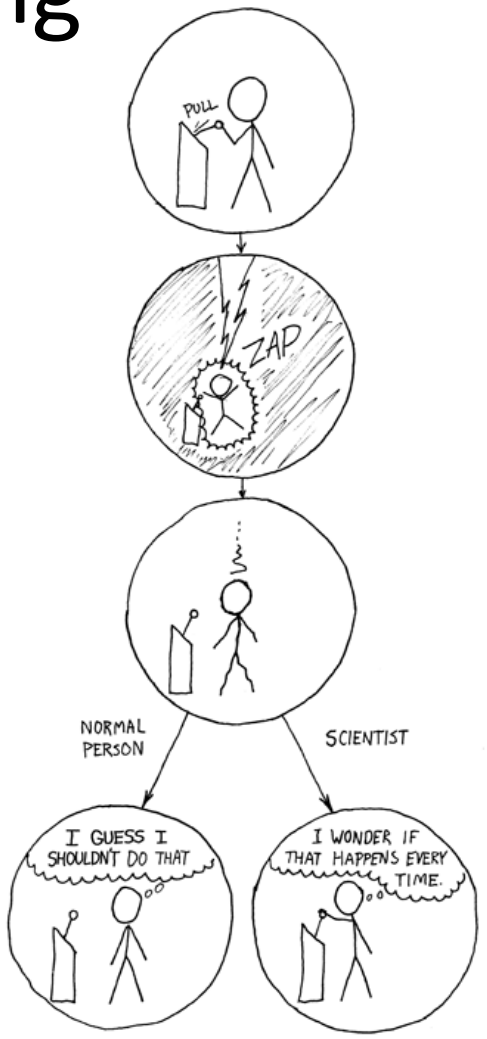
Empirical Software Engineering

Introduction



Details of Course

- Close to research
  - Discussion of research papers
  - Project: Application to example
- Discussion, questions, feedback: Any time!
- There will be group work, sometimes also on Laptops
- You can give a presentation on a topic that is especially interesting/relevant for you
- You can make suggestions on content of the course

Formal Things

- Oral exam
- Admission:
  - Homework assignments
  - Presentation of exercise results
  - Conducting an experiment and writing a report
  - Participate in other experiments
- Presentation for special topics
- On request, the project will be graded and can be used to improve the grade of the oral
- Deadline: 2 weeks before exam if you want it graded, 1 week otherwise

Project

- Evaluate a self-selected research question and write a report on it
  - Do comments support comprehensibilty of source code?
  - Does my new prototype improve a workflow?
- Working hours per person:
  - 40 hours of research +
  - 20 hours of writing
- 2 to 3 persons per project

Suggestion for a Project

- Via e-Mail, optional: an appointment
- Proposal contains (max 1 page)
  - Research question
  - Plan (bullet points)
    - What method, and why
    - What participants/case study/benchmark, and why
  - Expected result
  - Expected effort (rough estimation)

Grading Criteria

1. Relevant research question
2. Clear research hypothesis
3. Justified and suitable methods
4. Justified and suitable selection of participants
5. Quality of applying method (e.g., well-design interview question, plausible measures)
6. Quality of analysis (e.g., statistics, qualitative analysis)
7. Suitable discussion of validity
8. Clear and suitable structure of report (e.g., separation of data and interpretation)
9. Writing quality of report and adherence to template

Project Report -Points

- 0 to 2 points per criterion (3 for excellent realization)
- Grading can be used to improve grade in oral exam
  - In that case, the report needs to be handed in at least two weeks before exam
  - If grade should not be used, one week is sufficient

Points	Grade
> 17	1,0
16	1,3
15	1,7
14	2,0
…	…
8	4,0

Questions on the organizational part?

Guest Lecture

- Norman Peitek
  - How can neuro-imaging methods be used to evaluate cognitive processes?

LIN LEIBNIZ-INSTITUT FÜR NEUROBIOLOGIE MAGDEBURG

Who are You?

- Name
- Course of study
- Semester
- Existing experience
- Request for special topics

Goals of the Course

- Overview of available empirical methods
- Application to questions in computer science (e.g., for Master‘s thesis, Ph.D. thesis)
- To come from oppinions/plausibility to neutrality/objectivity
- Fun

Literature

- Jutta Markgraf, Hans-Peter Musahl, Friedrich Wilkening, Karin Wilkening, and Viktor Sarris. *Studieneinheit Versuchsplanung*, 2001. FIM-Psychologie Modellversuch, Universität Erlangen-Nürnberg.
- Jürgen Bortz. *Statistik für Human- und Sozialwissenschaftler*. Springer, 2004. http://www.springer.com/psychology/book/978-3-642-12769-4?changeHeader
- Anderson and Finn. *The New Statistical Analysis of Data*. Springer Texts in Statistics. 2000.
- Robert A. Donnelly Jr. *The Complete Idiot's Guide to Statistics*. Alpha, 2007

- In addition, different research literature.

What Do We Need Empirical Methods for?

Learning Goals

- Understand necessity for empirical research
- Differentiate empirical methods from other methods
- Understand problems of empirical research

Task

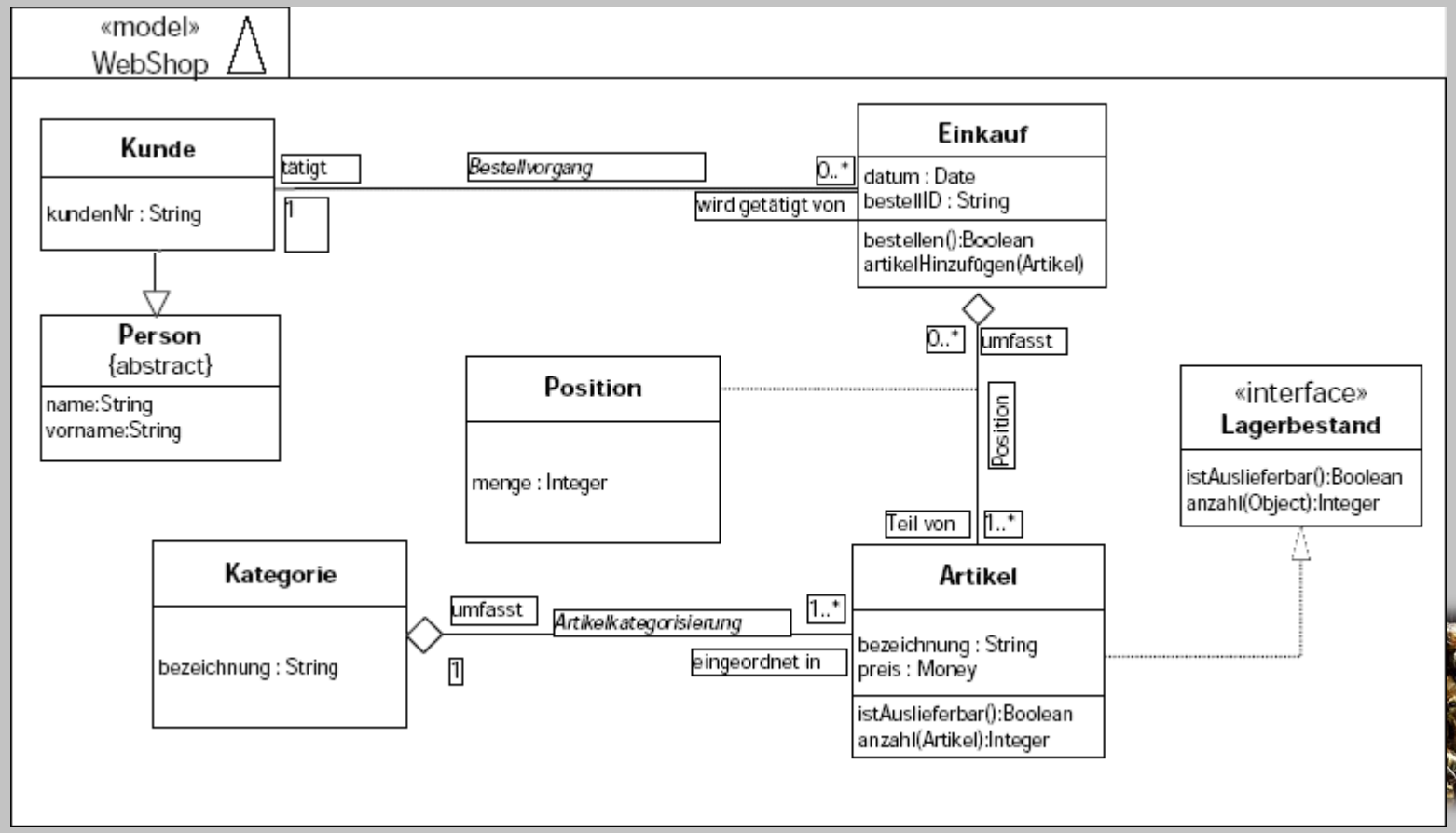
How would you evaluate the following statement:

The programming language Python makes developers more productive?

What solid insights do we have?

- What do you know about the following topics?
- What statement/theory is linked to this topic? What have you learned in other courses?
- Which evidence do you know (e.g., from other courses)?
- Does that match with your experience?
- What kinf of evidence would convince you?

UML


«model»
WebShop
Kunde
kundenNr : String
tätigt
1
Bestellvorgang
0..*
wird getätigt von
Einkauf
datum : Date
bestellID : String
bestellen():Boolean
artikelHinzufügen(Artikel)
Person
{abstract}
name:String
vorname:String
Position
menge : Integer
0..*
umfasst
Position
«interface»
Lagerbestand
istAuslieferbar():Boolean
anzahl(Object):Integer
Teil von
1..*
Kategorie
bezeichnung : String
umfasst
1
Artikelkategorisierung
1..*
eingeordnet in
Artikel
bezeichnung : String
preis : Money
istAuslieferbar():Boolean
anzahl(Artikel):Integer

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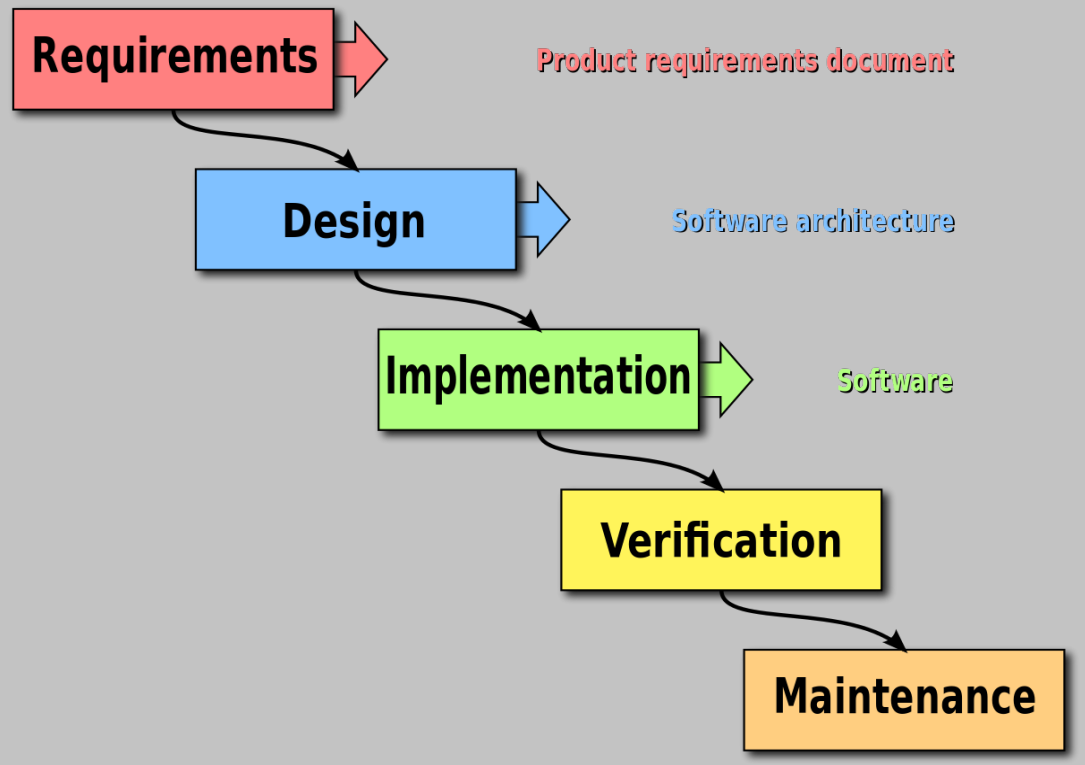
Development Processes



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Pair Programming

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Empirical Research

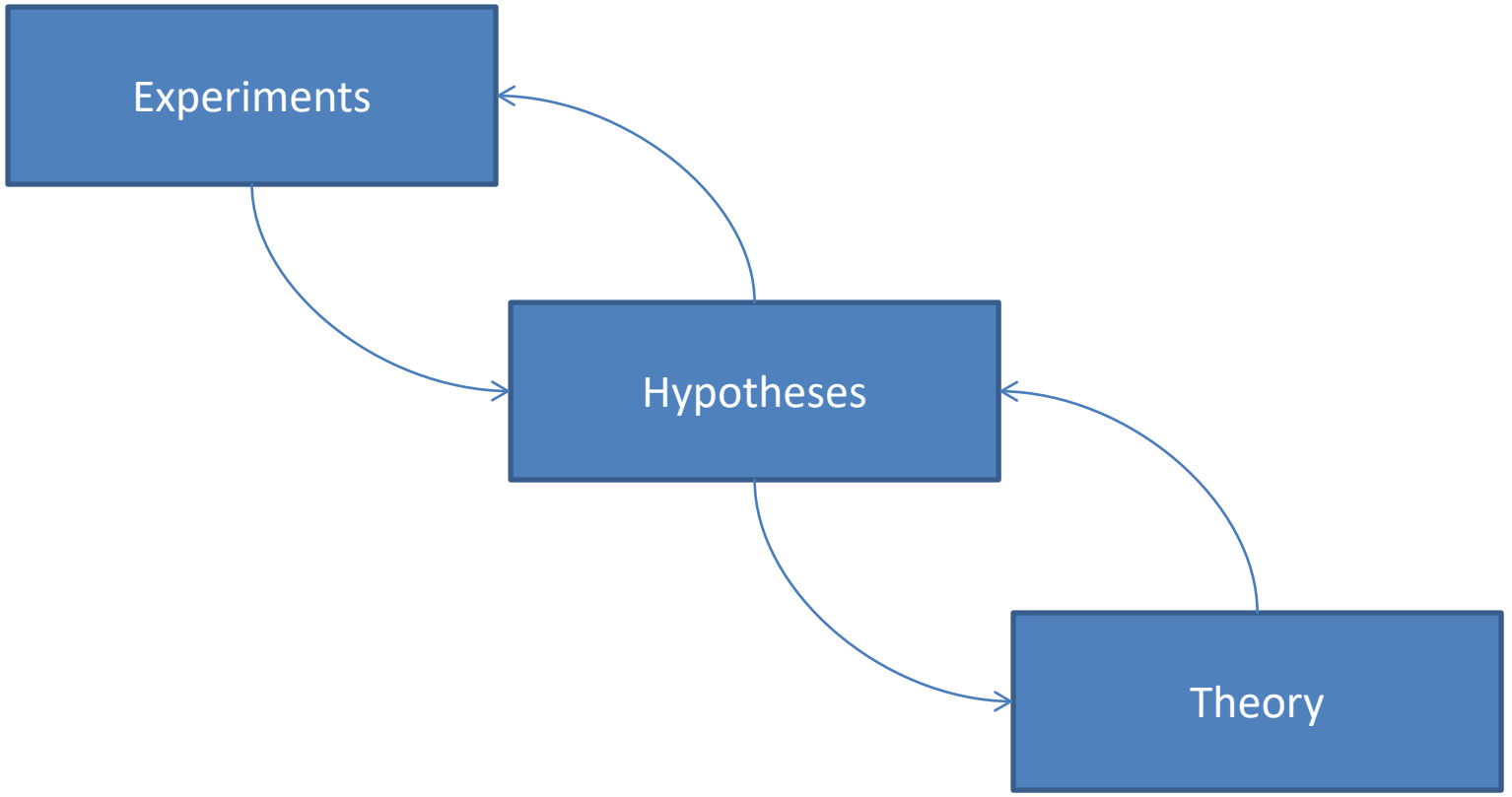
Empirical Research

- Greek (empeiría): Experience, Observation
- German dictionary:
  a) Method based on scientific experience to gain insights
  b) Knowledge gained from scientific experience

Empirical Research Does not Mean:

- Theoretical thoughts
- Intuition
- Random selection
- Authority
- Persistence
- Empiricism

The Scientific Method



Goals of the Scientific Method

- Theory
- Prediction
- Explanation

Scientist

The scientist builds in order to study;
the engineer studies in order to build.

F. Brooks. *The Computer Scientist as Toolsmith II.* Communications of the ACM, 39:3, 1996.

- Scientist
  - Understanding as goal (facts, relationships)
  - Construction as far as necessary to fulfill goal
- Engineer
  - Construction of something useful as goal
  - Understanding as a way to better construction

Computer Science

- Rooted in mathematics (theory)
- Electrical Engineering
- Today: huge engineering part in many areas (e.g., when constructing UIs)
- Used by people (psychology, politics)
- Empirical research is growing more and more important

Mathematical Proof vs. Empirical Research

- Proof of a closed system
- Formalization of statement and research topc
- E.g., mathematical induction

- Unchallengeable

- Cannot always be formalized
- E.g., interaction with people
- Result is observable, but not provable

- No final result
- Collect evidence
- Falsification

Statements that cannot be proven, but observed

- Example
  - *Copy & Paste causes errors*
- Behavior of users (errors) cannot be proven, because there is no formal model of a user
- But behavior of users can be observed (e.g., during or after development, we can examine whether errors are related to copy & paste)

Problem of the Human Factor

- Humans use a software tool or develop software
  - Human behavior is typically non-deterministic (mood, daily state of mind)
  - Intra-individual differences are difficult to determine
- Most likely large difference between indivuduals
  - Skills, education, personal preferences
- Many (possibly causal) relationships are currently unkown
  - When does a user/programmer make an error?
  - When is a UI/source code less usable/comprehensible?
  - …

Empirical Research – First Steps (1)

- Single observations?
  - Can one single observation be used as evidence for a statement?
  - Example 1:
    - Write a program „Hello World“ in Java. Let your colleague write „Hello World“ Python. Who needs more time?
    - Would this support Java or Python?
  - Example 2:
    - Write „Hello World“ in Java. The next day, write „Hello World in Python. The day after that, write „Hello World“ in Java.
    - Development time on Day 3 will be different than on Day 1 and 2. Can you draw conclusions based on that?
  - … not really …

Empirical Research – First Steps (2)

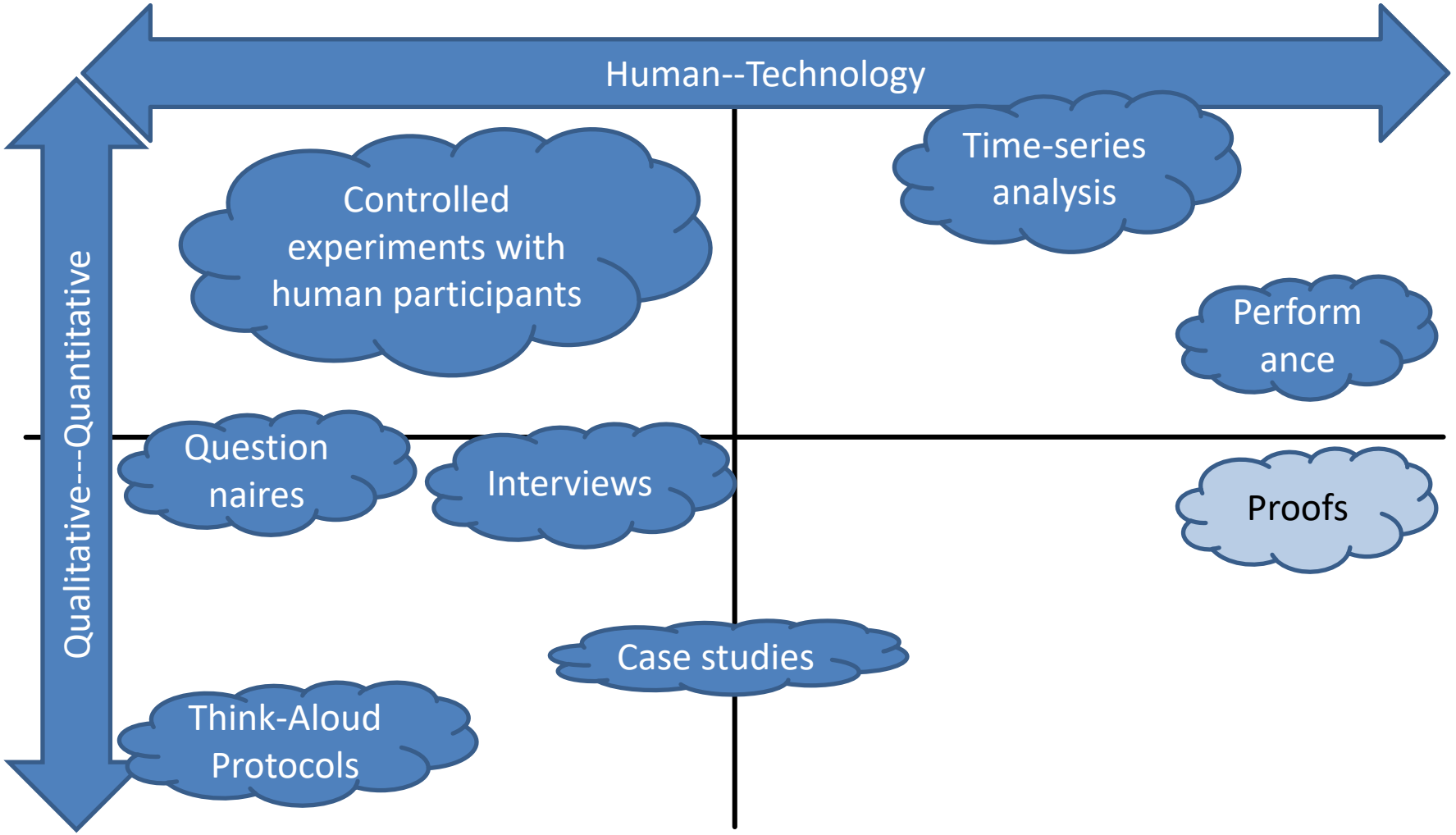
- Subjective perception?
  - Can the personal opinion be used to confirm a statement?
  - Example 3
    - Assume that you just love the new UI. Assume that your neighbour also loves the new UI. Does that mean that the new UI is good?
  - Example 4
    - Assume that the results of a survey show that most users love the new UI. Does that mean that the new UI is good?
- …not really…

Empirical Research – Apparent Questions

- How can we use observations as scientific method?

- Empirical methods:
  - Data collection: What kind of data can we observe where?
  - Qualitative vs. quantitative Observations: Which kind of information can we collect?
  - Logic of empirical research: How can we conclude statements or contradictions from data?
  - Experiment, field studies, case study, etc.: Under which conditions can we conclude what kind of statements/contradictions?

Overview


Human--Technology
Qualitative---Quantitative
Controlled experiments with human participants
Time-series analysis
Perform ance
Question naires
Interviews
Proofs
Case studies
Think-Aloud Protocols

Learning Goals

- Understand necessity for empirical research
- Differentiate empirical methods from other methods
- Understand problems of empirical research

- 1. Question in exam: Do we need empirical research?