

What is quality in research?

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Why is this important?

- As supervisors, we teach research
- As researchers, we should maintain and improve quality

What's the problem?

- Common view:
“I can't define it, but I recognize it when I see it!”
- But “**What is unclearly said is unclearly thought**”
“det dunkelt sagda är det dunkelt tänkta” (Esaias Tegnér 1820)
- Defining it makes it easier to teach it, and to improve it!
- **Why now?**
 - New situation with lots of applied and cross/inter disciplinary research



Why is this important?

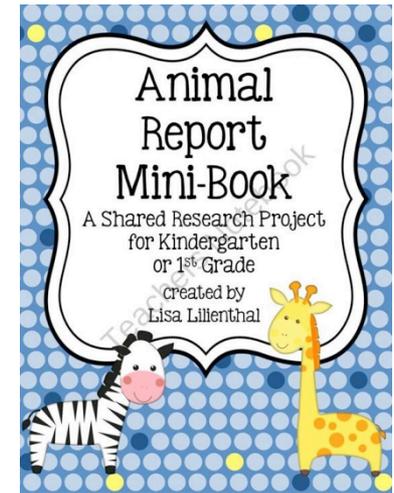
Quality seems to decline:

Retractions of research articles [1]:

- 10 times increase since 1975
- 67% are due to fraud, duplicate publication, and plagiarism

“Research” is used in very many different ways

- Children in kindergarten conduct research
- In everyday language, searching for information on the Internet is called research
- Companies conduct *market research*
- In science we normally mean something else



Definition

The **systematic investigation** into and study of materials and sources in order to **establish facts and reach new conclusions**... [Oxford Dictionaries]

still fits for kindergarten research ...

More pragmatic:

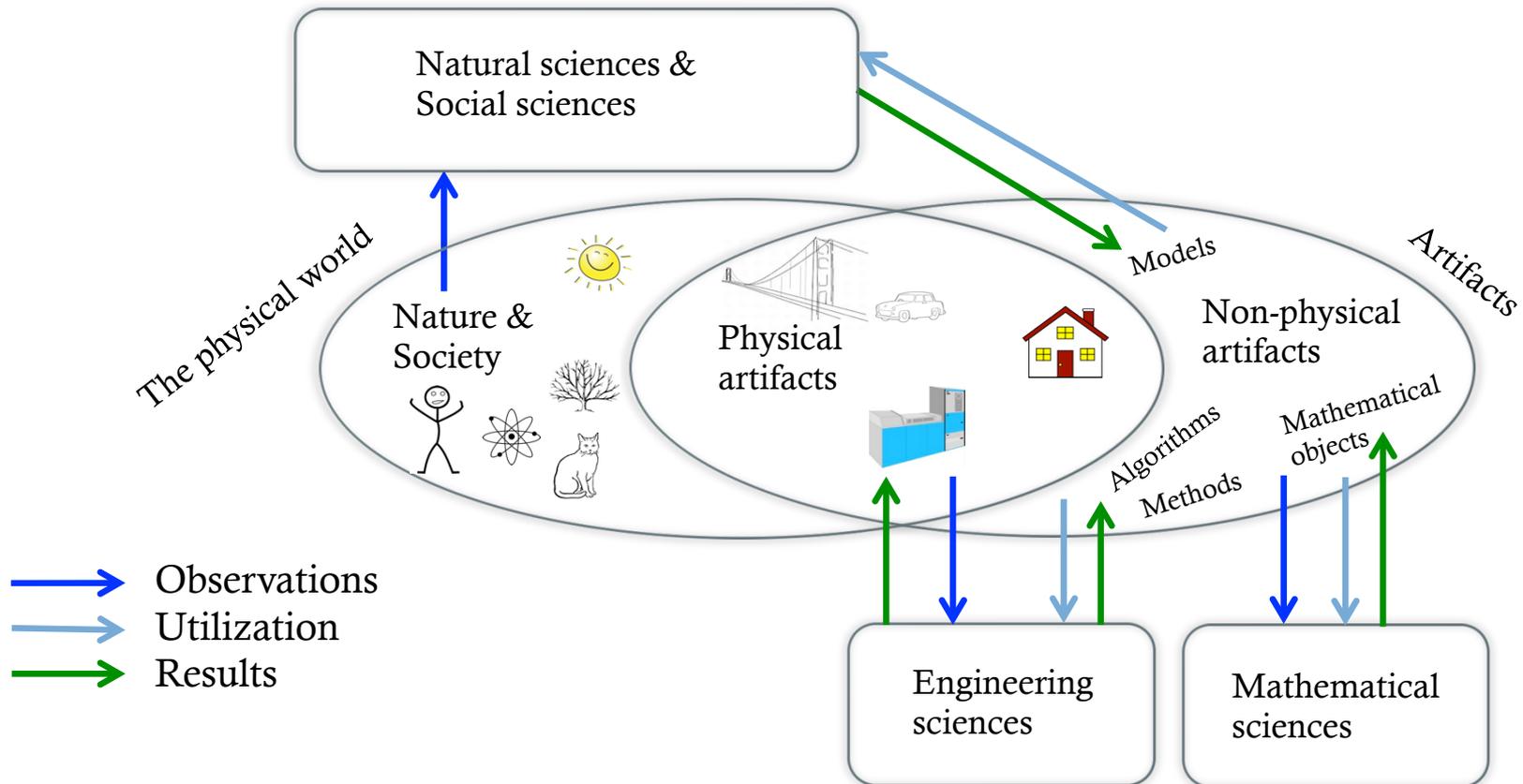
What researchers do (or should do...)

What are researchers doing?

some

Area	Goals	Typical activities	Results
Natural (and social) sciences	Increased knowledge of nature (and society)	<ul style="list-style-type: none">• Formulate a hypothesis• Test the hypothesis by experiments	Facts and models of nature (and society)
Mathematics (and basic CS)	Increased power of, and knowledge of abstract systems	<ul style="list-style-type: none">• Formulate a conjecture• Prove or disprove the conjecture• Develop new abstract concepts	Theory and proofs for the abstract systems
Engineering sciences (incl. applied CS)	Solutions to practical problems	<ul style="list-style-type: none">• Solve a previously unsolvable task• Solve a solved task, but in a better or different way• Solve an unsolved task	Algorithms, methodology, programs, machines

A model of research



- CS is partly an engineering science (applied CS), partly a mathematical science (basic CS)
- HCI researchers observe both humans and computers
- Physicists often develop devices

What characterizes good research?

1. Extrinsic quality indicators

- Depend on external factors: How research is rewarded
- Useful to evaluate research and researchers
- Provide limited guidance for how to conduct good research

2. Intrinsic quality indicators

- Depend on internal factors: How good research is recognized
- May provide guidance on how to conduct good research

1. Extrinsic quality indicators

Bibliometric indicators [3]

Reward	A sign of quality? Yes, but:
It gets published	There are many (bad) conferences and journals
It gets lots of citations	Citation indices are sometimes questioned
It leads to a PhD	It tends to be more and more like any education
It receives funding	The difference between R & D becomes more and more unclear

How are extrinsic quality indicators assessed?

It's all up to our peers!

- They affect who gets published, cited, a PhD, funded
- Peer reviewing is often used as definition of high quality [2]: "... *high quality research is research that stands the test of being scrutinized by highly recognized peers within the field,...*"
- Peers are the connection between Extrinsic and Intrinsic quality indicators

2. Intrinsic quality indicators

- How our peers judge research
- Informal guidelines & tips here and there
- Not too much written about it, in particular not for engineering sciences and mathematics
- “Unfortunately, general agreement about research quality in scholarly circles stops at the recognition of its importance” [5, p.49]

RAND Standards for High-Quality Research and Analysis [4]

The problem should be well formulated, and the purpose of the study should be clear.

The study approach should be well designed and executed.

The study should demonstrate understanding of related studies.

The data and information should be the best available.

Assumptions should be explicit and justified.

The findings should advance knowledge and bear on important policy issues.

The implications and recommendations should be logical, warranted by the findings, and explained thoroughly, with appropriate caveats.

The documentation should be accurate, understandable, clearly structured, and temperate in tone.

The study should be compelling, useful, and relevant to stakeholders and decisionmakers.

The study should be objective, independent, and balanced.

The study is comprehensive and integrative.

The study is innovative.

The study is enduring.

How are patents evaluated?



Requirements for US patents

- **Utility** - the invention should do what it is claimed to do
- **Novelty** - the invention must not already be known to the public
- **Nonobviousness** - the invention must be a nontrivial extension of what is already publicly known
- **Enablement** - the inventor must disclose and describe the invention in his patent application sufficiently to allow others to make and use the invention

Modified from www.quizlaw.com/patents

Applied to research



- **Utility** - the research must answer the question or solve the problem it addresses
- **Novelty** - the research results must not be already known in the research community
- **Nonobviousness** - the research must be a nontrivial extension of what is already known in the research community
- **Enablement** – the researcher must disclose and describe the research in publications sufficiently to allow others to replicate the work

Seem to be reasonable and important quality indicators for research.
All but Nonobviousness are straightforward to apply

Deciding what is a “nontrivial extension” is not always trivial

- Is it trivial if it is doable for an average student after 3-5 years at university?
- Applied and cross disciplinary research may seem nontrivial to a **single-domain** expert.

Example:

Is it trivial to use a 20 year old

- grammar model to detect objects in images?
- optimization algorithm to solve a problem in bio-chemistry

What if it is a 1 year old model/algorithm?

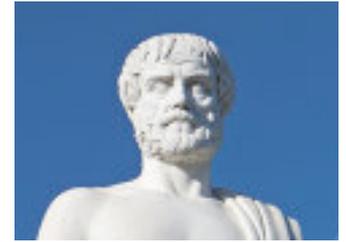
Sometimes *Yes* sometimes *No*

- What if I am the first one to come up with this trivial, and working solution?

Additional desired qualities

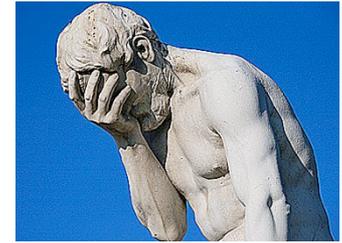
- The solution is better than alternatives (in one way or another)
- The problem is relevant and the results are needed and valuable
- The work provide general knowledge
- Not only about HOW the solution works, but also WHY and WHEN
- The solution is elegant (e.g. *Occam's razor*)
- Not only about results, but also about having a scientific approach:

A scientific approach



- Clearly defined task
- Proper use of earlier work
- Systematic work (?)
- Thoroughness
- Being critical towards one's own and other's work
- Objectiveness
- ...

Some undesired qualities



- Unclearly defined task or question
- **Not novel** – already done, maybe under another name or in another area
- **Obvious** – trivial combination of known methods/technology
- Confusing complexity with quality (Occam's razor in reverse)
- Not providing any general knowledge
- **Questionable utility** – the results only hold for selected suitable cases
- Results are not compared with state-of-the-art
- Results are not better than state-of-the-art in any respect
- **Lacking enablement** – results cannot be reproduced using the given information

References

- [1] Ferric C. Fanga, R. Grant Steen, and Arturo Casadevall (2012). Misconduct accounts for the majority of retracted scientific publications, Proc. Natl. Acad. Sc. U.S.A.
- [2] H Carlsson, Å Kettis, A Söderholm (2011). Research Quality and the Role of the University Leadership, SUHF expert group on university quality.
- [3] Moed, H. F. (2000). Bibliometric indicators reflect publication and management strategies. *Scientometrics*, 47, 323–346.
- [4] RAND Cooperation, Standards for High-Quality Research and Analysis (2014). CP-413 (2/14), Corporate Publications. Accessed March 3, 2014: http://www.rand.org/pubs/corporate_pubs/CP413-2014-02.html
- [5] Dörnyei, Z. (2007). *Research Methods in Applied Linguistics*. Oxford: Oxford University Press.

Related work

Chris Johnson Glasgow University

(http://www.dcs.gla.ac.uk/~johnson/teaching/research_skills/research.html)

“Computing science is an immature discipline ... Unfortunately the development of computing technology has not been matched by a similar development in academic research techniques. In the pursuit of technological goals, researchers have borrowed models of argument and discourse from disciplines as varied as philosophy, sociology and the natural sciences”.

The scientific method

The most common method in natural sciences: question, hypothesis, prediction, testing, analysis. Critics (Kuhn, Feyerabend, Lakatos) reject the idea of a single method that scientists follow. The scientific method has unclear applicability in engineering sciences.

The demarcation problem

How to distinguish between science and nonscience. Mostly fundamental properties of research areas like astrology/astronomy. Example: *falsifiability* (Karl Popper)