Scientific (and engineering) method – a mini-primer

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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

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

Engineering

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

Klaas-Jan Stol and Brian Fitzgerald. 2018. The ABC of Software Engineering Research. *ACM Trans. Softw. Eng. Methodol.* 27, 3, Article 11 (September 2018). https://doi.org/10.1145/3241743

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

Shaw, M. (2003). Writing Good Software Engineering Research Papers. In *Proceedings of the 25th International Conference on Software Engineering (ICSE 2003)* (pp. 726–736). IEEE Computer Society.