Scientific (and engineering) method – a mini-primer

KIV/OSN-E 2022
Přemek Brada
Why “method”

• Research (science) => new knowledge
• Engineering => new products

• Both need to avoid re-inventing the wheel
• Both strive for reproducibility of results
• Both require creativity as well as diligence
• Both have (in theory) no place for belief and lot of place for doubt
The Core

1. Idea / Hypothesis
2. Proof

=>

either: wow, new knowledge/product ("confirmation")
or:  hmm, did not work ("falsification")
or:  meh, been there before ("prior art")
Step 1 “Hypothesis” details

Research (science) 

• Hypothesis => Research question
• Observation
• Formulation (research questions, hypotheses, assumptions)
• Prediction

Engineering 

• Idea => Specification
• Market research
• Requirements
• Prototype / Proof of Concept
Step 2 “Proof” details

Research (science)

- Review of Related work (State of the Art)
- Experiment / Formal proof
- Analysis and interpretation
- Publication (incl. peer review)
- Independent verification

Engineering

- Design, construction (incl. research on state of the practice)
- Verification
- Putting into operation
- Evaluation


Research Methods

• Qualitative vs Quantitative
  • words – questionnaires, coding
  • numbers – measurements and surveys, statistics

• Primary vs Secondary
  • experiments, measurements, surveys, prototype implementations, models
  • literature reviews, meta analyses

https://research.com/research/primary-research-vs-secondary-research
Related work / State of the Art

- Prerequisite to experiments or formal proofs
- Avoid re-inventing the wheel
- Show you are well versed in the domain
- Get inspiration and prevent blind alleys
- Find open issues, unexplored topics
- Primary sources, secondary sources (gray literature)
Publishing in Science

• Way to disseminate knowledge (to researchers, practitioners, public)
• Way to perform independent verification (dispute, maybe disprove)
• Conferences (“paper”) – discuss, fast feedback, fresh results
• Journals (“article”) – make permanent, archive, solid proven results
  • significant differences in publishing culture (humanities x engineering x natural sciences and medicine) (computing torn between eng and nat ... )
• Open vs Closed access
• DOI, artefact repositories