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University of Agder
Norway

Research Methods

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Outline

- **Introduction to Research**
  - What is Research?
  - Research vs. Engineering
- **Problem Statement and Research Questions**
  - Research Problem
  - Aims and Objectives
  - “SMART” Research Objectives and Questions
- **State-of-the-Art and Literature Review**
- **Research Methodologies and Methods**
  - General Overview Design Science Research Methodology
  - Research Methods (Selection)
- **Groupwork (20min): select common research topic of interest; formulate Research Objectives and Questions; select applicable methodology and methods to achieve the objectives / proof hypothesis / answer questions**
- **Short group presentations and discussion**
  - Your research problem
  - Selected research approach, methodology(ies) and methods

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Outline for Block 1: «Introduction to Research»

1. **What is Research ?**
   - Types of Research
   - Types of (Computer) Sciences

2. **The Scientific Method**
   - Evidences and Proofs
   - Hypothesis, Theory, and Law
   - Fallacies

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Let’s go!

RESEARCH?!

Definitions of Research

- “Research is a disciplined process for answering questions about some aspect of the observable, touchable world” (Dixon, Bouma & Atkinson, 1987)
- “The systematic, controlled, empirical and critical investigation of hypothetical propositions about the presumed relations among natural phenomena” (Kerlinger, 1969)
- “The production of a publicly scrutinizable (verifyable) analysis of a phenomenon with the intent of clarification” (Reinharz, 1992)
- “A critical process for asking and attempting to answer questions about the world” (Dane, 1990)
- Not to forget: *Replication*
  - “Replication allows others to build on your work, provides an important check that reveals errors, improves the transparency and utility of work, and also uncovers the occasional fraud” (Sterman, 2000)

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What is Research?

- One step in the scientific method.
- Increasing the worlds knowledge.
  - Finding out something nobody else has found out before, and making this new knowledge available to the public.
- Finding out / discovering the *truth*.

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What is *'not'* Research?

- **Collecting facts or information with no clear purpose.**
- **Reassembling and reordering facts or information without interpretation.**

What is Research?

- Something that people (researchers/scientists) undertake in order to **find things out in a systematic way,** thereby **increasing their knowledge**.

Saunders et al. (2009)

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Research Characteristics

1. **There is a clear purpose to find things out**
2. **Data are collected systematically**
3. **Data are interpreted systematically**
4. **Replicability!**

What does '*to find out*' and '*systemically*' suggest?

Systematic suggests that research is based on logical relationships and not just beliefs.

"To find out" **things** suggests multiplicity of possible purposes of research e.g.

- ***describing,***
- ***explaining,***
- ***understanding,***
- ***criticizing,***
- ***analyzing,***
- ***replicating***

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Standing on the shoulders of others

- **Research always starts from prior knowledge.**
- **Prior knowledge is also called "State of the Art".**
  - Academic journals, conference proceedings, Ph.D. Thesis', Master Thesis', ...

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Purpose of Research – Motivation for Research

“Why to do Research?”

- **Knowledge Production (Modes 1 and 2)**
- **Basic and applied research**

Knowledge Production

Mode One

- Emphasizes research in which the questions are set and solved by the academic interests
- Emphasizing a basic or fundamental research rather than applied one
- Little emphasis on use of the research by practitioners.

Mode Two

- Emphasizes research governed by the world of practice.
- Highlights the collaboration both with and between practitioners.
- Offers a way of bringing together the supply side of knowledge represented by universities with the demand sides represented by the business.

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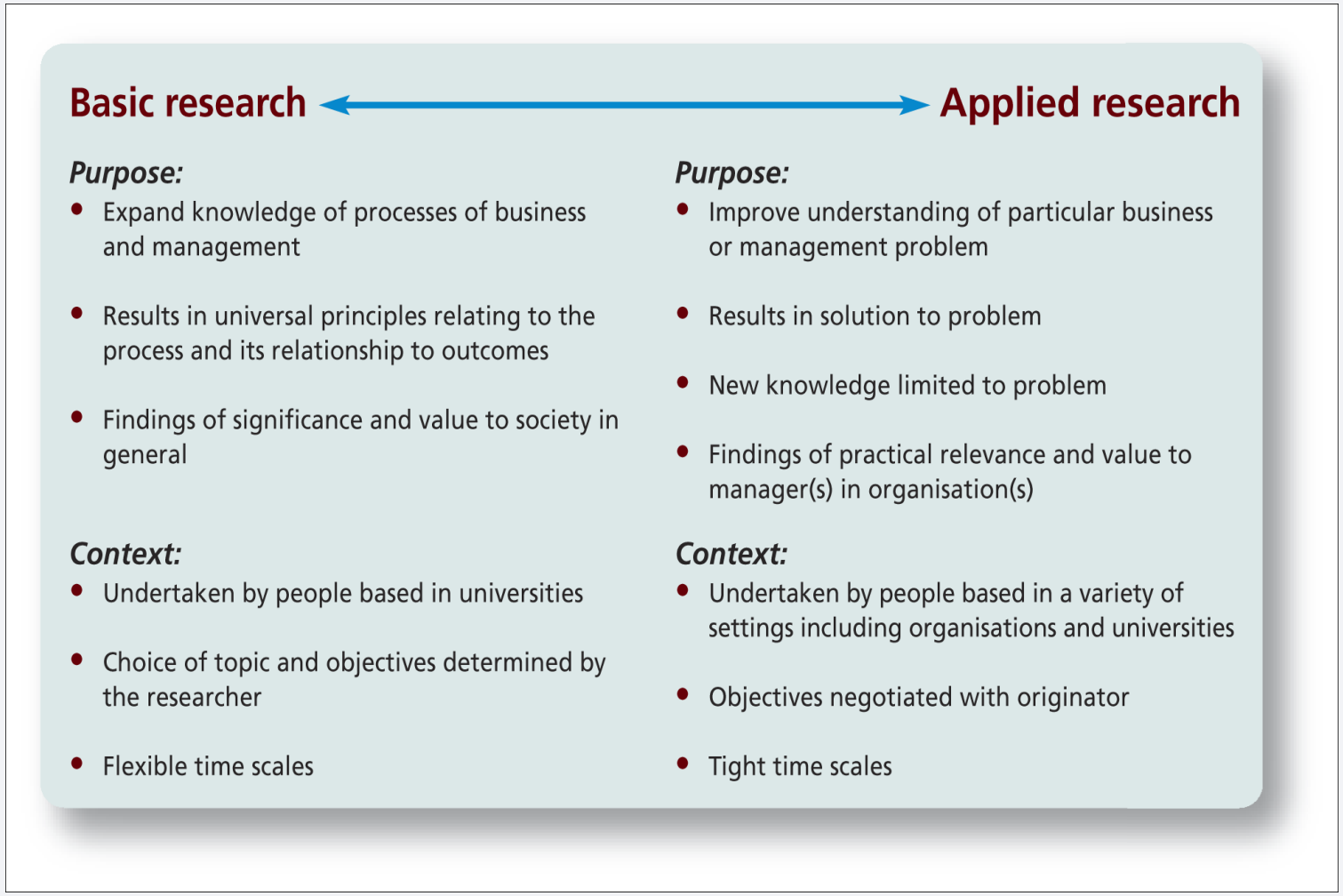
Basic vs. Applied Research



Sources: Easterby-Smith et al. (2008); Hedrick et al. (1993)

Introduction to Research

TYPES OF RESEARCH

Terminology

Methodology

The theory of how research should be undertaken

Methods

The techniques and procedures used to obtain data

Research based on Experiments

- (Galan, ~ 200): The liver continuously creates blood which is used up by the body. The heart is where the soul lies.
- (Harvey, 1628):
  - Theory: Liver does not create blood. The blood is relatively constant and the heart pumps it.
  - Hypothesis: If the liver creates blood, the blood will go out to the body, but not back.
  - Experiment: When you tie up an arm, the body parts before the arm swells up with blood, the body parts after get empty of blood.
- Hypothesis disproved. Galan cannot be correct. Evidence for Harvey's theory.

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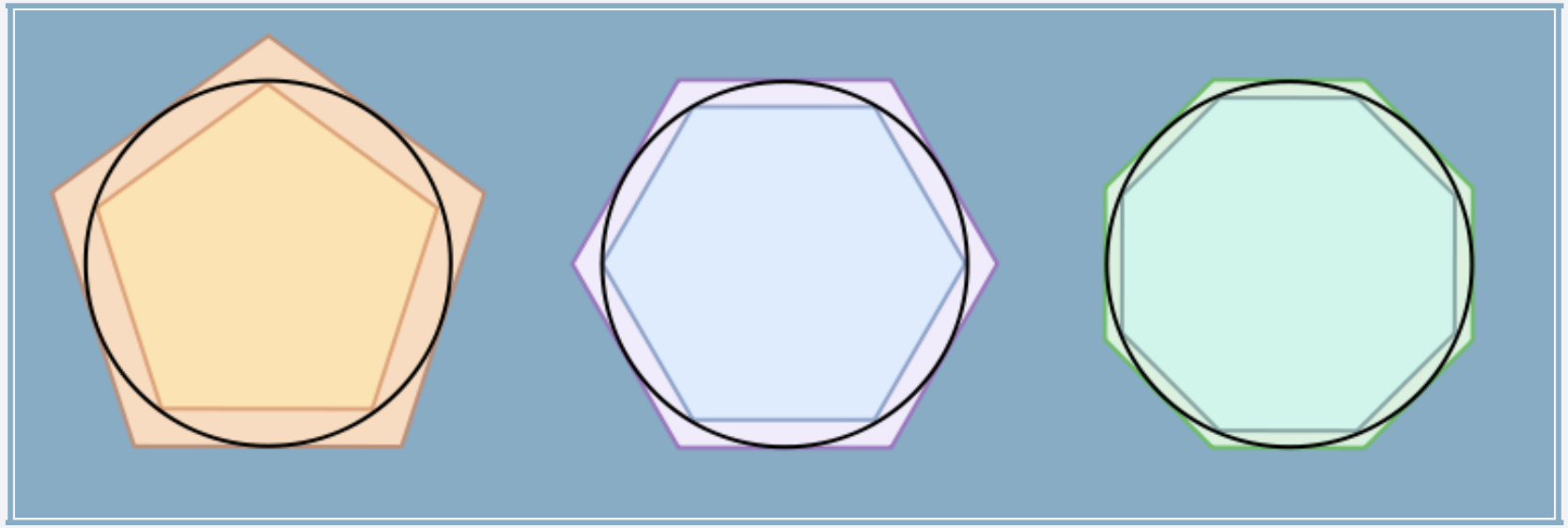
Research based on Analytics



- The circuit of the circle, O, must be less than the outer polygon, and more than the inner polygon.
- The circuit is $O = \pi * 2r \rightarrow \pi = \frac{O}{2r}$.
- π is less than $\frac{22}{7}$ and more than $\frac{223}{71}$.

Research based on Observations and Discovery

- (Flemming, 1928), Researching the growth of Staphylococcos.
- 1/100 petri dishes did not grow as expected. It had penicillin.

Introduction to Research

TYPES OF (COMPUTER) SCIENCES

Computer Sciences

Behavioural Sciences

Design Sciences

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Behavioural Science

- **Definition**: Create or verify **theories that explain or predict** individual or organisational **behaviour** in relation to the analysis, design, implementation, management and use of information systems.
- **Subject**: Interaction among people, technology and organisations
- **Goal**: The truth

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Design Science

- **Definition: Create artefacts that extend individual or organisational capabilities.**
- **Design science includes analysis, design, implementation, test and evaluation.**
- **Goal: Products or processes.**
- **In academia, only archetypes (prototypes), not commercial products.**
  - Purpose: Testing and/or Evaluation.
- **Examples:**
  - Prototypes (typically Technology Readiness Levels TRL 1-4)
  - Algorithms (incl. Encryption...),
  - Models, and
  - Applications (incl. Authentication, Access Control, ...).

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What type of Science is this?

- **Making an app that helps people escape from cruise ships?**

- Design Science
- Behavioural Science

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Design Science !

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What type of Science is this?

- **An algorithm that checks to what extent a text is describing an image.**

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Design Science !

What type of Science is this?

- **Information on whether/which/how many municipalities in Norway have their budget online.**

- Design Science
- Behavioural Science

What type of Science is this?

- **Information on whether/which/how many municipalities in Norway have their budget online.**

- Design Science
- Behavioural Science

Behavioural Science!

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SCIENCE VS. ENGINEERING

Difference between Science and Engineering

- **Science is about understanding the nature and is fundamentally *analytical* in nature.**
  - Often characterized by the scientific method.
  - Science may involve lots of engineering, but the engineering is part of the means.
- **Engineering is about the construction of new artefacts and is fundamentally *constructive*.**
  - Engineering may involve the use of the scientific method, but as part of the means.

[Simon, 1996]

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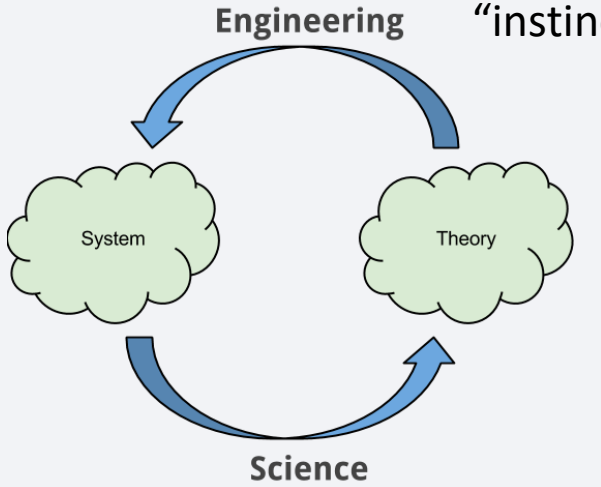
The traditional view

Scientists

- create knowledge
- apply that knowledge
- are trained in scientific method
- are thinkers

Engineers

- study the world as it is
- seek to change the world
- are trained in engineering design
- use explicit knowledge
- use tacit knowledge (experience, “instinct”)



More Realistic View?

Scientists

- create knowledge
- are problem-driven
- seek to understand and explain
- design experiments to test theories
- prefer abstract knowledge
- but rely on tacit knowledge

Engineers

- study the world as it is
- are problem-driven
- seek to understand and explain
- design devices to test theories
- prefer contingent knowledge (unexpected, possible, …)
- but rely on tacit knowledge (experience)

Mixed approaches of design and discovery

SCIENTIFIC METHODS

Source of image: http://www.wired.com/2011/06/the-arabick-roots-of-science-and-their-fruit-to-come/

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Before the Renaissance

Source of image:

https://en.wikipedia.org/wiki/Bloodletting

- **People did research how they felt like it, if at all. Sometimes experiments, sometimes not.**
  - Everything was subjective

Before the Renaissance

Source of image:

https://en.wikipedia.org/wiki/Bloodletting

- **People did research how they felt like it, if at all. Sometimes experiments, sometimes not.**
  - Everything was subjective
- **Then came the scientific method.**

After the Renaissance

Source of image:

http://www.wired.com/2011/06/the-arabick-roots-of-science-and-their-fruit-to-come/

- **The scientific method: Introduction, Methods, Experiments, Results, Discussion.**
- **It became possible to:**
  - compare research results.
  - disprove other research.
  - build upon others work.
  - find an Objective Truth.

Scientific Methods

EVIDENCES AND PROOFS

Evidences and Proofs

Evidence

Proof

…e.g. of a concept

Example of Evidence and Proof

- **Assumption (*Hypothesis*): All swans are white.**
- **Proof 1: Find all swans and check that they are white.**
- **Proof 2: Find at least one swan that is not white.**
- **Evidence 1: Find 10 swans and check that they are white.**
- **Evidence 2: Find 1000 swans and check that they are white.**

Note that (in most cases) experiments do not provide proof, but evidence.

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Proof (⇔ Conclusive Evidence)

- **A scientific proof cannot be disproved.**
- **Absence of proof is not proof of absence.**
- **Evidence for something is not necessarily proof.**

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Is it Evidence or is it Proof?

- **Evidence**
- **Proof**

- Chocolate is healthy based on statistics that people who eat chocolate live longer.
- Gravity is weaker on the moon based on that we actually went there, dropped objects and saw that the moved slower to the ground.
- Showing that my algorithm is faster than existing approaches based on several months of experiments.
- Showing that a user has better experience with web site 1 than with web site 2 based on user feedback.
- Showing that it is possible to have an electric car by actually building one.

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Evidence

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Evidence

- Showing that it is possible to have an electric car by actually building one.

Proof

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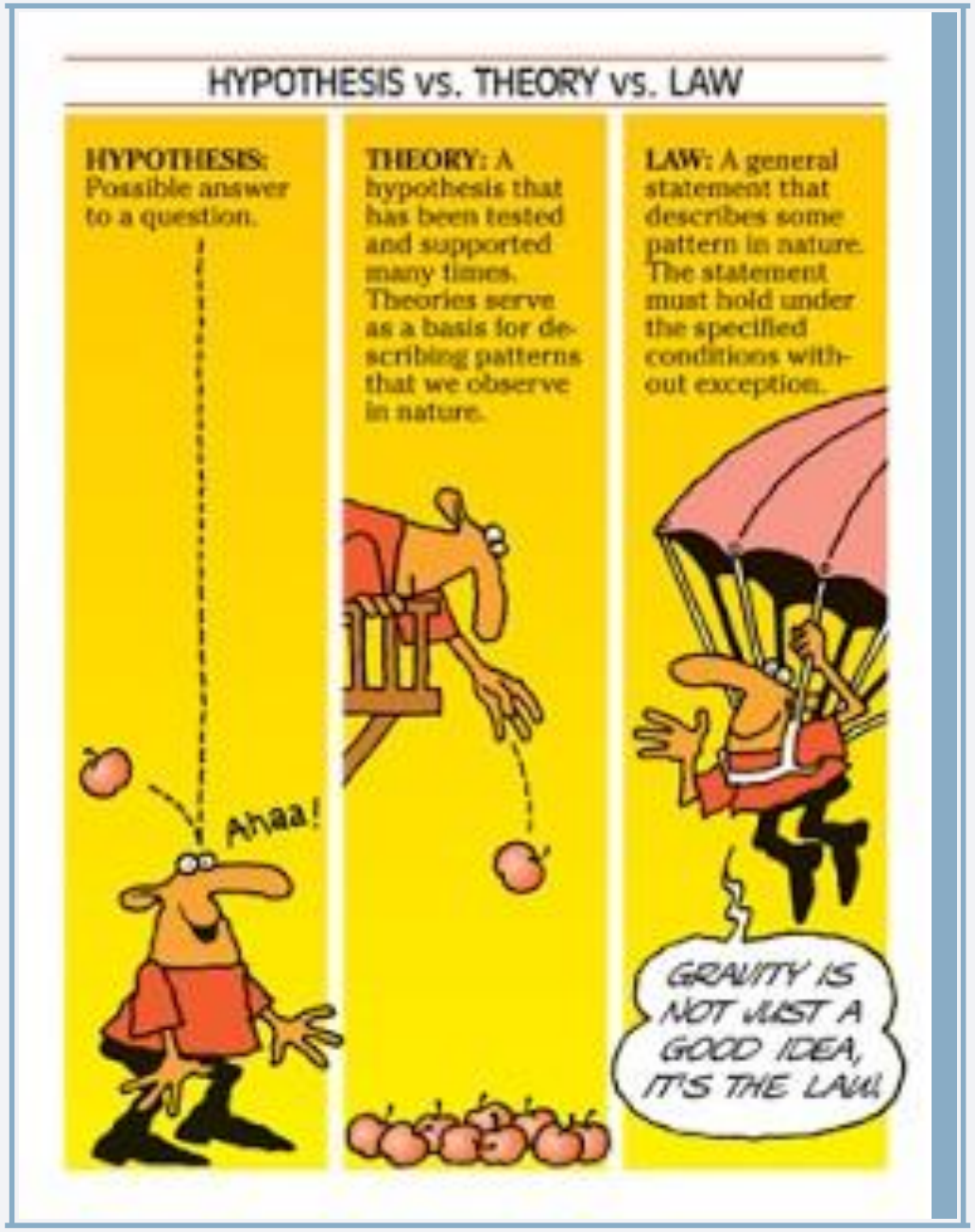
HYPOTHESIS, THEORY, AND LAW

Hypothesis vs. Theory vs. Law



Source of image:
http:/ /strangebananadailybluster.blogspot.no/2013/10/so-you-think-evolution-is-just-theory.html

Hypothesis

- **Statement that is true given some condition.**
- **Hypothesis: If you smoke, it is bad for your health.**
  - Not measurable
- **Consequent: People who smoke die younger.**
  - Measurable
- **If hypothesis, then consequent.**
- **If smoking kills, then people who smoke die younger.**

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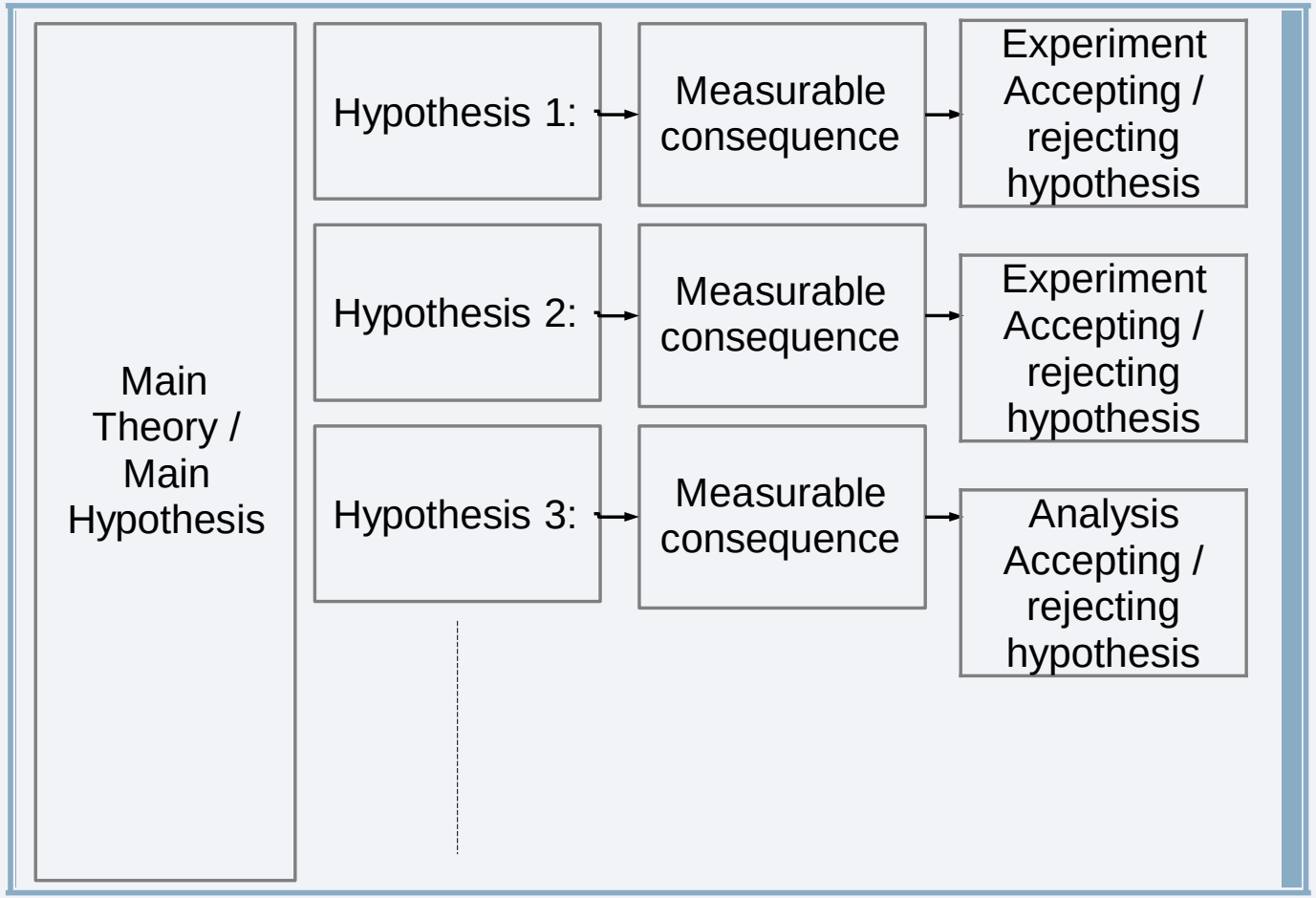
Hypothesis


Main Theory / Main Hypothesis
Hypothesis 1:
Measurable consequence
Experiment Accepting / rejecting hypothesis
Hypothesis 2:
Measurable consequence
Experiment Accepting / rejecting hypothesis
Hypothesis 3:
Measurable consequence
Analysis Accepting / rejecting hypothesis

Theory

- **In science, a *theory* is a well-substantiated, unified explanation for a set of verified hypothesis.**
- **It is the best “truth” known.**
- **A theory often starts as a hypothesis. Scientists will attempt to disprove the hypothesis. If it survives, it starts to become a theory.**
- **A theory can be strong or weak.**

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Law

- **A law is a theory that is detailed or formally described.**
- **Typically using match.**
- **Theory: Gravity**
- **Law *F = ma***

Common Misconceptions

- **Since a theory is not proven (with conclusive evidence), it is not the truth.**
  - In science, a theory is always the best known truth.
  - Very few things in the world are proven, that doesn't mean that they are not true.
  - Just because it is not proven, does not mean there is not scientific explanation for it.
    - Gravity, evolution, big bang, Archimedes, relativity, germ theory, cell theory, . . .

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Setting up Experiments

- **Experiments should always confirm or refuse your hypothesis.**
- **Representative**
  - Remove factors which may have impact on the data.
  - Easiest random and many samples

Not Representative

- **Hypothesis:** People who eat vitamin C have more energy.
- Group one (with vitamin C): Test on Mondays.
- Group two (without vitamin C): Test on Sundays.
- **Problem: ???**

- **Solution: ???**

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Not Representative

- **Hypothesis:** People who eat vitamin C have more energy.
- Group one (with vitamin C): Test on Mondays.
- Group two (without vitamin C): Test on Sundays.
- **Problem: Some people have hangover on Sundays and will perform worse on Sundays than on Mondays.**

- **Solution: ???**

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Not Representative

- **Hypothesis:** People who eat vitamin C have more energy.
- Group one (with vitamin C): Test on Mondays.
- Group two (without vitamin C): Test on Sundays.
- **Problem:** **Some people have hangover on Sundays and will perform worse on Sundays than on Mondays.**

- **Solution:** **Shuffle group two and one.**

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Hypothesis, Theory, or Law?

- **Hypothesis,**
- **Theory,**
- **Law**

- If we change web sites background to white rather than black, more people will notice the text.
- If we change a class to be active rather than passive, more students will learn.
- Active students learn more than passive students.

Hypothesis, Theory, or Law?

- **Hypothesis,**
- **Theory,**
- **Law**

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Hypothesis

- If we change a class to be active rather than passive, more students will learn.

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Hypothesis, Theory, or Law?

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Hypothesis

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Hypothesis

- Active students learn more than passive students.

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Hypothesis

- If we change a class to be active rather than passive, more students will learn.

Hypothesis

- Active students learn more than passive students.

Theory (if it gives unified explanation for a set of verified hypothesis...)

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Scientific Methods

PROBLEM STATEMENT AND RESEARCH QUESTIONS

Outline for Block 2: «Problem Statement and Research Questions»

1. Problem Statement and Research Questions

- General Background, Context, and Research Problem
- Aims and Objectives
- “SMART” Research Objectives and Questions

Statement of the problem and significance

- **General questions to be addressed**
- **Value of the research proposed**
  - Novelty, benefits to society
- **Ideas exciting; scope and resources realistic**

General Tips for the problem statement

- **Start with the “big picture” motivating your research**
  - Problems faced
  - Broad goals (aims)
- **Describe the context for your study**
- **Briefly describe your research plans**
  - How they answer your initials questions/problems
- **Explain the value of your work**
  - Possible broader implications?

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Relevant Literature Review

- **Make a case for the importance of the research**
- **Give a brief background and context**
- **Use respected references to support your arguments**
  - Quality rather than quantity
  - Need to support your major points
- **Use references that are most respected in the field**
  - Some references review the ‘state of the art’ in your area
  - Make sure you include relevant recent references

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Relevant Literature Review

- **Maybe you are trying to show there is a gap in current research or you are building on existing research**
- **Try and choose references to cover different arguments**
- **Maybe use tables or figures to summarise key findings from previous research work**

Preliminary Results

- …can also provide justification for the proposal
- …give you credibility
- …help to establish your competence

Overall Aims

- **Your overall aim should naturally follow on from your literature (and preliminary results if they exist)**
- **They should be broad and general statements of intent**
- **They should explain the overall purpose of the research**

Conceptual or empirical model

- **A conceptual, theoretical or analytical model might help you frame your research questions**
- **Diagrams might be useful to include explaining your model**
- **It might feed from preliminary results presented**
- **It might show the context with which your ideas sit**
- **Not a requirement – only include if useful / relevant**

Objectives and Hypotheses

- **Objectives are more focused than aims**
- **Key attributes of objectives are:**
  - **S**pecific / Significant
  - **M**easurable
  - **A**ttainable / **A**ppropriate
  - **R**elevant / **R**ealistic
  - **T**ime-bound
- **SMART objectives is the acronym often used !!**

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Research Question Criteria (for a master and PhD projects)

- **Can it be asked and answered ?**
  (Is there an answer? Can information be found to answer?)

- **Can sources be found in English ?**
  (Shouldn’t be translated)

- **Will you find experts whose words and work will support this ?**
  It can’t be about how you feel or think… - it is about what you can prove!

- **Are all terms in the question clearly defined and understood by all in the field ?**

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Criteria for a good question

- **Is it worthwhile to answer?**
  Does it add to the discussion in the field?
- **Is the topic focused?**
  Can it be answered on 80 pages?
- **Is the topic broad enough to work on it for six months?**
  Not trivial or already answered.
- **Can the topic be scientifically treated?**
  Not just conjecture or in “pseudo” areas
- **Does the question fit squarely in the area of study?**
- **Does the topic avoid hypothetical discussion?**

  (No “What if …. didn’t happen?”)

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RESEARCH METHODOLOGIES AND METHODS

Outline for Block 3: «Research Methodologies and Methods»

“The philosophy that will guide your research”

1. **Primary vs. Secondary Research**
2. **Qualitative Research**
3. **Quantitative Research**
4. **Information Systems Research**

PRIMARY VS SECONDARY RESEARCH

Which to use and when?

Secondary Research

- **Information already available**
  - Research articles/books/reports/Web site content
    ⇔ "*Systematic Literature Review*"
  - Debates
- **Is it trustworthy? ⇔ Risk of bias**
- **How will you gain confidence in the information?**

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Primary Research

- **Your own contribution**

- **Gaps / Open Questions in the existing literature**
- **Hypothesis to test**
- **New questions**
- **New observations**
- **etc.**

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QUALITATIVE VS QUANTITATIVE RESEARCH

Which to use and when?

Qualitative Research

- **Normally used for exploratory research and to help develop concepts**
  - Observation, focus groups, case studies, practice, in-depth interviewing
  - Testing functionality
  - More subjective, small sample sizes (4-5 participants)
  - Diversity of subjects' experiences ⇔ how is something experienced by different persons / subjects, and what are the different experiences?

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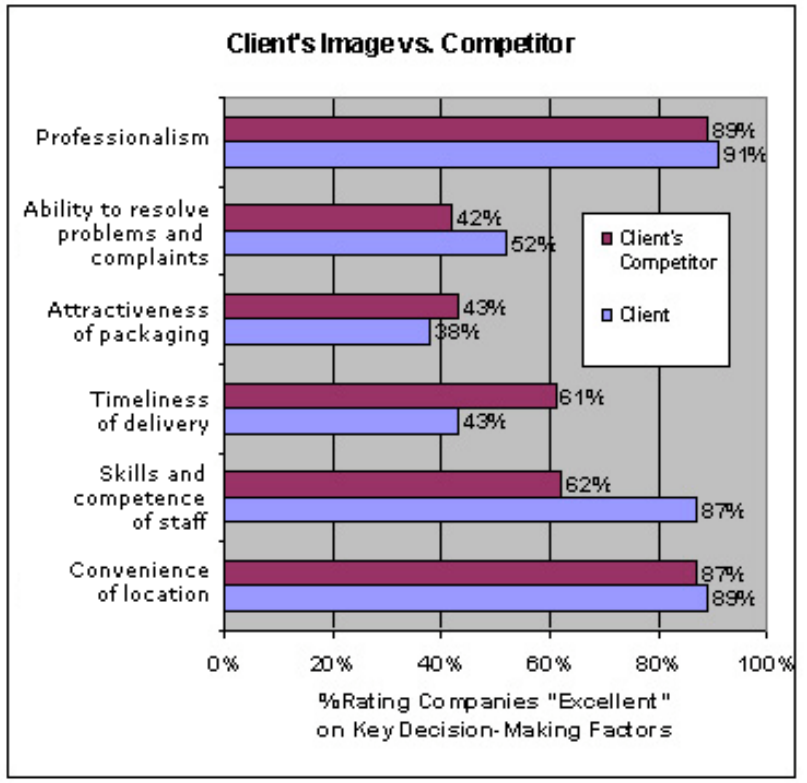
Quantitative Research

- **Normally used for measurement, evaluation or testing performance**
  - Scientific, large sample sizes, empirical, statistical analyses
  - Reliable, repeatable, precise, controllable



INFORMATION SYSTEMS (IS) RESEARCH

Information Systems (IS) Research Discipline

- **“The goal of information systems research is to produce knowledge that enables the application of information technology for managerial and organizational purposes.”**
- **closely aligned to other research disciplines, such as**
  - **computer science**,
    incl. ***Information and Communication Technology (ICT)***
  - organizational science,
  - management science,
  - economics,
  - and systems engineering
- **Involves and utilizes Qualitative and Quantitative Research Methodologies and Methods**

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SOME INSIGHTS ON RESEARCH METHODOLOGIES AND METHODS

QUALITATIVE METHODS

Some Qualitative Research Methods

- **Focus Groups**
- **Ethnography**
  - Observations / Measurements
  - Questionnaires
  - Interviews

FOCUS GROUPS

Focus Groups

- Group discussion on a particular topic / issue
- Run by a moderator / facilitator
- You can gain a wide range of responses in a short time
- Used for idea generation or evaluation/feedback

ETHNOGRAPHY

Ethnography

Ethnography is the rigorous study of people's everyday lives

It takes place with people in their natural setting and studies their everyday lives whether at home, at the office, in hospitals, or in other environments

Ethnography

Ethnography uses *participant observation and interviews* to capture and describe people's ***behaviour, beliefs and values***

GATHERING INFORMATION

OBSERVATION, PARTICIPATION, INTERVIEWS, SELF REPORTING

Observation

- **Make observations, draw inferences, ask people, construct hypotheses and act on them**

Participant Observation

- **Ask participants for their observations**

- **Risks:**
  - Pure observer: danger of failing to understand the perspectives of participants
  - Pure participant: can create “over rapport” and cannot distance from their own accounts, beliefs and behaviours

Interviews

- Use people to get information of what cannot be observed (from an external perspective / position)
- To check inferences made from observations
- To record the accounts (reports, descriptions, explanations) and stories of interviewees

Interviews

- Interviews can be formal and pre-agreed or informal and spontaneous
- Cast the interviewee in the role of expert consultant

Interviews

- **Structured**
- **Semi-structured**
- **Unstructured**

Semi-structured interviews

- **Use non-direct interviewing in which the interviewee is allowed to talk at length in his or her own terms**
- **Directed questioning can create misleading results**

Semi-structured interviews

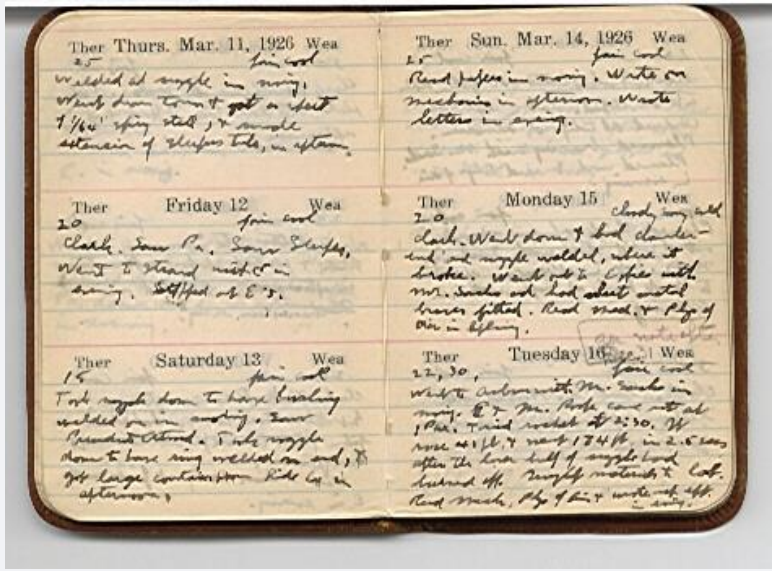
- **One-to-one interviews preferable**
- **Sometimes interviewing a couple of friends/colleagues together might be appropriate**
  - “Go on, tell him”, “What about when you …”

Semi-structured interviews

- **“How do I know if the interviewee is telling the truth?”**
  - The aim is not to gather “pure” data free from bias
  - The goal is to discover the correct way to interpret the data

Self reporting

- **Allow participants to collect data themselves**
  - Diary entries
  - Self-observations
  - Self-initiated recording
  - Daily logs
  - Relationships between people



- **Provide workbooks, blogs, use cameras, mobile phones**

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DATA ANALYSIS
QUALITATIVE RESEARCH

Data Analysis

- No strict scientific method to employ
- Making use of video editing software on a PC can be very useful for reviewing efficiently
- Sometimes transcribing the interview can be helpful

Data Analysis

- Look for interesting patterns and themes
- Compare data collected with common-sense knowledge, official accounts or previous theory
- See if there are inconsistencies among the views of different groups or individuals or between what people say and do
- Look how context affect motivations and behaviours

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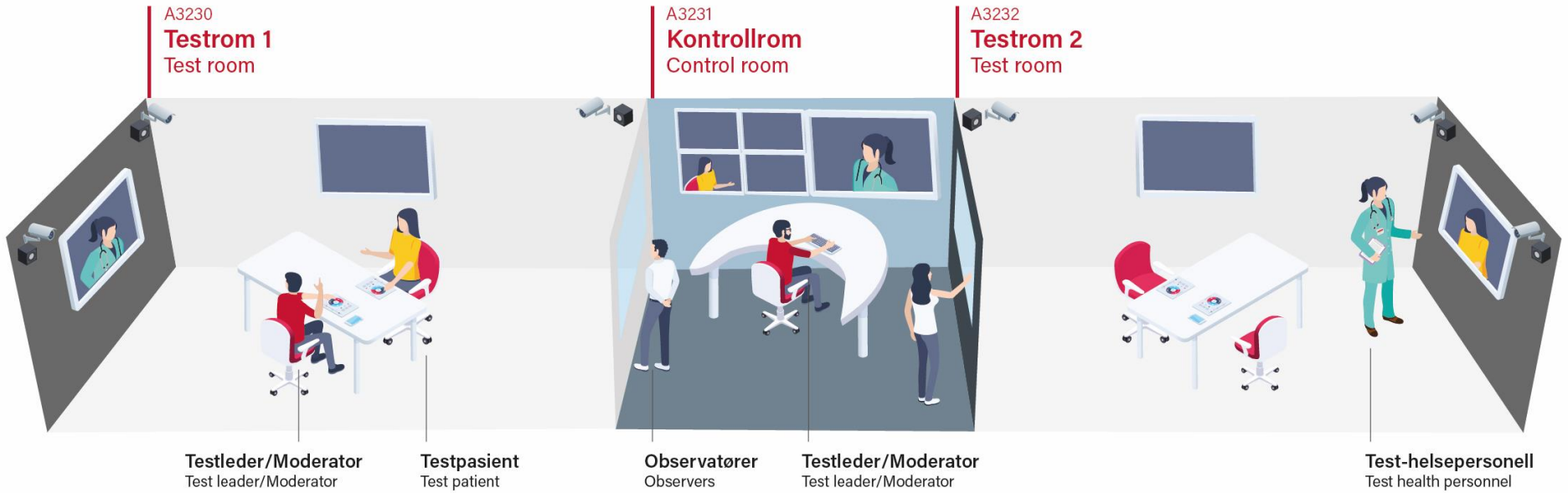
QUANTITATIVE METHODS

Example Experiment

- **Usability Study**
  - Design study (mock-up / simulation)
  - Prototype
  - Product
  - …

BrukertestLAB
Usability lab



Bruksområder
Applications

Interaktive testscenarier
Interactive test scenarios

Forskning, utdanning og innovasjon
Research, education and innovation

Test av teknisk utstyr og brukergrensesnitt
Test of technical equipment and user interface

- **Funksjonalitet**
- **Grafisk utforming**
- **Finne feil**
- **Testmiljø:** **Lyd, lys og hvordan det påvirker testdeltakere**

- Functionality
- Graphic design
- Fault-finding
- Test environment: Sound, light and how it affects test participants

Deltakere
Participants

Testpasient
Test patient

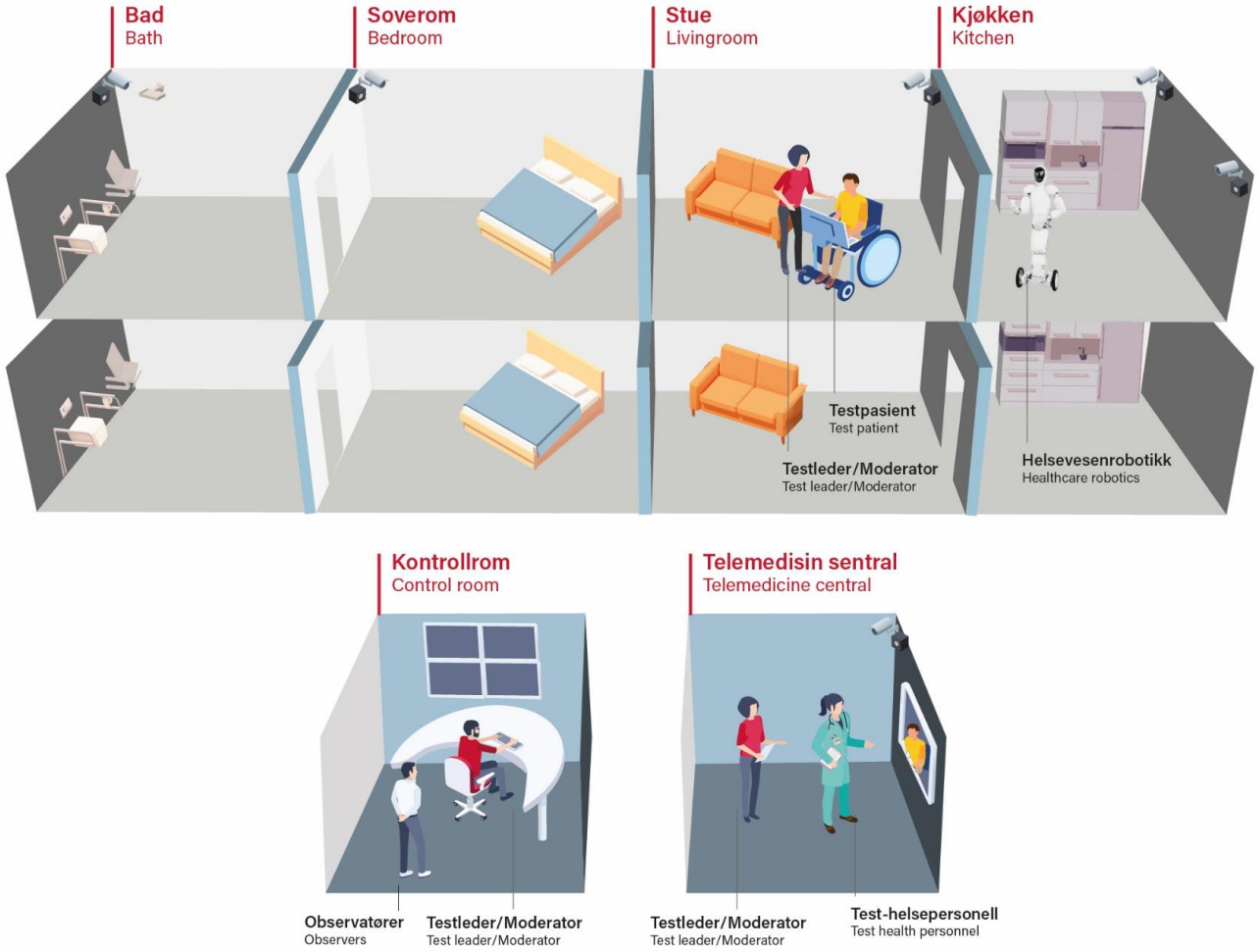
Test-helsepersonell
Test health personnel

Testleder/Moderator
Test leader / Moderator

Observatører
Observers

Usability Lab

Boligsimulator
Housing simulator



Living Lab ("Home Simulator")

Bruksområder
Applications

Interaktive testscenarier
Interactive test scenarios

Forskning, utdanning og innovasjon
Research, education and innovation

Simulering av digitale pasientforløp
Simulation of digital patient processes

- **Informasjonsflyt** - Information flow
- **Arbeidsflyt** - Workflow
- **Teknologistøtte** - Technology suppor

Hvorfor: systematisk analysere forbedrings-potensiale, feil, nye måter å arbeide på, test av ny teknologi i natulige omgivelser

Why: systematically analyze potential for improvement, mistakes, new ways of working, testing new technology in a natural environment

Types of Measurements / Data

- **Nominal**
  - Categories of things, e.g. male/female, occupation
- **Ordinal**
  - Ranking data, e.g. best to worst, liked to hated
- **Interval**
  - Differences between values can be compared, e.g. age, population size, test scores
- **Ratio**
  - Allows comparison in terms of ratios, e.g. ratio of weight and height

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Questionnaires

- **Questionnaires are a common approach for recording information**
- **Modes of recording**
  - Personal (face-to-face) interviews
  - Telephone
  - Email, website (e.g. surveymonkey)
  - Post

Questionnaires

- Use the following **rules** when designing a questionnaire:

1. Keep the number of questions to a minimum

2. Keep the questions simple. Answers should be "Yes/No/Don't know", or offer at least four alternatives

3. Avoid ambiguity – make sure the respondent really understands the question (avoid ‘generally’, ‘usually’, ‘regularly’)

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Questionnaires

- Use the following **rules** when designing a questionnaire

4. Seek factual answers, avoid opinions

5. Make sure at the beginning you have a cut-out question to eliminate unsuitable respondents

6. At the end, have an identifying question to show the cross-section of respondents

Questionnaire Uses

- **Before and after Experiment Testing / Qualitative Research**
  - Screen people before you start the study
    - Gathering basic information on participant
    - Expectations on study
  - Post study questionnaire
    - Reflections on how the study went
    - Ratings on satisfaction / performance
    - Suggestions for improvement

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Likert Scale

- Rate something on a scale of 1 to 4 (or more), ranging from ‘strongly agree’ to ‘strongly disagree’
- ⇔ Ordinal measurement / assessment

FIGURE 6.1 The Rosenberg Self-Esteem Scale

Circle one response for each of the following ten items.

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I feel that I am a person of worth, at least on an equal basis with others.	1	2	3	4
2. I feel that I have a number of good qualities.	1	2	3	4
*3. All in all, I am inclined to feel that I am a failure.	1	2	3	4
4. I am able to do things as well as most other people.	1	2	3	4
*5. I feel I do not have much to be proud of.	1	2	3	4
6. I take a positive attitude toward myself.	1	2	3	4
7. On the whole, I am satisfied with myself.	1	2	3	4
*8. I wish I could have more respect for myself.	1	2	3	4
*9. I certainly feel useless at times.	1	2	3	4
*10. At times I think I am no good at all.	1	2	3	4

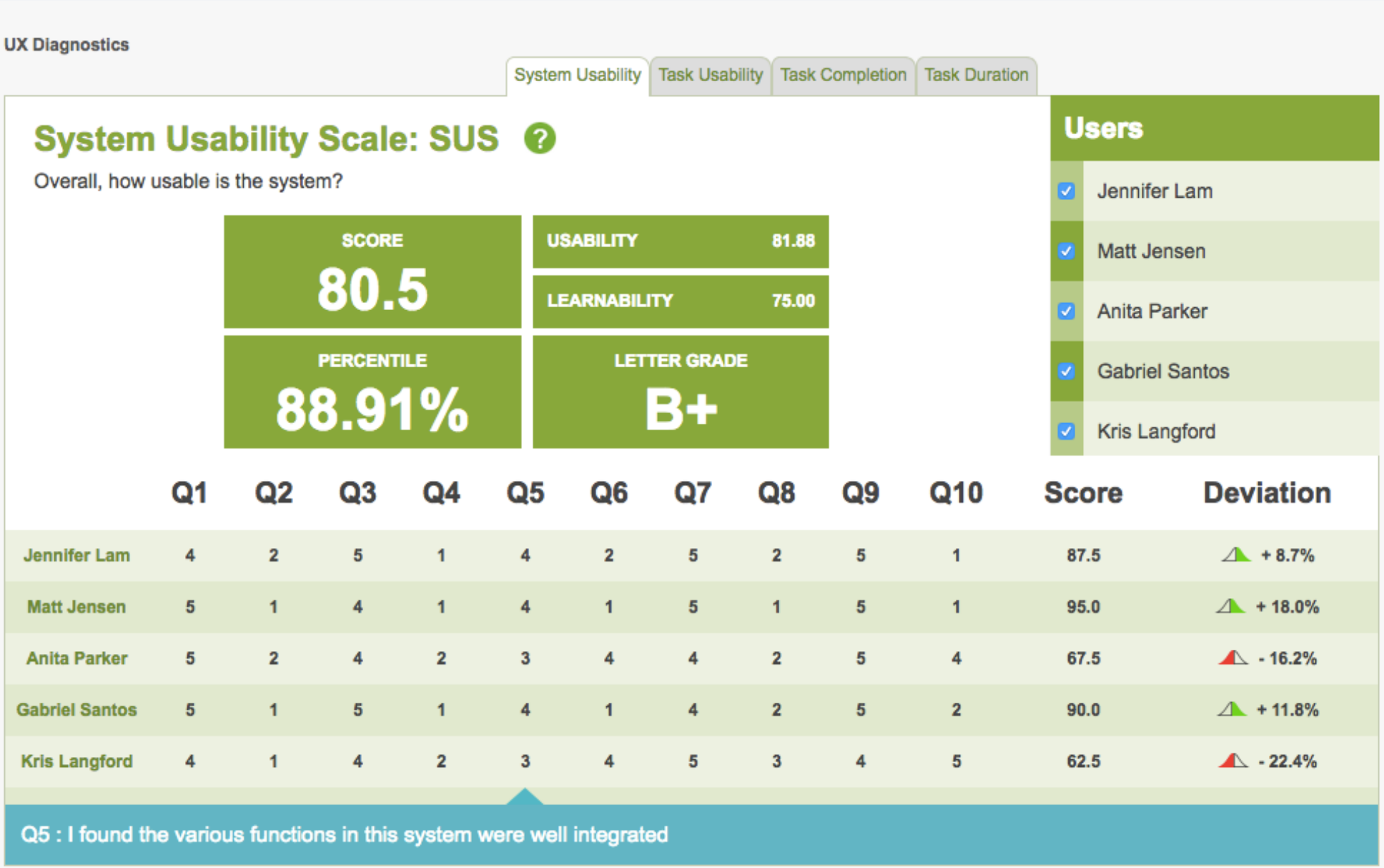
*Items marked with an asterisk have reversed wording. The numbers on items with reversed wording should be reversed before summing the responses for the ten items. For example, on item 3, “strongly agree” becomes 4, “agree” becomes 3, “disagree” becomes 2, and “strongly disagree” becomes 1.

Source: Morris Rosenberg’s “Self-Esteem Scale” from pp. 325–327 of *Society and Adolescent Self-Image*

Example: System Usability Scale (SUS)

	The System Usability Scale Standard Version	Strongly Disagree					Strongly Agree
			1	2	3	4	5
1	I think that I would like to use this system frequently.		O	O	O	O	O
2	I found the system unnecessarily complex.		O	O	O	O	O
3	I thought the system was easy to use.		O	O	O	O	O
4	I think that I would need the support of a technical person to be able to use this system.		O	O	O	O	O
5	I found the various functions in this system were well integrated.		O	O	O	O	O
6	I thought there was too much inconsistency in this system.		O	O	O	O	O
7	I would imagine that most people would learn to use this system very quickly.		O	O	O	O	O
8	I found the system very awkward to use.		O	O	O	O	O
9	I felt very confident using the system.		O	O	O	O	O
10	I needed to learn a lot of things before I could get going with this system.		O	O	O	O	O

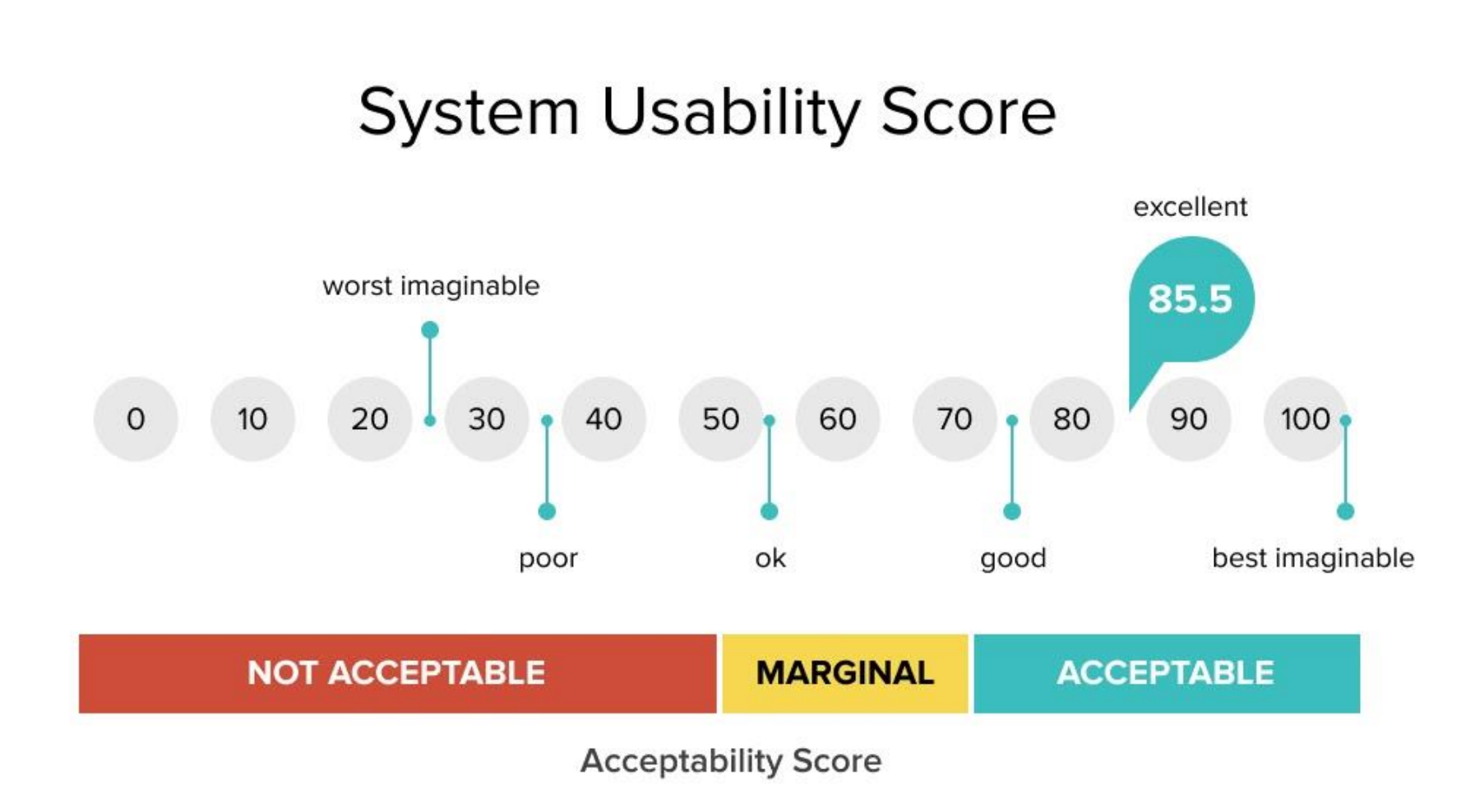
SUS



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score	Deviation
Jennifer Lam	4	2	5	1	4	2	5	2	5	1	87.5	+ 8.7%
Matt Jensen	5	1	4	1	4	1	5	1	5	1	95.0	+ 18.0%
Anita Parker	5	2	4	2	3	4	4	2	5	4	67.5	- 16.2%
Gabriel Santos	5	1	5	1	4	1	4	2	5	2	90.0	+ 11.8%
Kris Langford	4	1	4	2	3	4	5	3	4	5	62.5	- 22.4%

Q5 : I found the various functions in this system were well integrated

SUS Evaluation



SUS Analysis

Data Analysis Approaches

- **Microsoft Excel**
  - Percentages, averages, variations
  - Tables, Graphs
- **SPSS (Statistical Package for Social Scientists)**
  - As above
  - Correlations (relation between different measurements)
  - Differences in Data (statistically significant)
  - Recommended Reading: ‘Discovering Statistics using SPSS’ by Andy Field

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INFORMATION SYSTEMS (IS) RESEARCH DISCIPLINE

Information Systems Research

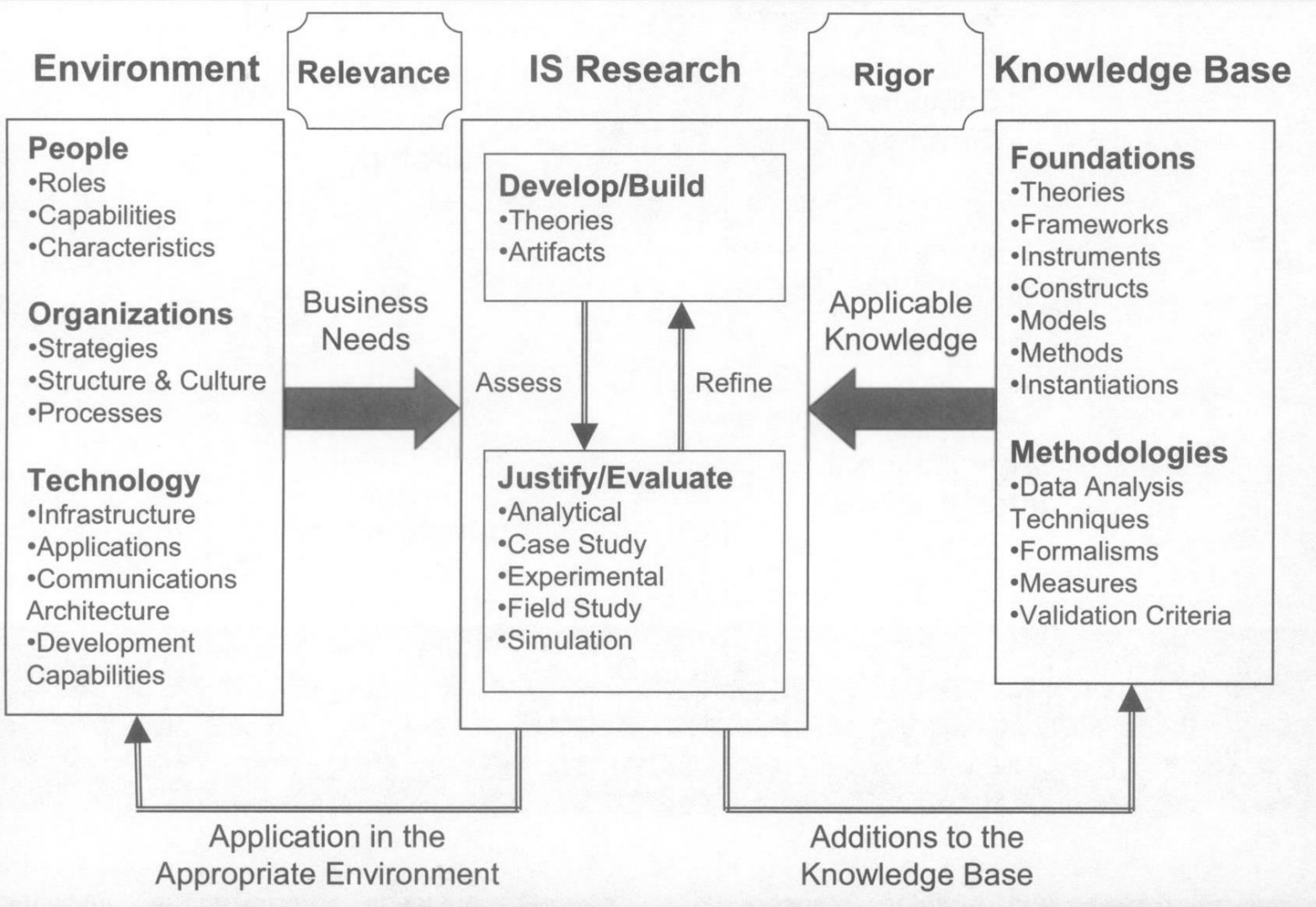
- **Information Systems Research** is characterised by two foundational and complementary research paradigms:
  - ***Behavioural-science***
  - and ***Design-science***

- **Behavioural-science research**
  - develops and verifies theories explaining or predicting human behaviour
- **Design-science research**
  - creates and applies new innovative artefacts (applications, services, …), which are used to achieve knowledge and understanding of the corresponding problem domain, and with that to extend the boundaries of human and organizational capabilities.

A. R. Hevner, S. T. March, J. Park, and S. Ram, "Design science in information systems research," MIS Quarterly, vol. 28, no. 1, pp. 75–105, 2004. [Online]. Available: http://www.jstor.org/stable/25148625

Information Systems Research Framework

taken from Hevner et al (2004)



Information Systems Research Framework

- built around two complementary research phases:
  - **Develop/Build phase:** theories are developed by ***behavioural-science*** research, and artefacts are built by ***design-science*** research
  - **Justify/Evaluate phase**: theories are justified, and artefacts are evaluated. Developed theories and built artefacts are assessed by justification and evaluation activities, leading to refinement of theories and artefacts.

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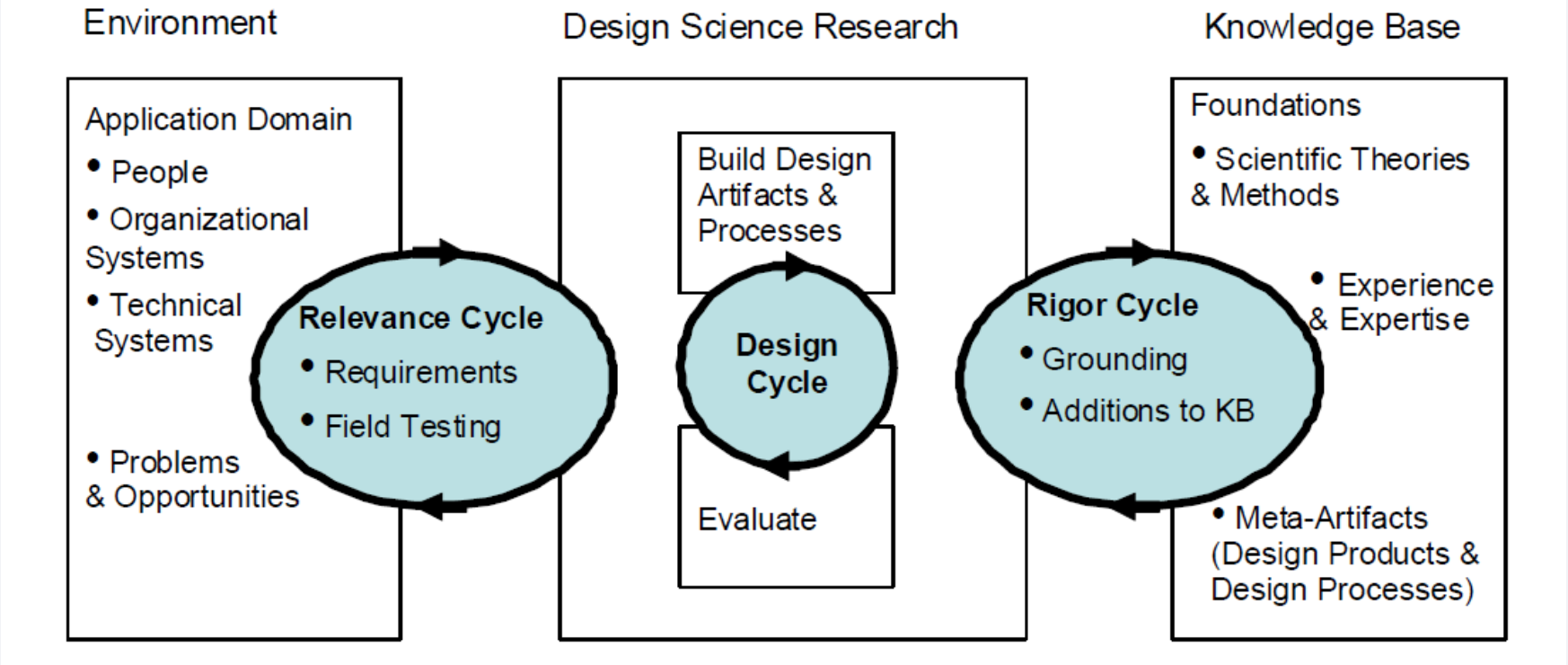
Design Science (DS) Research in Information Systems (IS)

- Design Science Research Cycles



A. R. Hevner, "A three cycle view of design science research," Scandinavian journal of information systems, vol. 19, no. 2, p. 4, 2007.

Design Science Research Cycles
(Hevner 2007)

- ***Relevance Cycle***:
  - initiates DS research with an application context that provides requirements for research and also evaluation criteria
  - research output, e.g. artefact (application, service), is returned into environment for study and evaluation in specific application context
- ***Rigor Cycle:***
  - ensures innovation by consideration of established scientific theories and methods together with domain experience and expertise in setup and execution of project
  - research results (i.e. new knowledge) is added to growing knowledge base (KB)
- central ***Design Cycle:***
  - heart of any DS research project:iterative process of research activities between artefact construction, evaluation, feedback and refinement of design

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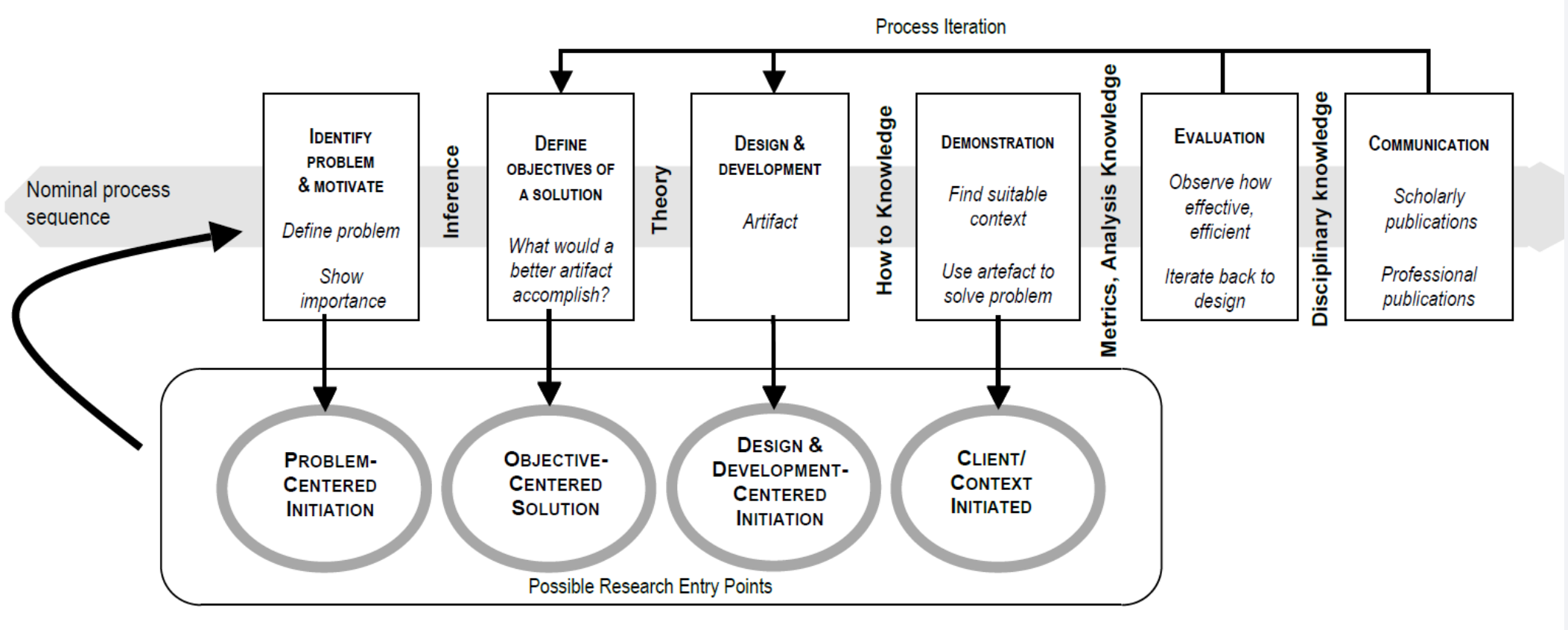
Design-Science Research Guidelines

taken from Hevner et al (2004)

Table 1. Design-Science Research Guidelines

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Design Science Research Methodology (DSRM) Process Model



K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, "A Design Science Research Methodology for Information Systems Research," Journal of Management Information Systems, vol. 24, no. 3, pp. 45–77, 2007. [Online]. Available: http://www.tandfonline.com/doi/abs/10.2753/MIS0742-1222240302

Design Science Research Methodology (DSRM) Process Model

- **6-steps process model:**
  - (1) problem identification and motivation
  - (2) definition of the objectives for a solution
  - (3) design and development
  - (4) demonstration
  - (5) evaluation
  - (6) communication

- **⇔ various methods and tools applicable for each process step!!!**

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DSRM step (3): Design and development

- Create the ***artefact***!
- Artifacts are potentially ***constructs***, ***models***, ***methods***, or ***instantiations*** (each defined broadly) or "***new properties of technical, social, and/or informational resources***"
- Design research artifact can be any designed object in which a research contribution is embedded in the design
- Could be development of "mock-up", emulator or proof-of-concept prototype
  ⇔ functional validation and UI design analysis (*qualitative*)
- Could be development of simulator or proof-of-concept prototype
  ⇔ performance testing and analysis (*quantitative*)
- Design and development includes determining the artifact's desired functionality ***(⇔ requirement elicitation / analysis)*** and its architecture and then creating ***(⇔ solution design, development and implementation)*** the actual artefact

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DSRM step (4): Demonstration

- “Demonstrate use of artifact to solve one or more instances of the problem.”
- could involve its use in ***experimentation, simulation, case study, proof, or other appropriate activity***
- E.g. ***Pilot Studies; “Field Trials”:***
  - Make sure you practice your study first with a test run
  - Make the necessary changes as required to your design and procedures
  - Study solution / fulfilment of technical requirements:
    - “Does it work as desired?” ⇔ *qualitative* validation
    - Security, … ⇔ *qualitative* tests and validation
    - “How does it perform?” ⇔ *quantitative* performance analysis
  - Run user trial:
    - “Does it fulfill user expectation and needs?” ⇔ *qualitative and quantitative s*tudy of usability, using interviews, questionnaires, …

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DSRM step (5): Evaluation

- Observe and measure how well the artifact supports a solution to the problem
- Evaluation involves comparing the objectives of a solution to actual observed results from use of artifact in the demonstration

DSRM step (5): Evaluation

taken from Hevner et al (2004)

Table 2. Design Evaluation Methods	
1. Observational	Case Study: Study artifact in depth in business environment
	Field Study: Monitor use of artifact in multiple projects
2. Analytical	Static Analysis: Examine structure of artifact for static qualities (e.g., complexity)
	Architecture Analysis: Study fit of artifact into technical IS architecture
	Optimization: Demonstrate inherent optimal properties of artifact or provide optimality bounds on artifact behavior
	Dynamic Analysis: Study artifact in use for dynamic qualities (e.g., performance)
3. Experimental	Controlled Experiment: Study artifact in controlled environment for qualities (e.g., usability)
	Simulation – Execute artifact with artificial data
4. Testing	Functional (Black Box) Testing: Execute artifact interfaces to discover failures and identify defects
	Structural (White Box) Testing: Perform coverage testing of some metric (e.g., execution paths) in the artifact implementation
5. Descriptive	Informed Argument: Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artifact's utility
	Scenarios: Construct detailed scenarios around the artifact to demonstrate its utility

DSRM step (5): Evaluation

Methods for ***Recording*** of Test / Trial:

- Think about what method is most suitable and why
  - Measurements
  - Audio
  - Audio / Video
  - Handwritten Notes (observation of usage)
  - Questionnaires
  - Interviews

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Important in future: Inter- / Multi- / Transdisciplinarity

- **Example: eHealth**

- **Definition:**
  "eHealth is the use of information and communication technologies (ICT) for health". [WHO]

⇔ cooperation between various Computer Science specialists and healthcare practitioners is required !

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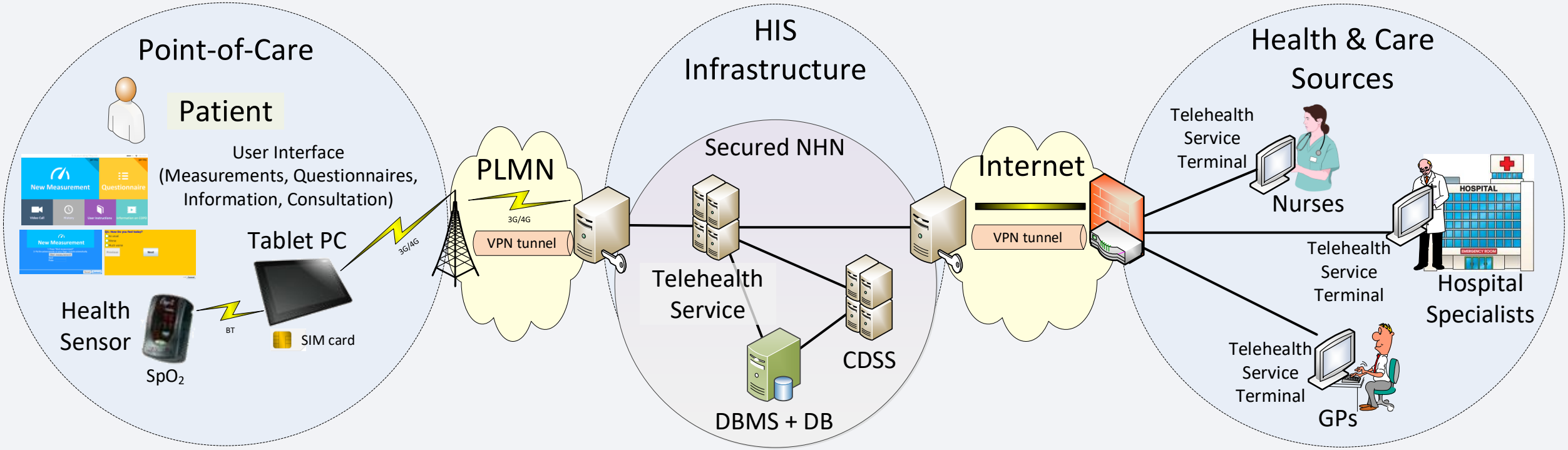
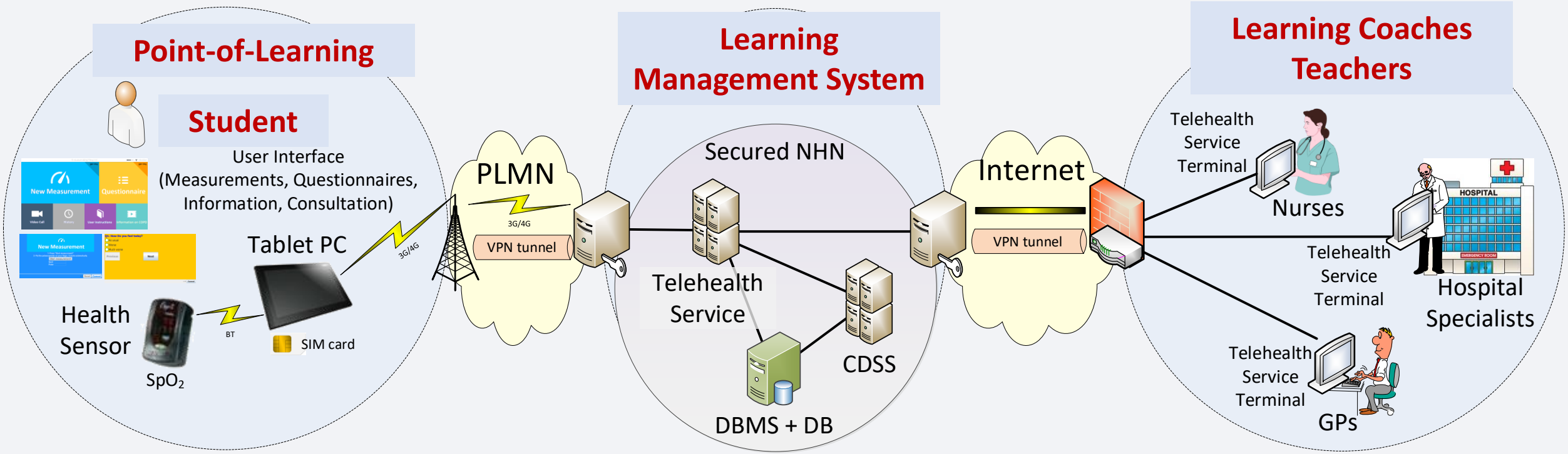
Example: Research about telehealth system



Involved Requirements and Corresponding Experts:

- System Architecture and Software Design; software engineering; security and privacy protection
- Usability: Human Computer Interaction (HCI);
- Healthcare Decision Support: health & care specialists (nurses, GPs, hospital)

Related Example: Distance Learning / Online eLearning



Involved Requirements and Corresponding Experts:

- System Architecture and Software Design; software engineering; security and privacy protection
- Usability: Human Computer Interaction (HCI);
- Learning Methods and Content: Education experts; Learning Content Providers

- **Future Learning needs multi-disciplinary approaches and methods!**

Reference Texts

- Might, M. (2012), "*The illustrated guide to a ph.d.*", [Online; accessed 2-October-2012].
- Simon, H. (1996). "The sciences of the artificial". MIT press.
- Catherine Dawson (2009*) "Introduction to Research Methods"*, How to Books Ltd.
- Robert Burns (2000) "*Introduction to Research Methods"*, Sage Publication Ltd.
- A. R. Hevner, S. T. March, J. Park, and S. Ram (2004) "Design science in information systems research," MIS Quarterly, vol. 28, no. 1, pp. 75–105. [Online]. Available: http://www.jstor.org/stable/25148625
- A. R. Hevner (2007) "A three cycle view of design science research," Scandinavian journal of information systems, vol. 19, no. 2, p. 4.
- K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee (2007) "A Design Science Research Methodology for Information Systems Research," Journal of Management Information Systems, vol. 24, no. 3, pp. 45–77. [Online]. Available: http://www.tandfonline.com/doi/abs/10.2753/MIS0742-1222240302

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