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The Enculturation to Technoscience

Analysis of Novices' and Experts' Views of Modelling and Learning Modelling Practices in Nanophysics

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Nanophysics as Technoscience

Epistemological Viewpoint to Technoscience (Tala 2009):

Physics is constructed through technological action which means creation and manipulation for control.

- Technology not only limits, but also modifies and defines the physical knowledge and physical reality accessible to us.
- Technology has an epistemological and cognitive role in concept formation of physic, to the extent that it influences our ontological positions.

Tala, S. 2009: *Science & Education 18 (3-4)*

Especially, in the interdisciplinary nanoresearch, there is no any other entry to nanoworld than through learning to control technoscientific models.

Research Frame: A Phenomenological Case Study

- How are the ideas of technoscience related to the views of practicing scientists or actual scientific practices?

  → How do these views become addressed in the enculturation to the field?

- The informants: the Finnish material physicists studying nanophenomena by realistic simulations; six experts and five PhD students (=novices).

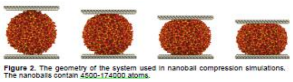


Figure 2. The geometry of the system used in nanoball compression simulations. The nanoballs contain 4500–174000 atoms.

- Multidimensional method: questionnaire & the publications informants select and on those semi-structured interview.

  → Qualitative content analysis.

Objectives of Realistic Modeling

We "do application-motivated basic research." (an expert = E)

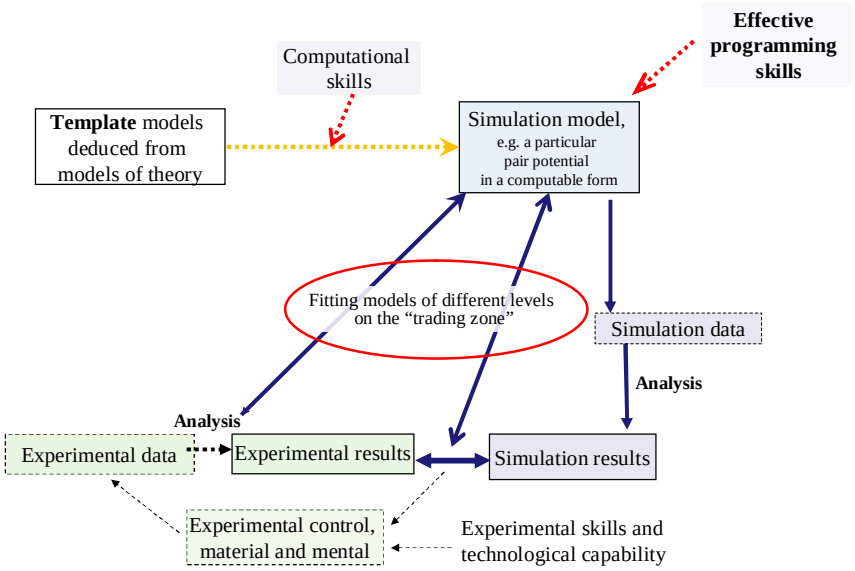
"Basically, what my experimental colleagues give me - is for an example - could you please explain why it [experimental result] is like that. Not simply to explain, but sometimes [to give] a proof why this [result] can be used as an effective rule for the construction of the materials." (E)

"I am looking for such an intuitively clear model, which includes the central processes and not so much others." (a novice = N)

Then, "everyone follows that model." (E)

However in fact, "a model doesn't care about the actual conditions or claim that it explains them. The only important property of a model is its functionality." (N, E)

Experts' View of the Construction and Justification



Examples of the Citations about the Process

"The whole molecular dynamics, would not function, if the frequently repeated calculations were not made as simple as possible and quick for computers to calculate."

"One has to coarse grain after coarse graining."

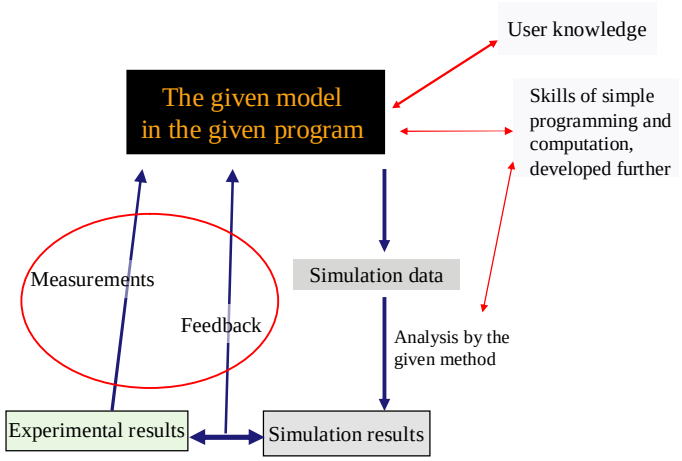
"The physical model fitted in computer, is never the same than the original physical template... It becomes a kind of new theory."

Since "the time and length scales of the dynamic simulations are strictly limited,… the scales of simulated and experimental systems often do not meet."

The usage of general templates easies the transfer of modeling skills: "One of the strengths of our group is just that what we have learned about [modeling] metals can be used directly in explaining a phenomenon connected to carbon nanotubes or vice versa."

"There is no any other way to learn [modeling] than the one going via hands-on working. Sweat, blood and tears –principle."

Novices' View of the Process & "Black-Boxing"



In the beginning, novices learn to use the black-boxes. But computers are always kinds of black-boxes in scientific modeling, also for the developers of the models and programs.

Examples of the Novices' Responses

"I have repeat some measurements carried out by other researchers and reported. If I got the results of the same kind as the others, I would know I have used the program in a right way." (a beginner)

"The question how the model is derived, is not an easy one and I can not answer it. You should not ask me, but from [the developers of the model]... I only use it."

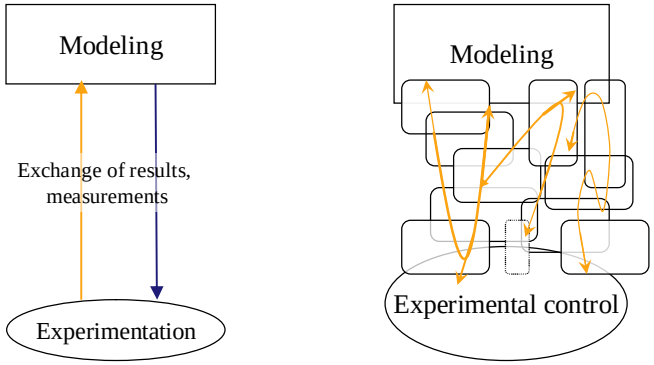
"All the brainwork, on which the code bases, has been performed before... Thus, one not need to think, what happens in it."

"The harmonic oscillator is used nearly everywhere in physics...Interactions in these simulations become modeled by harmonic potential." So, "these models are naturally quite simple, and thus do not represent a system very well."

The most advanced novice: "I develop a potential model for gold-thiol systems."

Relating the Modeling to Experimental Reality

Novices' view → Enculturation → **Experts' view**



Expertise means perceiving the process as iterative and interactive, guided by shared intention for scientific and technological control for understanding.

Examples of the Citations about the Trading Zone

Novices

"The bare model becomes fitted with experimentation." (N)

"On the basis of, what I have understood from articles [about the experimental results]." (N)

"The program I use involves [the experimental values needed]." (N)

Experts

"We discuss with experimentalists what can be done and what should be done ." (E)

"What is important in the dialect... is a very simple idealized model... It is not truth in reality, but it... makes understanding of complicated phenomena easier." (E)

"Then, everyone follows that model... Experimentalists start thinking in terms proposed by this." (E)

"However, then it [the process] is iterative." (E)

"We should not forget that we are studying mental projection... It is what we see." (E)

Summarizing Enculturation to Technoscience

Technoscientific view (Tala 2009) becomes supported and contextualized through the views of practitioners of nanoscience.

- The state of experimental technology directs research interest and possible applications select between the projects before launching one.
- Technological capability and tractability figure out the simulation model and modeling results more than truth bringing out an independent and practical role of modeling.
- Skills play central role in the construction and justification and thus expertise is reached only through ”hand-on” participation in the iterative process:
  - ”Apprentice-master system”
- On the more advanced level, a novice is, the more merged he considers the mental and material control over phenomena.
- Learning modeling as technoscience, is a natural viewpoint to the enculturation to material physics and these ideas seem to fit also many other fields of science.

Implications for Education

- Understanding through manipulation and control is a natural approach for a child.
- *Technoscientific* ideas are promoted also by experts of science.

→ Could the science and technology based elements be merged in education also there between the extremes?

→ Since technology essentially defines the nature of science, the view of *technoscience* should be addressed on all levels of education.