Educational science as enigineering science, not natural science

Marc J. de Vries

Whom do I hope to inspire?

- Engineering educators
  - Be more active users of and participants in educational research
- Educational researchers
  - Seek to make the gap between research and practice as small as possible
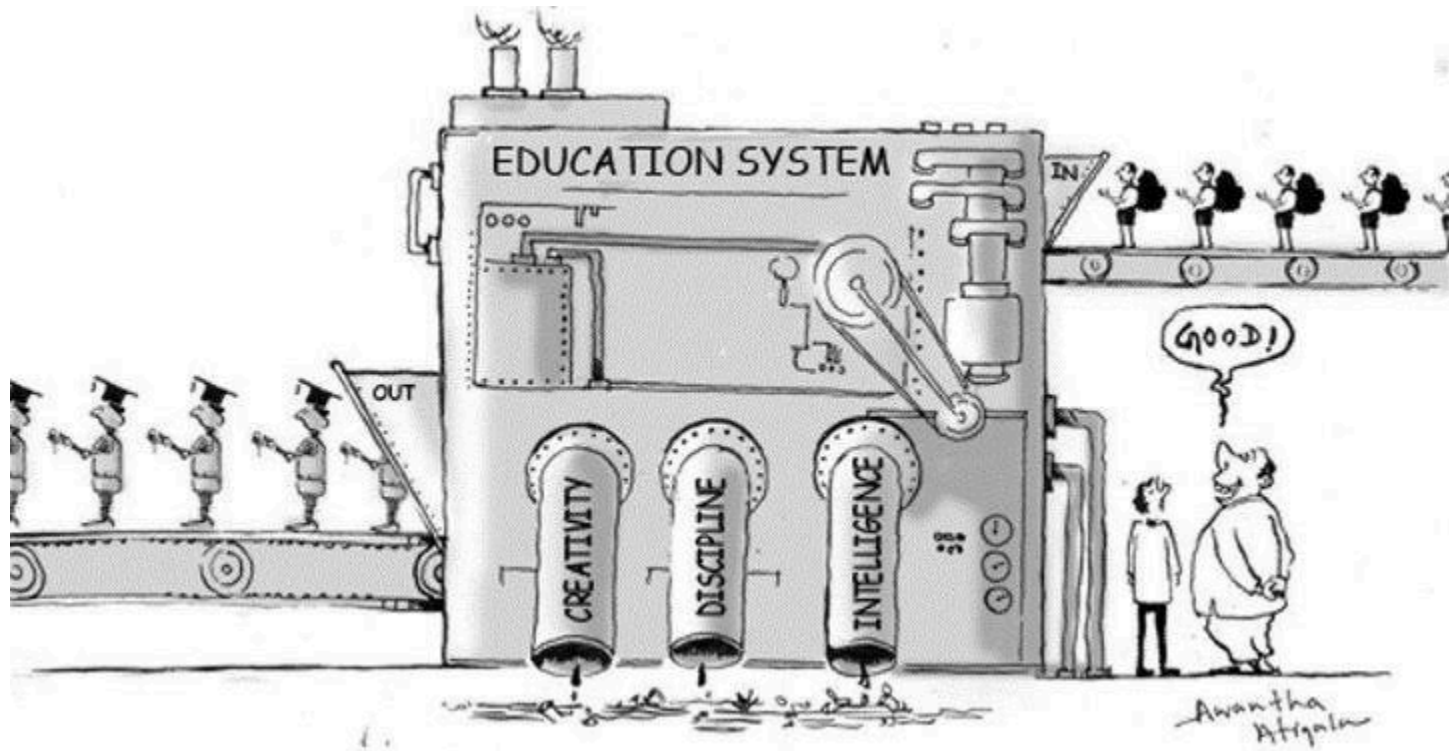
A possible misunderstanding
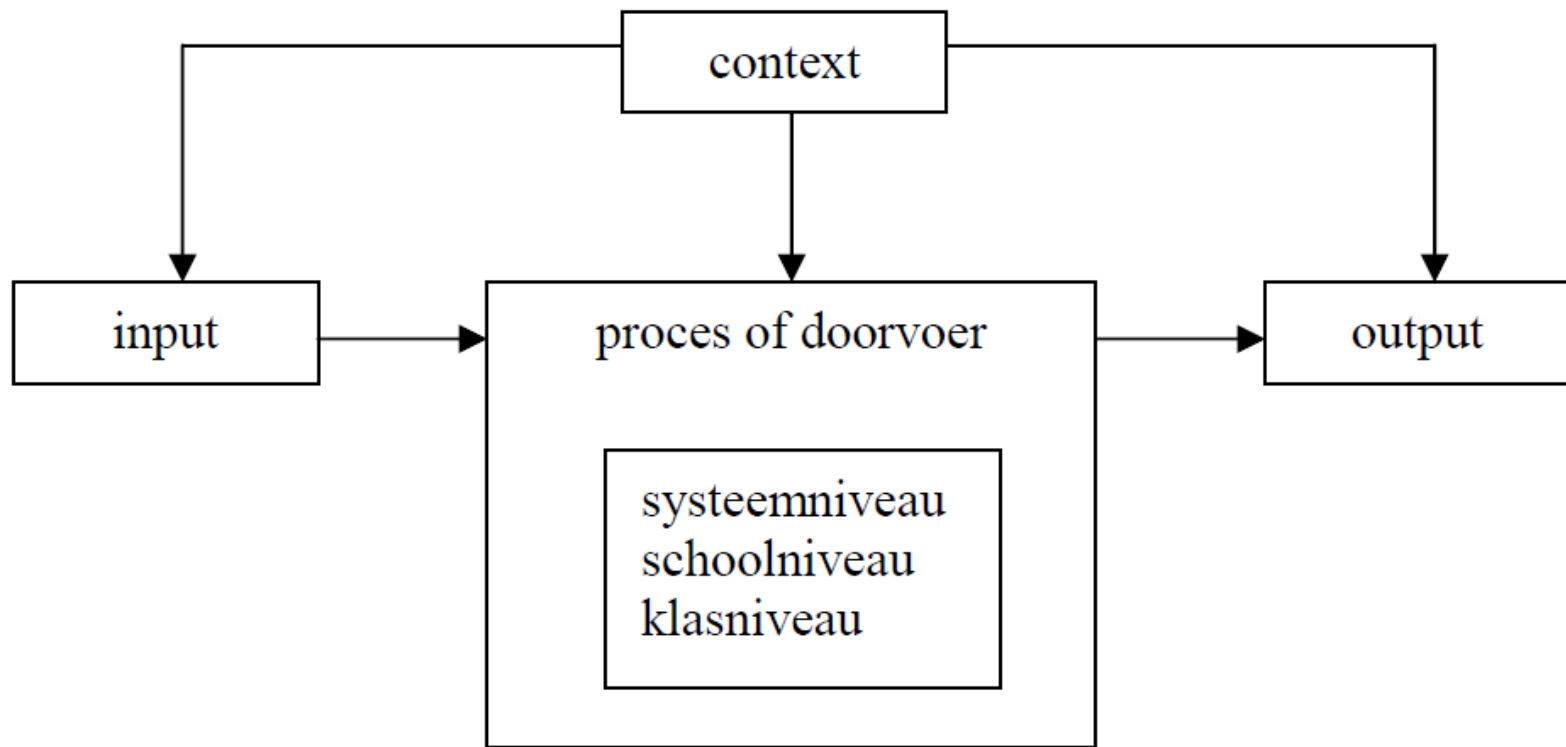
- No lack of appreciation for natural sciences

"Frankly, _I_ even find it hard to believe
some of the things I've been coming up with."

Another possible misunderstanding

• No plea for education as something that can be 'engineered'

From a Dutch report on quality of education: an engineering perspective
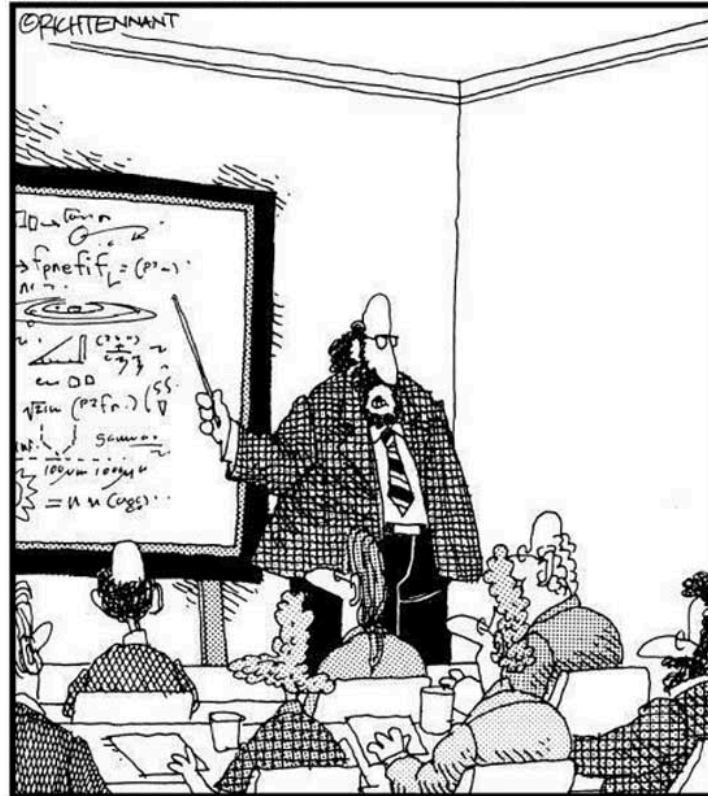
Then what do I plea for?

- Regarding educational science as a science that aims at improving education, not just describing it
  - . . . and drawing the consequences of that!

Education as the object of research: what is that?

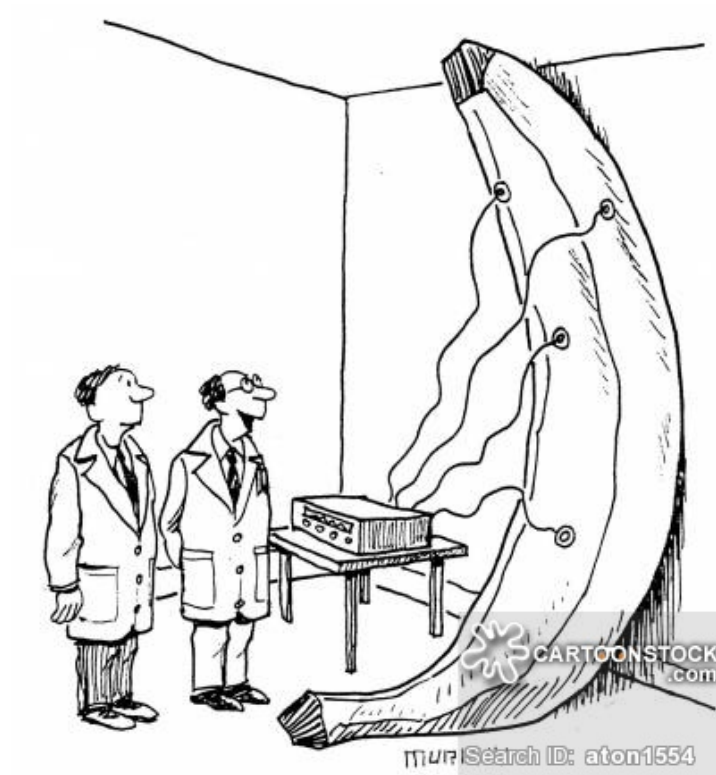**Wenn alles schläft und einer spricht, den Zustand nennt man Unterricht!**

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Do the findings matter?

Looking for the obvious?

"All tests point to the same conclusion: it is indeed a big banana."
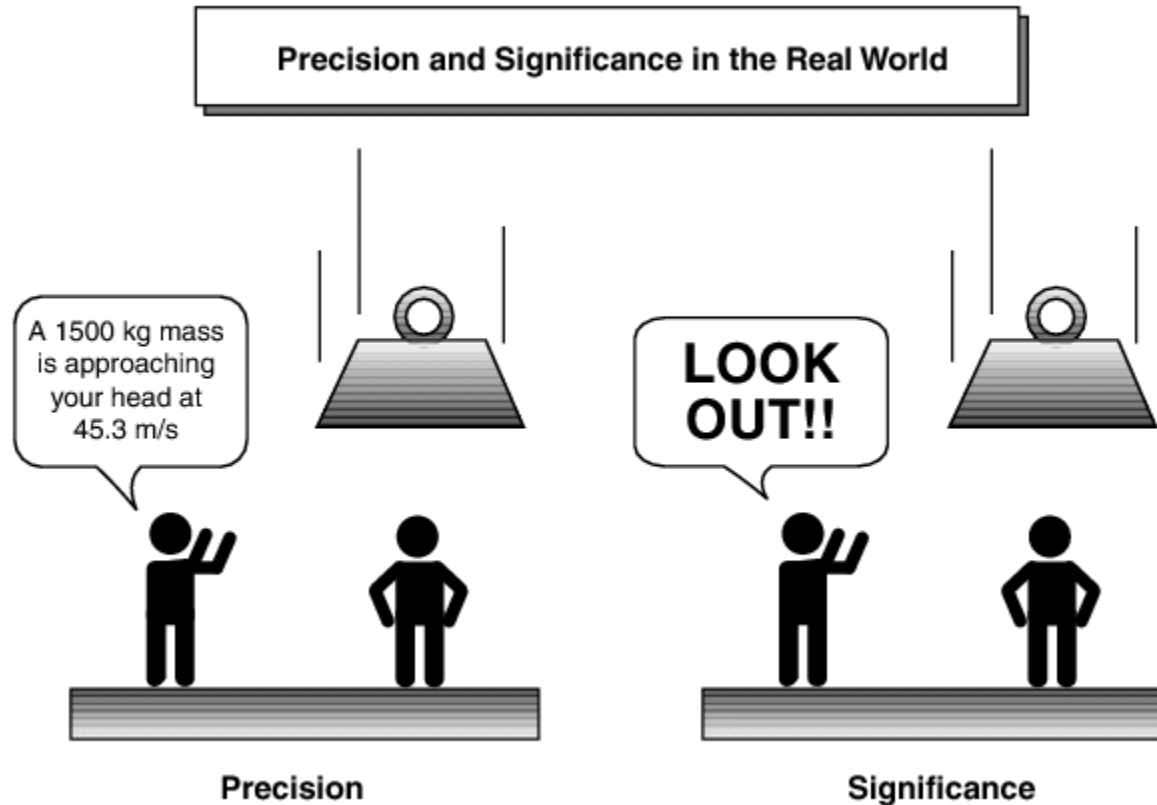
Limitations of the demand for total control

Researchers and educators: a communication issue also

A matter of criteria

KNAW report Quality assessment in designing and constructing disciplines (2011)

- Scientific criteria: publications and designs
- Social criteria: external use, internal use, involvement of stakeholders

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An example

- The Role of Students' Attitudes and Motivation in Second Language Learning in Online Language Courses
- Conclusions: The findings reinforced the importance of students' motivation and attitudes in second language study

- Firstly: that sounds pretty obvious!
- Secondly: does it give me any clues for improvement?

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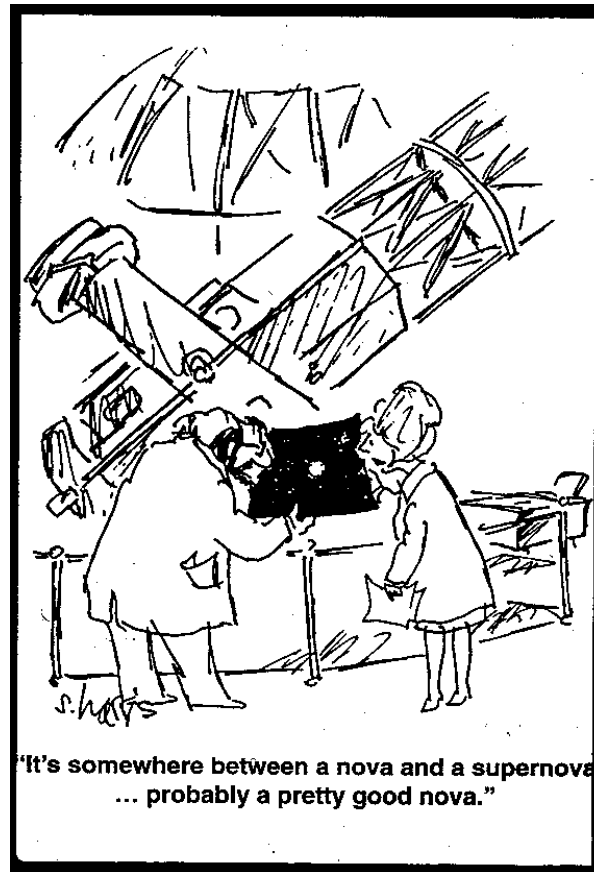# Correlations are interesting, but causality is more practical
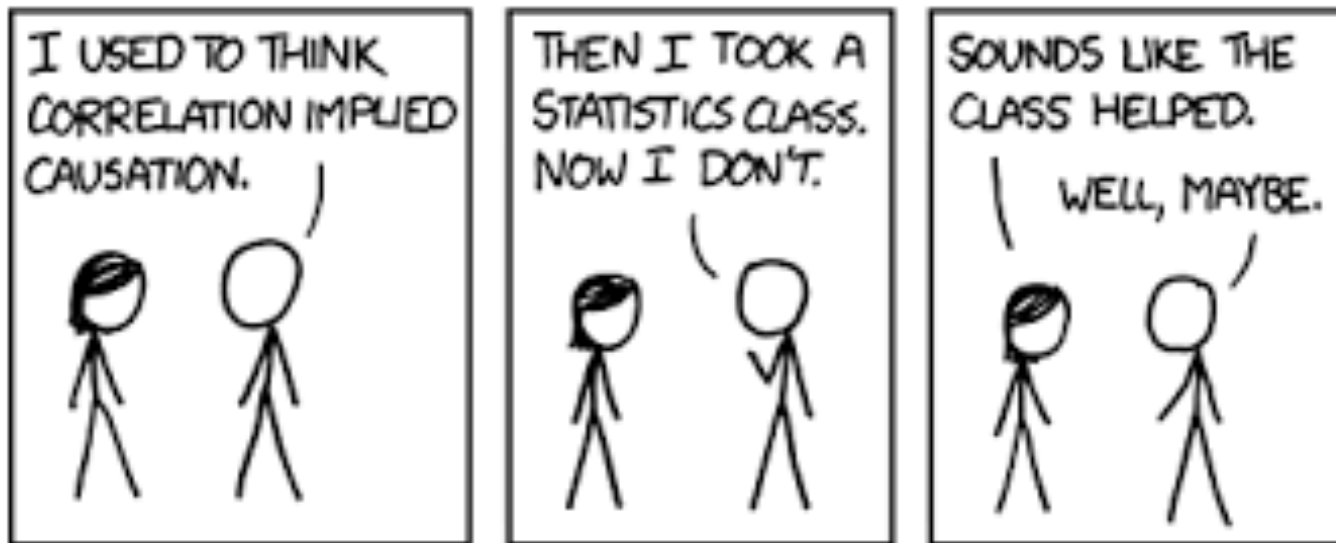
Sectorplan Educational sciences 2014 (committee Rullmann)

- Challenge: increasing the impact of (educational) research by enhancing the relation with practice and policy
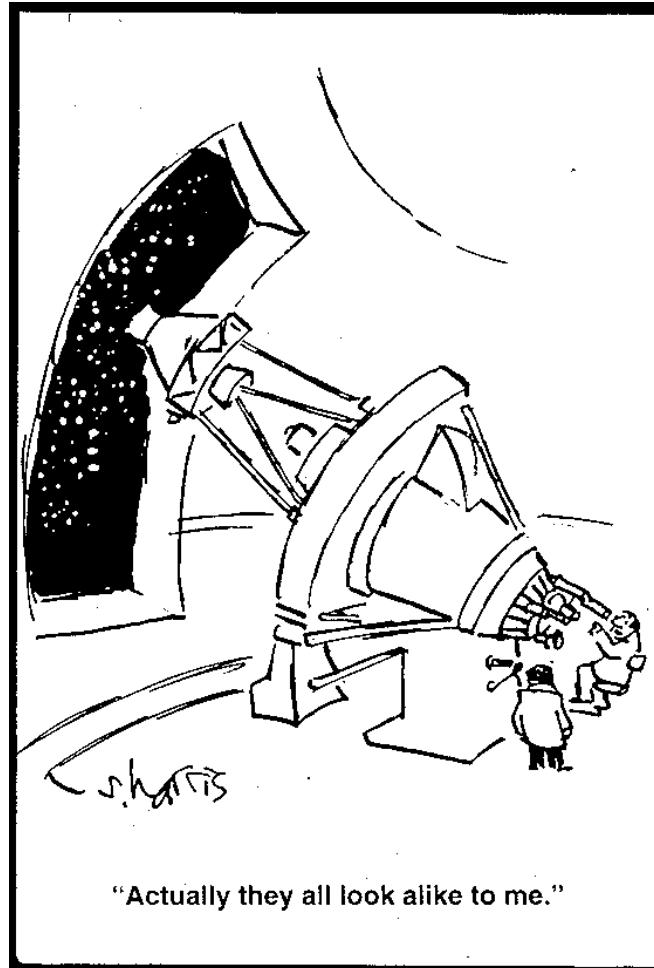
Characteristics of natural sciences

- Purely descriptive, no normativity *in* the content of knowledge
  - Norms do feature in the criteria *for* knowledge of course
- 'Maximum' generalisation, context-independency
- 99% propositional knowledge

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# Normativity in the content of science knowledge . . . hmm

"It's somewhere between a nova and a supernova … probably a pretty good nova."

The danger of over-generalization

"Actually they all look alike to me."

Characteristics of engineering sciences

- Partly descriptive, partly normative
  - Knowledge of functions
  - Knowledge of good practice, rules of thumb
  - Knowledge of standards
- Limited generalisation, context-dependency of knowledge
  - Between strictly nomothetic and strictly ideographic (Windelband/Rickert)
  - Gorowicz/MacIntyre: sciences of the particulars (rather than universals)
  - Not too far away from artefact-in-design
- Propositional and non-propositional knowledge
  - E.g., practical considerations, design instrumentalities (Walther Vincenti: What Engineers Know and How They Know It)

The miracles of technology, not of science

"I think you should be more explicit here in step two."
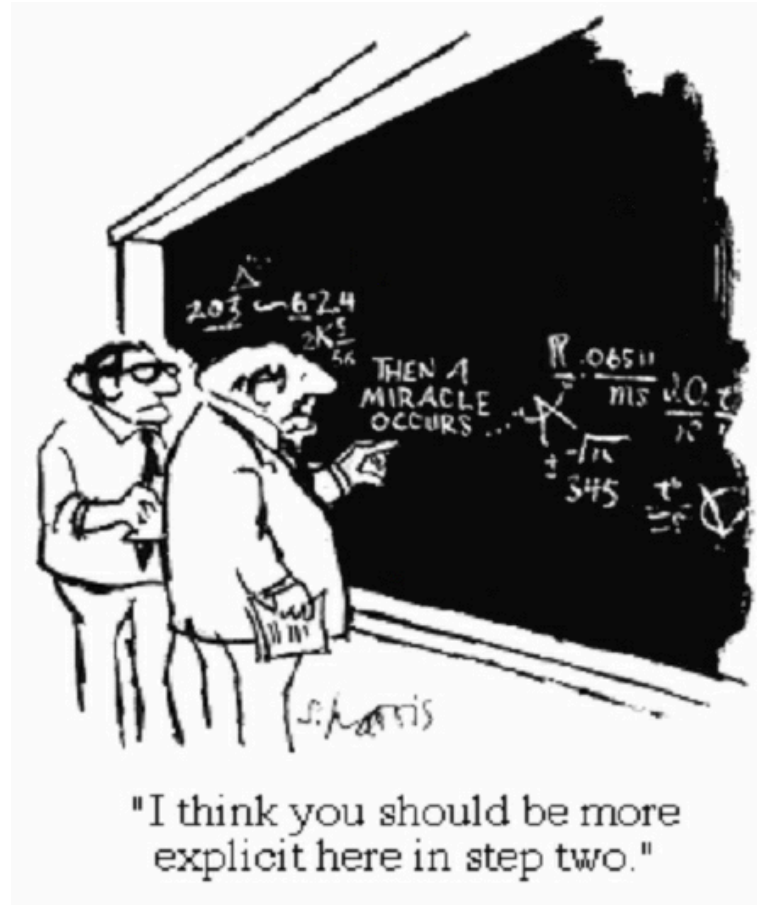
How do engineers do it?

- Put together an artefact, based on experience and the knowledge we have
- Examine its performance
- Fiddle with variables and test for the effect on performance
- Improve the design
- Go through that cycle until time and/or money is up
- Result: better design and some knowledge about the relation between physical and functional properties
- In the long run: generalize

# Design-based research: the engineering approach

- Real situation, not laboratory-like
  - Full complexity with as a result no complete control over total set of variables
- Dual goal: tested artefact/intervention and knowledge (local, but cumulative)
- Both descriptive (but particularly concerning controllable variables) and normative
- Mixed-methods
- Not only cause-effect (theoretical) reasoning but also means-ends (practical) reasoning
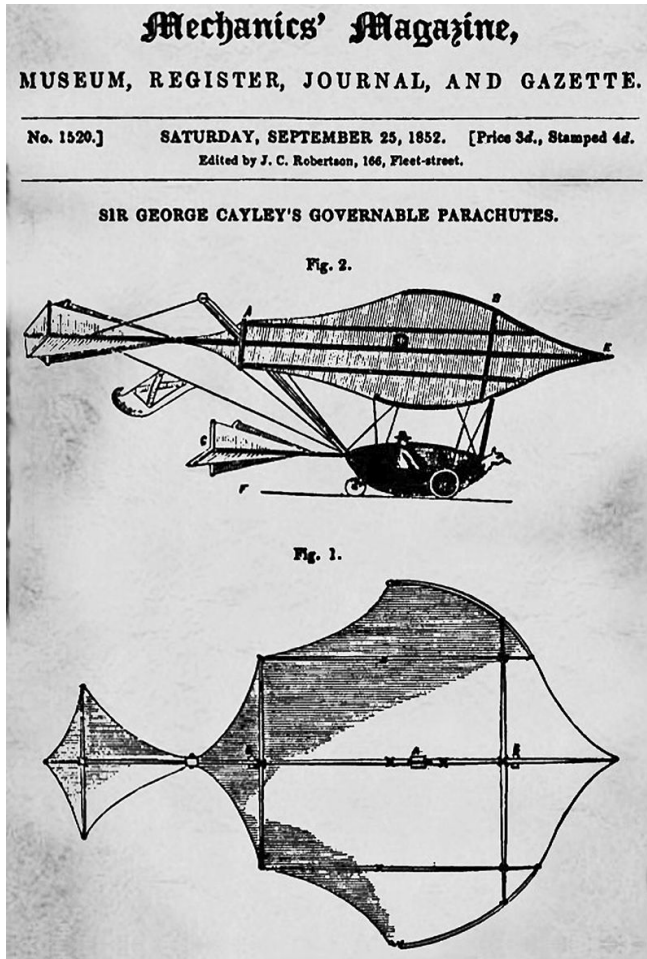
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First give it a shot
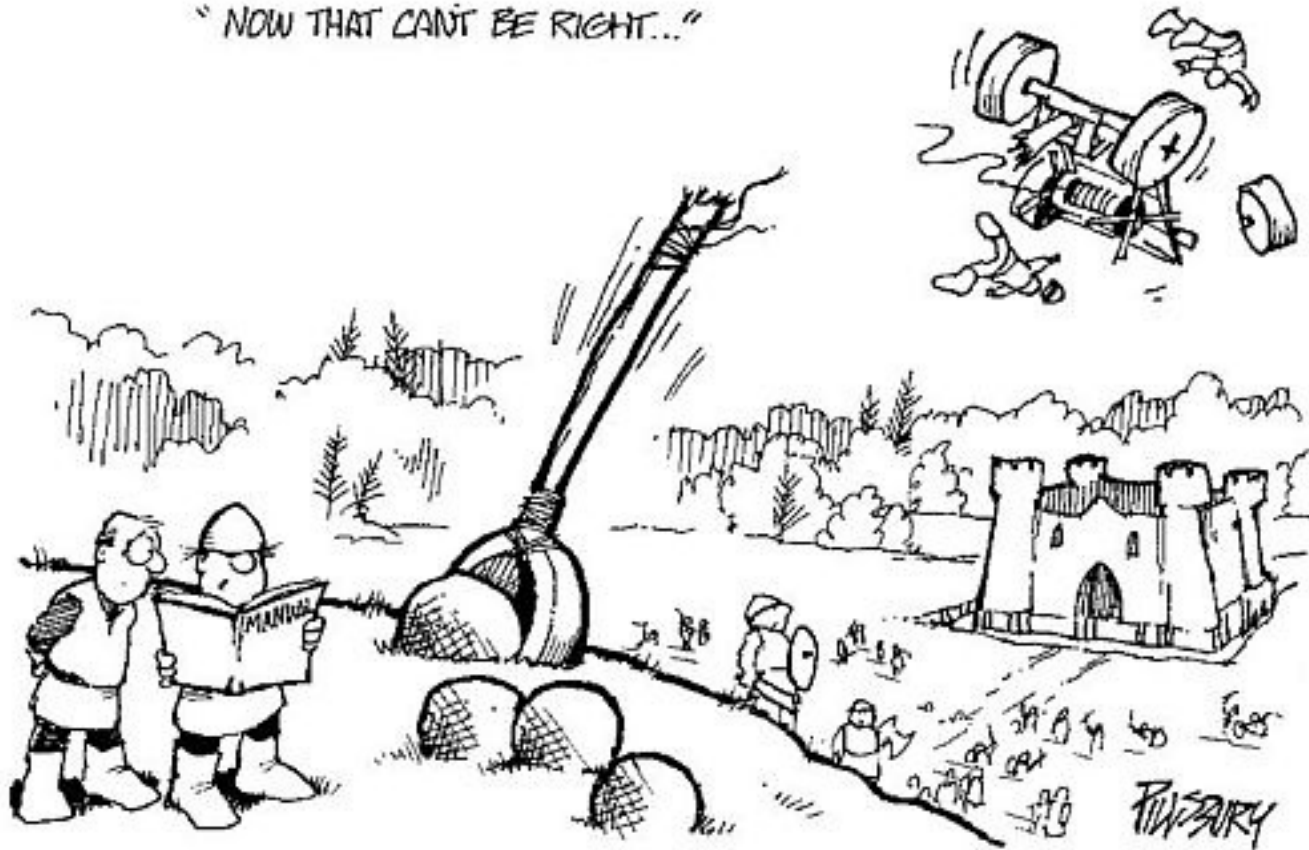
# Then make changes and investigate the effects
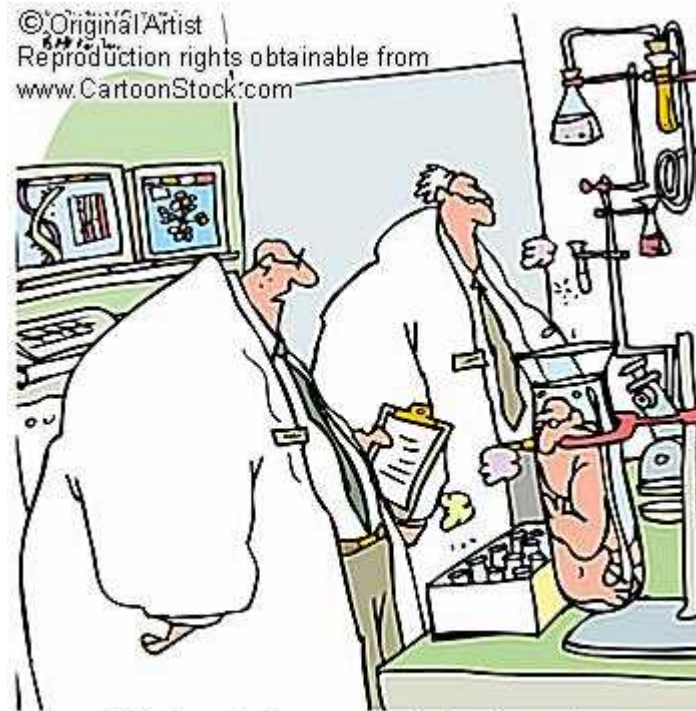
Example: aerodynamics

How about educational science?

- Descriptive research remains valuable
  - Source of inspiration for interventions
  - Helps find the underlying mechanisms for relations between intervention characteristics and performance of intervention
- Normative research should be seen as not 'un-scientific' or 'less scientific'
  - Allow for more 'messy' research set-ups
  - Allow for more context-specific outcomes
  - This does not mean that all 'tinkering' is acceptable!

O yes, there can be a concern about qualitative studies, but that does not disqualify it all
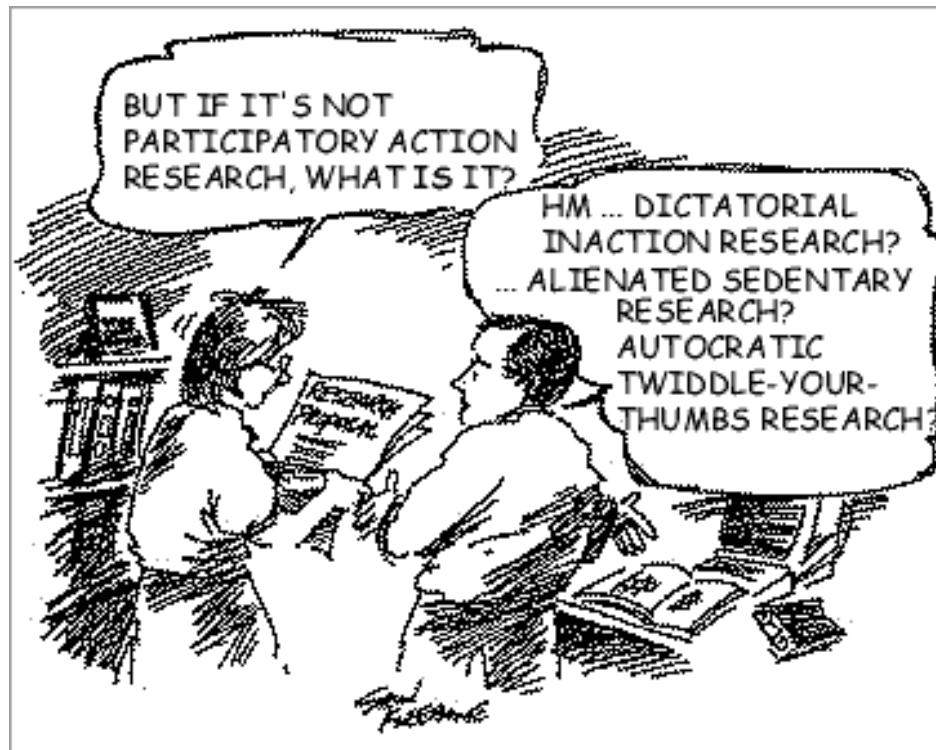
Role of the teacher

- Extreme: the teacher as researcher
  - Issues of independence, possible lack of methodological expertise
- More modest: the teacher as problem owner, participant in decision-making and advisor in publication process
  - Issue of possible lack of common 'language'
- Least challenging: the teacher as the access to respondents
  - The 'traditional' situation
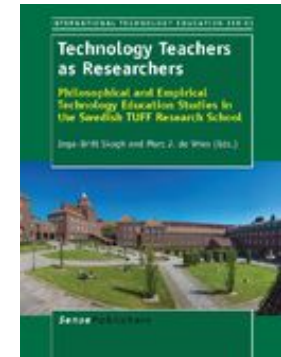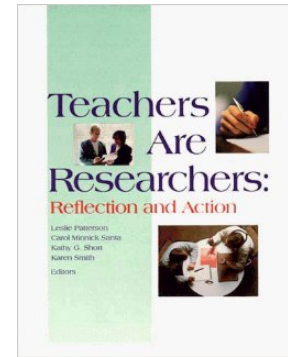
Where do we stand today?
20 posters observed

1 purely descriptive

19 normative (efficienvy, effectiveness, 'good practice', accuracy, etc

3 fully design-based

9 with explicit link to theoretical theory

10 with no explicit link to educational theory

9 with explicit teacher involvement
   (7 teacher as researcher)

11 with unclear teacher involvement

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Closing remark

- It would be good if the 3TU CEE would include in its program
- more design-based studies
- that bring together researchers and researchers
- in an effort to entangle the development and improvement of engineering education and research
- in which the effect of changes in these interventions on the performance of these interventions is studied

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That was it. I hope it was clear.