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Research methods and methodology

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Example..

Let's publish a paper for this nice Bahamas conference...

What about a hashing function for searching large image databases (internet -> \$\$\$\$!)

Efficient hashing for large image databases

1. Intro (there are so many images!)
2. The Algorithm (pseudo-code)
3. Example (it works)
4. Conclusions (it really works!)

- Research methodology?
- Objective?
- Related research?
- Validation?

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Science fiction and fact

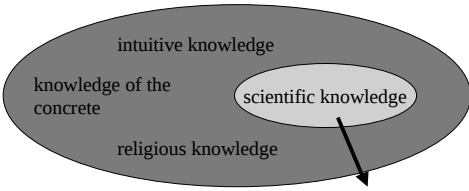
• Objective knowledge • Repeatable experiments • Valid reasoning • Unbiased • Revealing • Researcher as the shy and cooperative genius	• Opinion, taste, hype • handwaiving • rhetoric • university politics • dull, uninteresting • researchers highly competitive and over-self-confident
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Knowledge and scientific knowledge



Focuses on

- the abstract
- using logical reasoning
- acquired methodologically

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Course overview



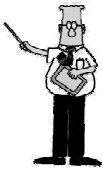
- Introduction (Hans Weigand)
- Philosophy of empirical sciences (Richard Starmans)
- Philosophy of formal sciences (John-Jules Meyer)
- Research design (Hans Weigand, Hans Heerkens)
- Research methods (Hans Akkermans)
- Research methods in
 - Agent Systems (Catholijn Jonker)
 - Machine Learning (Antal vd Bosch)
 - IR (Djoerd Hiemstra)
- Examples from two Ph.D. students
- How to write an article (Hans Akkermans)

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Overview of this introduction

- Basic research methodology (Verschuren/Doorewaard)
- What is IS/CS research? Wieringa, March
- Research paradigms in IS
- Research as communication



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Research Methodology

- **Types of research**
- Conceptual research design
 - Research objective
 - Research questions
 - Definition of concepts
- Research planning

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Empirical cycle

- Hypothesis
- Experiment
- Evaluation



“is it true? (and why?)”

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Design cycle

- Design
- Simulation/implementation
- Evaluation



“is it possible?” (and how?)

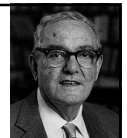
Note: In CS, “implementation” can range from model to proof-of-concept prototype to full implementation

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H. Simon, The Sciences of the Artificial



The engineer, and more generally the designer, is concerned with how things ought to be - how they ought to be in order to attain goals, and to function ... With goals and “oughts” we also introduce into the picture the dichotomy between normative and descriptive. Natural science has found a way to exclude the normative and to concern itself solely with how things are ... Artificial things can be characterized in terms of functions, goals and adaptation.

Research methods: simulation and decomposition

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Theory/practice oriented

- Theory-oriented: develop or test theory
 - Involves *experimentation*
- Practice-oriented: solve a problem
 - Involves *intervention*.

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Research quadrant

empirical	physics, sociology	political poll
	“develop incremental NL parser”	“develop web-site”
design	theory-oriented	practice-oriented

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Research Methodology

- Types of research
- **Conceptual research design**
 - Research objective
 - Research framework
 - Research questions
 - Definition of concepts
- Research planning

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Research objective

- Start exploring the project context
- Formulate research objective
 - useful (added-value)
 - feasible
 - clear
- The objective is to ... by ...

↗

your contribution

↖

your overall result

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Theory oriented

- Theory development
- Theory testing (cf. Glaser & Strauss)

A theory is more than accumulated knowledge, it provides a perspective (abstraction, interpretation) and is explanatory/predictive

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Practice-oriented

- Problem finding
- Diagnosis
- Design
- Intervention
- Evaluation

Different kinds of research and research questions

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Research framework

- Specify short *objective*
- Determine the *object*
- Establish the *nature* of the research
- Determine *ingredients*
- Visualize

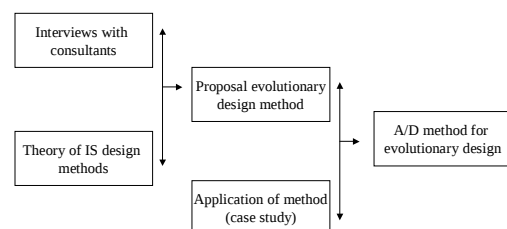
NB: often, a research project combines several research types

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Research framework visualized (example master project)



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Example: vd Heuvel (2002)

“a methodology for objectifying legacy systems”

1. Problem definition *Explorative, desk research*
2. Related research *Literature review*
3. Design of solution *Meta-modeling*
4. Validation of proposed solution
 - Logical consistency *metamodel*
 - Implementability *prototype*
 - Plausibility *field experiment*
5. Assessment of research results

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Research questions

- The questions that you state **yourself** for getting at your objective
- Main question/subquestions
- Requirements:
 - Effectiveness (do you reach your objective?)
 - Efficiency (balance between goal and means)
 - Steering function
 - What type of knowledge is required?
 - What material needs to be gathered?

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How to get at research questions?

- By exploring the research framework
- By unravelling key concepts
- Use knowledge hierarchy:

What is the best?
Is A better than B?
Is it possible?

prescriptive
evaluative
predictive
explanatory
descriptive



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Research Methodology

- Types of research
- Conceptual research design
 - Research objective
 - Research framework
 - Research questions
 - Definition of concepts (tomorrow)
- **Research planning**

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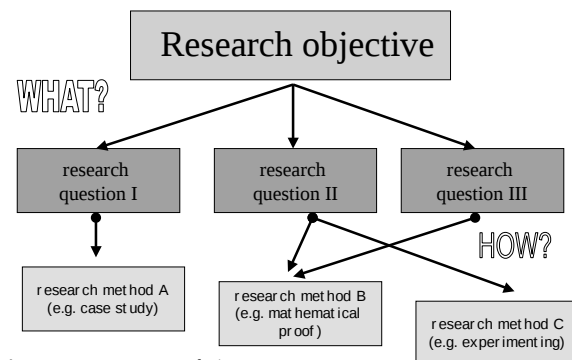
Research planning : HOW?

- Research material
 - People, documents, observation
 - Data sources, knowledge sources
- Research strategy
 - Survey, experiment, case study, grounded theory approach, desk research, ...
- Time planning

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Arrows represent your choices

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Concluding remarks on research methodology

- Research needs preparation (GIGO)
- Be aware of the choices that you make
- During execution, the framework should always indicate the purpose of what you are doing at that moment.
- As research is a creative process, adapting the framework on the way is natural and should always be possible.

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What is IS/CS research?

Is CS a *science*?

Is CS an *engineering* discipline?

Is it a *formal* science, branch of mathematics?

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Wieringa/Heerkens

- Characterizes CS as design science
- Design is aimed at solving some problem (action problem, world problem)
- The design itself is not research (contra Popper), but the other steps in the intervention cycle give rise to knowledge problems that can be addressed by scientific research
- Sometimes solving a knowledge problem requires solving an action problem

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March/Smith

- CS/IS research should integrate design and “natural science research”
- Design is aimed at creating things
- Basic design activities: build and evaluate
- Natural science is aimed at developing theory – not restricted to natural phenomena, can also apply to artifacts (contra Simon)
- Basic science activities: theorize and justify

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March/Smith research framework

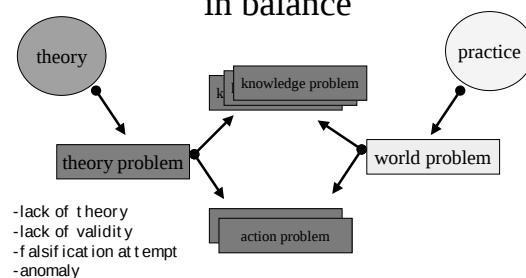
	build	evaluate	theorize	justify
constructs				
model				
method				
instantiation (working program)				

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Theory and Action in balance



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Ramesh et al

- Based on empirical study of publications
- Focus in CS is on formulating (80%) rather than describing or evaluating
- Research methods: mainly conceptual/mathematical
- Low reference to other discipline (some mathematics)

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Why mathematics?

- Conceptual clarity
 - like precise definitions in Law
 - Could perhaps be reached also by UML diagram
- As a research method
 - to validate certain claims
- For the development of a (predictive) theory
 - not really different from e.g. game theory in Economics
 - Example: relational algebra, complexity theory, ..

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Research paradigms in IS

- Positivism (Comte) and rationalism (Descartes)
- Post-modernism (Foucault, Derrida), cf. interpretivism, constructivism, ...
- Pragmatism (Peirce, Dewey, Rescher)
- Critical theory (Habermas)

Cf debate between rationalist AI tradition (Schank, Stefik/Bobrow) and Winograd & Flores, to which also Suchman contributed.

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Interpretivism

The aim of interpretive research is to understand how members of a social community, through their participation in social processes, enact their particular realities and endow them meaning, and to show how these meanings, beliefs and intentions of the members help to constitute their social action (Orlowski & Baroudi, 1991)

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Pragmatism

Not in the sense of opportunism, but concerned with action rather than with being

“There is no such thing as genuine knowledge and fruitful understanding except as the offspring of *doing*... Only by wrestling with the conditions of the problem at first hand, seeking and finding his own way, does he think“

“Thinking is not different in kind from the use of natural materials and energies ..”

Knowledge of a thing is knowledge of what you can do with it.

Tries to bridge empirical science and design science.



Ch. Peirce



John Dewey

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Critical theory

- Knowledge is not neutral - be critical about assumptions such as the technical imperative to improve efficiency
- Knowledge must be legitimated by consensus and democratic discourse
- Knowledge is not neutral – science should serve social goals such as emancipation



Jürgen Habermas, 1973

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Research as communication

- Researchers communicate via papers, presentations, discussions
- In communicating, they make descriptive and normative statements (validity claims)
- These claims may be challenged by others, leading to discussion
- Discussion is as essential as research activities itself

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So ...

- Communicate! (publish, discuss, review,...)
- Be clear! (Grice's conversational maxims)
- Take communication partners seriously!
 - Read related research
 - Try to understand
 - Refer
 - Consider their goals and expectations
- Don't "drop an idea"; try to convince!
- Justify your claims!

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Maxim of Quantity:

1. Make your contribution to the conversation as informative as necessary.
2. Do not make your contribution to the conversation more informative than necessary.

Maxim of Quality:

1. Do not say what you believe to be false.
2. Do not say that for which you lack adequate evidence.

Maxim of Relevance:

Be relevant (i.e., say things related to the current topic of the conversation).

Maxim of Manner:

1. Avoid obscurity of expression.
2. Avoid ambiguity.
3. Be brief (avoid unnecessary wordiness).
4. Be orderly.

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How to justify your claims?

"Ik ben er nog steeds van overtuigd dat zoals ik het doe je het moet doen want anders zou ik het niet doen."



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How to justify your claims?

- Grounding (empirical, simulation, ...)
- Careful reasoning
- Examples (not just for explanation, but to put your claim to the test)
- Delimitation
- Be clear about the status of your claim.

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Literature

- *Designing a research project* – P. Verschuren, H. Doorewaard. Utrecht, 1999.
- *Designing Information Technology in the postmodern age* – R. Coyne, 1997
- *Qualitative methods in management research* – E. Gummesson
- *The sciences of the artificial*. H. Simon, 1967
- *Research in Computer Science: an empirical study* -Ramesh et al, 2004
- *Design and natural science research on information technology* - March, Smith, 1995

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