What is this Science called Requirements Engineering?

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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:
• 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 $\approx$ 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 (interaction) 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)

• (1) Descriptive validity (D) (Toulmin, 1958)
  – 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)

- **(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) Implementation** 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 e³value 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.

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**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