjective theory: “It describes, explains or predict something. It is a coherent explanation to who, what, when, where, how and why questions” (L. Given, 2008)
- Research theory: “It is based on hypotheses tested and verified multiple times by detached researchers” (J. Bortz and N. Döring, 2003)

## Hypothesis

- “It is a statement that proposes a possible explanation to some phenomenon or event.” (L. Given, 2008)
- It is **grounded in theory**, **testable** and **falsifiable**
- It is an universally, usually quantified statement written as a conditional sentence

If <independent (cause) variables>,
then <dependent (consequences) variables>

# Limitations of empiricism


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**Empirical research is based on the principle of falsifiability of hypotheses and not on verification.**

**The quality of empirical results, explanations and predictions depends on the quality of the**

- Underlying models
- Empirical process, i.e. the quality of the design, execution, data collection, and data analysis

Results represent probabilities
(they are not necessarily deterministic)

# Concepts and Definitions (1/2)


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- Empirical
  - based on, concerned with, or testable by **observation or experience**
- Empirical research
  - research based on observation or experience
- Empirical study
  - a **detailed and planned** investigation and analysis of an object
- Study object
  - processes, products, people, resources, organizations, etc.
- Subject (participant)
  - individual who is or becomes a participant in an empirical study

# Concepts and Definitions (2 / 2)


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- Data
  - Items or units of information generated and recorded through empirical research
- Quantitative data
  - Information that can be counted or **expressed numerically** (e.g., time in hours, effort in person months, LOC)
    - Data collection methods: Measurement, test instrument, survey, quantitative content analysis, …
    - Data analysis by using statistical methods
- Qualitative data
  - Information that consist of words, images or objects (e.g., participants' statements, audio/video recording, web pages, online chat group conversations, documents)
    - Data collection methods: Observation, interviews, focus groups, content analysis
    - Data analysis is based on interpretation, thematic coding and categorization

# A2. Research paradigms


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| MODEL | What they say |
|---|---|
| Positivists<br><br>e.g., H. de Saint-Simon, P.-S. Laplace, A. Comte | … believe that a reality exists,<br>… believe that the researcher and the researched person are independent of each other<br>… pursue objectivity by recognizing the possible effects of biases<br>… have the view that in the social as well as natural sciences, data derived from sensory experience, and logical and mathematical treatments of such data, are together the exclusive source of all authentic knowledge.<br>… follow the approach of “verification”. |
| Post-positivists<br><br>e.g., K. Popper, T. Kuhn | … accept that theories, background, knowledge and values of the researcher can influence what is observed<br>… believe that human knowledge is based not on unchallengeable, rock-solid foundations, but rather upon human conjectures. The assertion of conjectures is justified by a set of warrants.<br>… generally retains the idea of objective truth<br>… they hold that reality can be known only imperfectly and probabilistically.<br>… replaced “verification” with falsification |

# A2. Research paradigms


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| MODEL | What they say |
|---|---|
| Constructivists<br><br>e.g.,<br>E. Kant, J. Piaget,<br>H. A. Simon | … believe that scientific knowledge is constructed by scientists and not discovered from the world.<br>… argue that the concepts of science are mental constructs proposed in order to explain sensory experience.<br>… believe that there is no single valid methodology in science, but rather a diversity of useful methods.<br>… take an opposition to positivism, which is a philosophy that holds that the only authentic knowledge is that which is based on actual sense experience and what other individuals tell us is right and wrong. |

Empirical process

# Research paradigms


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| | Quantitative research (Post-positivism) | Qualitative research (Constructivism) |
|---|---|---|
| What is the nature of reality? | Objective, singular, and independent from the researcher (reality can be known only imperfectly and probabilistically) | Subjective and multiple, as seen by participants in a study (constructed by researcher) |
| What is the relationship between researcher and subject? | Researcher is independent from that being researched | Researchers becomes an insider |
| What is the research process? | • Deductive<br>• Testing hypotheses<br>• Static design<br>• Context free<br>• Generalizations for predicting, explaining and understanding | • Inductive<br>• Building hypotheses<br>• Emerging design<br>• Context bound<br>• Patterns and theories for understanding |
| Representatives | • T.Kuhn, K. Popper, … | • E. Kant, J. Piaget, H. A. Simon, … |

# Research paradigms


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| Quantitative research (Post-positivism) | Qualitative research (Constructivism) |
|---|---|
| Natural sciences | Social sciences |
| Laboratory | Field |
| Deductive | Inductive |
| Standardized, structured | Open, flexible |
| Particular | Holistic |
| Explanative / Explaining | Explorative / Understanding |
| Measuring | Describing |
| Statistical sample (large) | Case (small) |

Details

# Famous Experiments
# S. Milgram, 1960 – Obedience Experiments


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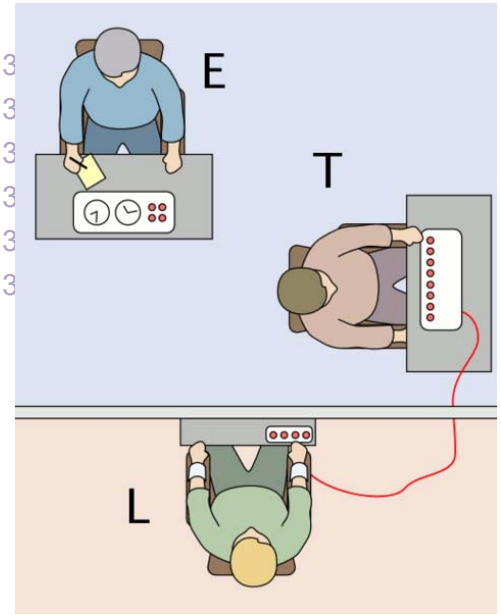


**Milgram wanted to know how far ordinary people would go in delivering painful shocks to a peer, when commanded to do so by a scientific authority.**

Milgram recruited volunteers -- ordinary residents -- to deliver the shocks. He recruited actors to be the subjects who would receive the shocks. The final player was the authority figure, a scientist who would remain in the room for the study's duration.

The authority figure began each experiment by showing the unknowing volunteer how to use the shock machine. The machine allowed volunteers to deliver up to 450 volts, a shock labeled as highly dangerous.

Next, the scientist told the volunteers they were testing to see how shocks might improve word association recall. He instructed the volunteers to shock learners (actors) for wrong/no answers and to raise the voltage as the experiment progressed.

The learners cried out whenever they received a shock. At about 150 volts, they would demand to be freed. The scientist encouraged volunteers to continue delivering shocks no matter how agitated the learners became.

**Some volunteers stopped at about 150 volts, but most kept going until they reached the maximum shock level of 450 volts.**

ethics vs. scientific interest





http://en.wikipedia.org/wiki/Milgram_experiment

# Famous Experiments
# J.V. McConnell, 1955 – Memory RNA


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**They conditioned planaria by pairing a bright light with an electric shock. After repeating this several times they took away the electric shock, and only exposed them to the bright light. The flatworms would react to the bright light as if they had been shocked.**

The idea was to explain how long-term memories were stored in the brain. The theory behind it was that because RNA encoded information, and because living cells could produce and modify RNA in reaction to external events, it might also be used in neurons to record stimuli.

One experiment that was purported to show a chemical basis for memory involved training planaria (flatworms) to solve an extremely simple "maze", then grinding them up and feeding them to untrained planaria to see if they would be able to learn more quickly. The experiment seemed to show such an effect.

**No blinded experiment has ever reproduced the results.**

**It was later suggested that only sensitization was transferred, or that no transfer occurred and the effect was due to stress hormones in the donor.**

Observer bias and lack of external replication



http://en.wikipedia.org/wiki/Planarian

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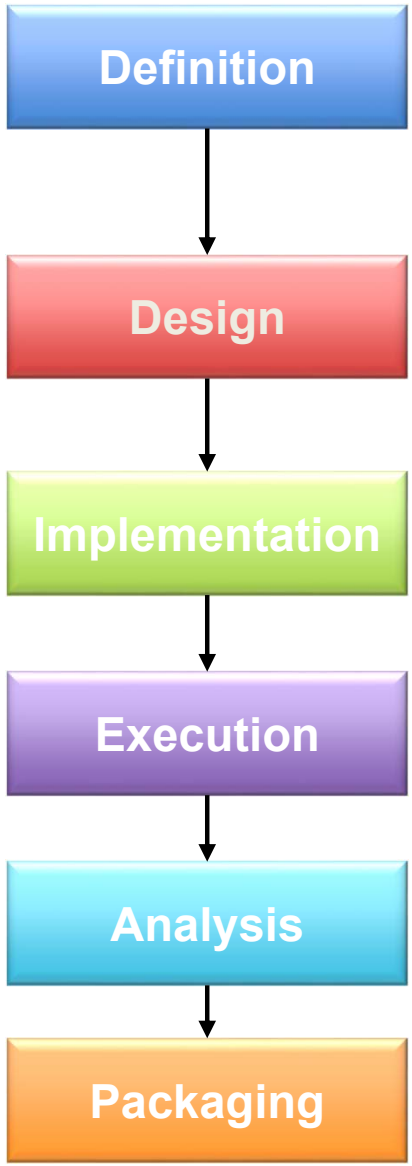


**Determine study goal(s) and research hypotheses). Select type of empirical study to be employed.**

**Operationalize study goal(s) and hypotheses). Make study plan: what needs to be done by whom and when.**

**Prepare material required to conduct the study.**

**Run study according to plan and collect required data.**

**Analyze collected data to answer operationalized study goal and hypotheses.**

**Report your study so that external parties are able to understand results and context of the study.**

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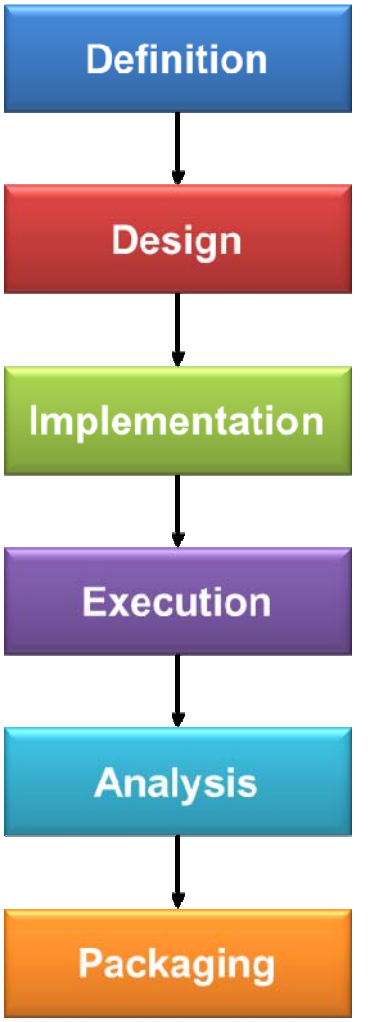
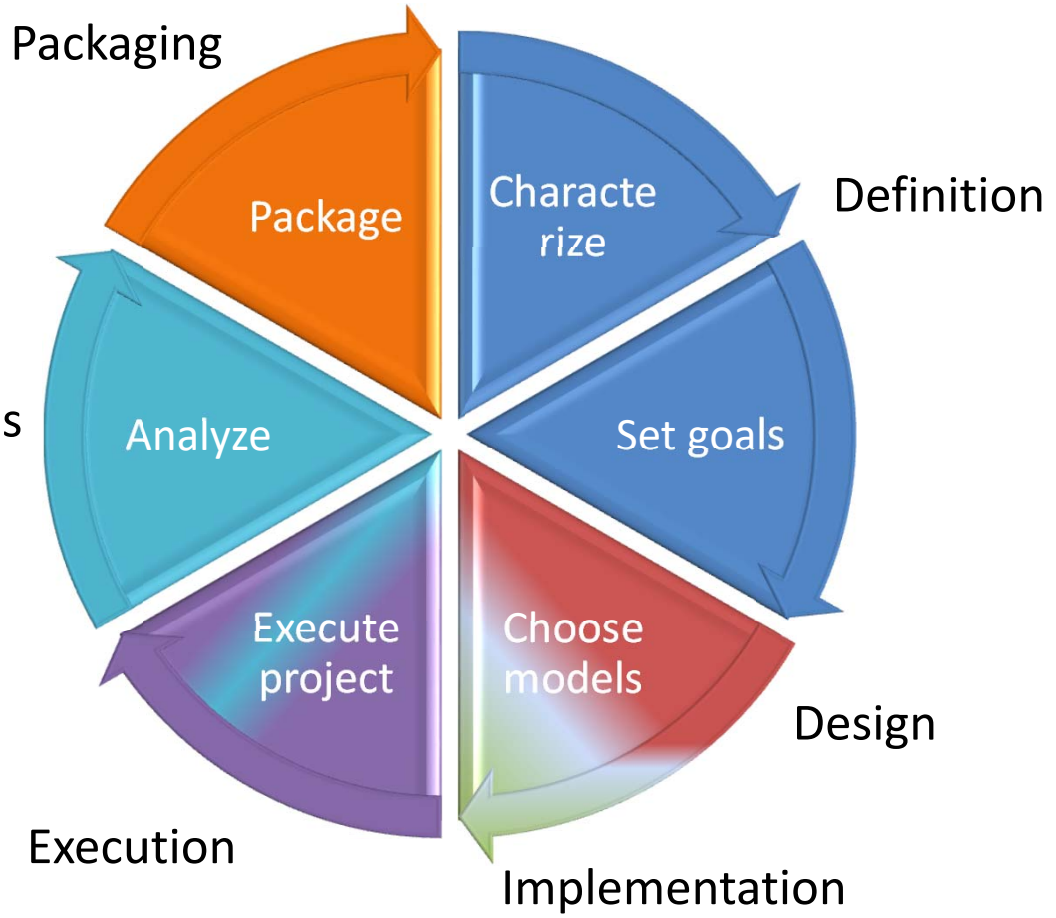
## QIP vs. the Empirical process




QIP- Details