ED13A-0607

How the world gains understanding of a planet: earth-scientific communication and education

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River and delta morphodynamics

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1. Problem definition

• Public and scientists don't seem to understand each other;
• Outraged or confounded reactions of laypeople to natural disaster shows that their understanding is limited;

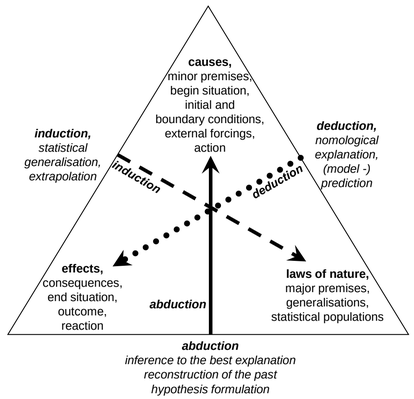
→ How can the earth-scientific understanding of the public be improved?

2. Approach

• Distinguish pragmatic and scientific explanation
• Define criteria for scientific understanding
• Determine how earth-scientists gain understanding
• Assess different learning processes
• Review science communication and education

3.1 Earth-scientific explanation

• Earth scientists study the structure, the phenomena and processes, and the history of the Earth (*Kleinhans et al, 2005*).
- Induction, deduction, and abduction
- Causal explanation
- Reconstruction of the past



Three types of explanation based on causes, effects and laws, two of which are necessary to arrive at the third. Several alternative terms encountered in literature are given. Problems of induction are well known. Abduction is fallible in practice due to various sorts of weak underdetermination. Deduction, particularly in the form of computer modelling, is also strongly hampered by underdetermination problems.

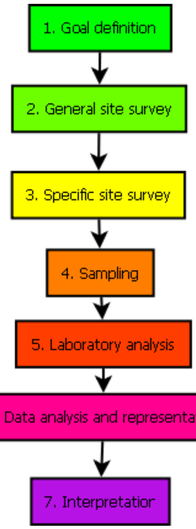
3.2 Understanding by scientists

• Criterion for *Understanding of Phenomena* (De Regt and Dieks, 2005):
"A phenomenon P can be understood if a theory T of P exists that is *intelligible* and meets the usual logical, methodological and empirical requirements."

• Criterion for the *Intelligibility of Theories* (De Regt and Dieks, 2005):
"A scientific Theory T is intelligible for scientists (in context C) if they can *recognize qualitatively characteristic consequences* of T without performing exact calculations."

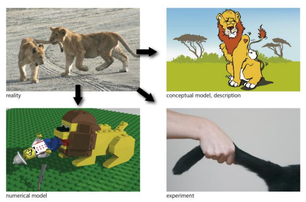
3.3 How to reach understanding? The geo-toolbox

1. Goal definition
2. General site survey
   - *Geo-tool 1: Maps*
   - *Geo-tool 2: Images*
   - *Geo-tool 3: Symbols*
   - *Geo-tool 4: Diagrams*
   - *Geo-tool 5: Remote sensing*
3. Specific site survey
   - *Geo-tool 6: Analogies*
   - *Geo-tool 7: Simulations*
4. Sampling
   - *Geo-tool 8: Sketches*
   - *Geo-tool 9: Cross-sections*
   - *Geo-tool 10: Categorization*
   - *Geo-tool 11: Classification*
   - *Geo-tool 12: Fieldwork*
5. Laboratory analysis
   - *Geo-tool 13: Experiments*
6. Data analysis and representation
   - *Geo-tool 14: Modelling*
7. Interpretation and conclusions

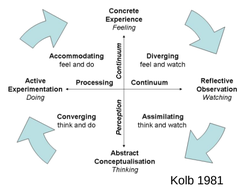


Integrating theoretical and embodied understanding

• gained through fieldwork, experimentation, model building
• leads to recognition of qualitatively characteristic consequences of a theory → intelligibility → understanding



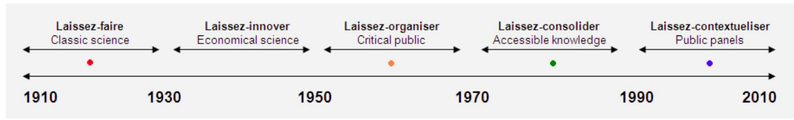
Three geoscientific ways to interrogate reality. "to twist the lion's tail" and observe what would happen – Lord Bacon's view on doing experimental science – is not commonly possible with large watersheds or the weather system because it is dangerous. Instead, we twist tails of down-scaled representatives of lions: cats (bottom right), which may lead to scale problems. Thirdly, modelling based on established laws (bottom left) is limited in general representativeness of nature by the choices of laws, parameters, numerics and initial and boundary conditions.

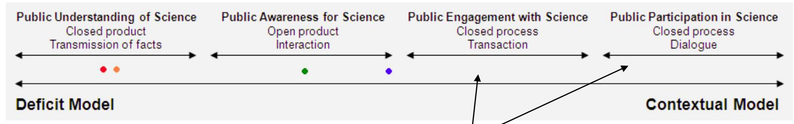


Kolb 1981

3.4 Communication

•Classical science museums
•Traditional science museums
•Modern museums
•Science Centers





here lies the challenge

4. Synthesis: How convey understanding to laypeople?

• Provide context
• have laypeople gain their own understanding by using the geo-toolbox

• Understanding by laypeople:
- Deep approach
- Procedural understanding
- Motivated by questions from laypeople's frame of reference → participation in public projects (e.g. river renaturalisation)

Conclusions

Earth-scientific understanding
- o is *not* earth-scientific explanation
- o is gained by individual earth-scientist, by *using* geo-toolbox (combining theoretical and embodied understanding)

Communication
- o is pragmatic explanation
- o developed from one-directional to dialogue
- o involves frame of reference (context) of receiver (laypeople)

Public understanding
- o is also gained through geo-tools