What is this **Science** called **Requirements Engineering** ?

Hans Akkermans
(VUA, The Netherlands, AKMC Knowledge Management)
Jaap Gordijn
(VUA, The Netherlands)

Assessing **RE research**

- Ongoing debate in **RE** and **related disciplines**:
  - **Requirements Engineering**:
    Wieringa, Maiden, Mead, Rolland: **WMMR** classification of RE research papers to facilitate the reviewing process by per class criteria
    (plus: Viewpoint of Wieringa)
  - **Management Information Systems**: Behavioral Science & **Design** Science:
    - Hevner, March and Ram: strict Simon-based guidelines, using a research framework: "Environment [Relevance] IS Research [Rigour] Knowledge Base"
- Recurring themes:
  - What is a **proper scientific methodology** to **evaluate** and **validate** produced **claims** to **knowledge** and how we **formulate** theory?
    - How do we know that claims are **theoretically** *and* **practically** "correct"?
  - To what is(?) the **design** of an IT artifact part of **scientific research**
  - What is an appropriate **relationship** between **scientific research** and **societal relevant practice**?
    - Usability & actionability, reflective learning, not a linear chain

What is **(RE) Research**?

- *WMMR*: **Categories** of **research foci** with their **own** distinctive evaluation criteria
  - Evaluation research, solution proposals, validation research, philosophical work and experience reports
  - “broad church”, **inclusive formulation**
  - Research is concerned with **knowledge claims** that can be **evaluated** and **validated** in some way
- A **social practice** focused on the **production of claims to knowledge** through a **process of inquiry**, in a way that is:
  - ***Relevant***: knowledge is about something of interest
  - ***Systematic***: process of inquiry is carried out in a systematic, critical and rigorous fashion
  - ***Transparent***: claims are produced and argued for such that they are clear and open to critical scrutiny for *others*

Images of Science (1/2): **Exact Sciences**

- **Theory**
- Theory ≈ formal math and its machinery
- **Fundamental “first” principles**
  - Axiomatic basis for theory (Euclid as classical role model)
  - Conceptual organizational power (parsimony, Occam’s razor)
  - Contrast with purely empirical, “phenomenological” models
  - Abstract; distant from directly observable reality
  - Often overlooked: many steps between principles and test in observable reality
  - Principle-based formal theory as core of scientific approach

- **Experiment**
- **Validation** by **controlled observation & experimentation**
  - Experimental method as core of scientific approach
  - Simulation as lab experiment

Engineering as **Research**

- Traditional **views**: (both natural and social sciences)
  - "Just" **practical application** of existing scientific knowledge
    - Assumption: knowledge transfer is linear value chain
- WMMR (RE): **Engineering is closely related to Research**
  - **Engineering cycle**: problem investigation, solution validation, implementation validation are all research activities
- **Research** using the **scientific method**, for **problem-solving** goals related to **practice** (rather than general explanation and prediction)
    - Assumptions: nonlinear value chain, &
    - Goals other than explanation can be part of science
- So, design as ≈ Simon says **but**:
  - With **context inclusion** and **problem formulation** (not just solving)
  - With e.g. **holistic solving strategies** (patterns, templates, etc.) (not just search, aka "the next move")
  - With **close interaction** between practitioners and researchers

Images of Science (2/2): **Social Sciences**

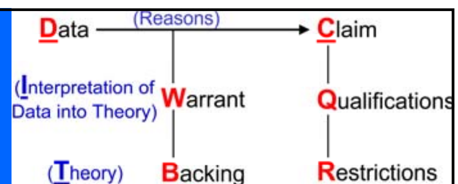
- **cf. Natural Science model**
- Theory ≈ (ideally) formal **math** and its machinery
- "**Quantitative**" approach
    - Variable networks
    - Statistics
    - "Objective" stance
    - Predictive, explanatory
- Empirical research:
  - Validation by **controlled** observation and experimentation
    - Experimental method as core of scientific approach
    - Separation of context of discovery and justification (confirmation)

- **"Interpretive" Humanities model**
- Theory ≈ **coherent conceptual system** (in natural language)
- "**Qualitative**" approach
    - Human as agent, subject
    - Knowledge as social construct
    - "Subjective" stance
    - Explanatory, understanding
- Empirical research
  - Interpretation by **observation**, **interview**, **text/conversation** and symbolic **(inter)action** analysis
    - Subject/Context-inclusive methodology as core of scientific approach
    - Discovery and justification (confirmation) seen as cycle

Experiments as **validation instrument**

- WMMR: **Validation** research:
  - Logico-mathematical proof
  - Thought experiment
  - Computational simulation and analysis
- WMMR: **Evaluation** research
  - The “classic” laboratory experiment
  - Field experiment
  - Practice/experience-oriented field study
- In the end it boils down to:
  - Construction of a **rational**, **communicative argument**

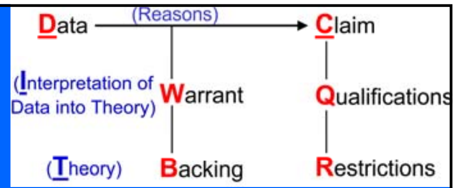
Concept(s!) of Validity (1/2)



(Toulmin, 1958)

- (1) **Descriptive validity (D)**
  - Are my data (“facts”) right, do I have a truthful (or at least adequate) description of the situation I am considering?
    - Triangulation plays an important role here: check and cross-check
    - Cf. similarity with case in court, detective: “beyond reasonable doubt”
- (2) **Theoretical validity (T)**
  - Is the general theory (framework, model) I use adequate for the situation (maybe not perfect, but “good enough” given my goals)
    - Any model or theory emphasizes certain aspects and ignores others, is an abstraction of your reality: is this emphasis OK or helpful for what you want?
- (3) **Interpretive validity (I)**
  - Is the way in which I interpret my data (facts) in terms of my theory (framework/model) right or at least adequate for my purpose?
    - Construct (“**D + T**”), for example, construct validity in statistical research
    - How you apply your general theory to the specific situation and fit your facts into it

Concept(s!) of Validity (2/2)



(Toulmin, 1958)

- (4) **Internal validity (C_{INT})**
  - Are the claims (conclusions) I derive (by reasoning R) right **within** the situation I am considering?
- (5) **External validity (C_{EXT})** = **Generalizability**
  - Are my claims more generally right outside the situation I am considering? What other situations, what sense, to what degree?
    - Statistical generalization (survey); Analytical/theoretical generalization (case study, lab)
- (6) ***Implemention* validity (A)**
  - Do claims yield concrete **action guidance for practice**?
    - (cf. org. learning, action research, reflective professional practice, **pragmatic societal relevance**: cf. Argyris, Schön)

Validation: **Goodness of fit**

- **Theories have implications, or rather, implication networks**
  - They have many, and related, things to satisfy at the same time
- **Evaluation of theory is overall "network" function**:
  - Find out **to what extent/degree** a theory's unavoidable implications are **acceptable** (theoretically, empirically, pragmatically)
  - **Overall "goodness of fit"** with range of empirical evidence *and* with other (established) theories, models, assumptions
  - Much more than and significantly different from hypothesis testing

Example: **Choices *e*^{3}*value* Business Ontology Research** Programme

- **Nature of knowledge claim goals:**
  - Action guidance (design-like): How to "architect" networked value constellations?
    - Secondary, derived goals: understanding, explanation
- **Nature of theory formulation**
  - Ontology as formal conceptualization and theory formation approach
- **Nature of testing and validation**
  - Computational paradigm (model-based tooling, (design) simulation)
  - Case studies in different field contexts (different industries, countries)
  - Action research related to socio-technical innovation with IT/IS
- **Why not traditional empirical business research?**
  - Fundamental problems with population concept (i.e. undercuts rigour: dubious applicability of "SPSS" research style)
  - Yields contemporary phenomenological regularities only (insufficient contribution to strong theory based on fundamental principles)
  - Big gap to actionable knowledge claims and reflective professional practice (i.e.

Finally: RE as Science (And what makes it different)

- There is no *simple*, *unique*, *fixed*, or *universal* recipe how to do research (not in general, but certainly not for RE)
  - No such thing as "the" scientific method; Different types of validity
  - Theory formulation & evaluation such that it allows for context inclusiveness.
- RE should have **actionable results**: from syntax – semantics – **pragmatics**, and back
  - Analyzed as dynamic interlinked socio-technical system
- Challenges:
  - More depth in its **level of theory** (learn from natural sciences),
  - More **rigor in empirical study** (learn from social sciences, incl. case study)
  - And its **design/problem solving work** must become more specific and less vague (learn from engineering sciences)

Recent papers of us about the same topic

- Hans Akkermans, Jaap Gordijn, "**Ontology Engineering, Scientific Method, and the Research Agenda**", EKAW 2006 (http://www.e3value.com/bibquery/?key=AkkermansOE2006)
- Jaap Gordijn, Hans Akkermans "**Early Requirements Determination for Networked Value Constellations: A Business Ontology Approach**", (http://www.e3value.com/bibquery/?key=EarlyReqDet2006)

