Is Scientific Modeling an Indirect Methodology?

This article was inspired by reading papers of Peter Godfrey Smith and Michael Weisberg, especially, P. Godfrey-Smith (2006: The strategy of model-based science, Biology and Philosophy 21(5):725-740) and M. Weisberg (2007: Who is a Modeler? The British Journal for the Philosophy of Science 58(2):207-233).

Both authors promote the idea that modeling is an "indirect way" of theorizing. Modelers are trying to understand "a complex real world system *via* understanding of a simpler, hypothetical system that resembles it in relevant respects" (Godfrey-Smith, p. 726). There is another - "direct way" of theorizing - "seek to directly represent the workings of the real-world system" (p. 730). Weisberg tries to elaborate on specifics of the "direct way" calling it ADR ("abstract direct representation", see p. 210).

My first point is that this distinction unnecessarily complicates the picture. In fact, ADR can be better understood as a form of modeling.

As an example of "working directly with the real-world system", Weisberg considers the way in which Mendeleev produced his Periodic Table of chemical elements. "This scientific activity constitutes theory construction, but not modeling. Mendeleev represented chemical phenomena *directly*, without the mediation of a model. Although his theoretical descriptions of elemental properties and trends were abstract, they were descriptions of properties of the elements themselves." (Weisberg, p. 215). However, Weisberg is ready to accept (p. 215) that the result of Mendeleev's work (the Table) "might be considered as a model".

I would insist that not only the result of Mendeleev's work, but also his *starting point* was not as "direct" as it may seem. Indeed, Mendeleev did not hold in his office the samples of all 63 chemical elements known at the time! Instead, he used theory and data from books and papers, and this theory and data were produced during a long highly non-trivial history. Aristotle could not create a periodic table of the four "elements" of his time! Could the non-trivial chemical theory of Mendeleev's time be considered as a "direct representation of reality" (i.e., as "finally, true"), and not as an attempt of modeling (i.e., in part, as a hypothetical theory)? At least, the notion of atomic weight used by Mendeleev was not completely "true" - it was refined later by the discovery of isotopes.

Mendeleev may have believed in the partly hypothetical chemical theory of his time as a "direct representation of reality". Perhaps, he did not try to guess in advance, which parts of it were true, and which were not. This is why he did not *feel* himself as a modeler. But, definitely, he was working within a model constructed by the previous generations of chemists! (By the way, who could be the first person in history *feeling* himself as a modeler? Bolyai, Gauss, Lobachevsky? Or, Plato?)

In a similar way, one can analyze other examples of alleged "direct theorizing" mentioned by Godfrey-Smith and Weisberg: Buss' work in evolutionary theory and Darwin's theory of atoll formation. And conclude that, in fact, "direct theorizing" is *undeliberate modeling*, believing that the model (theory) one is working in, is "finally, true".

Perhaps, some objections against the above argument will be raised by referring to some subtleties discussed in the literature: the *model - theory* relationship, and the *model - representation* distinction.

In computer science, we do not regard these subtleties as important. We are used to a simpler picture: there are *models*, and there are *means of building models* (patterns, templates, formal languages, meta-models, ontologies, theories, generic software systems, etc.). For example, one can build a Newtonian model of the Solar system by specifying some initial mass, distance and velocity data of Sun and planets. But one can define also a Newtonian *template* for building models of arbitrary planet systems (a model of an "abstract planet system"). From such a template, by specifying parameters appropriately, one can obtain a particular model of the Solar system. From this point of view, the *theory* of Newtonian mechanics is functioning as a set of *methods* for building models (and model templates) of mechanical systems.

The Newtonian theory allows several different formulations (i.e. representations) that are provably equivalent (traditional, Lagrangian, Hamiltonian). Does this mean that there is some "Newtonian mechanics" that exists independently of these formulations? You may think so, but why do you need to? How do you intend to use such a "theory without formulations"? This is why the *model - representation* dictinction might not be taken too seriously. What really counts, are equivalence proofs of different representations.

And now, the main point. It seems, Godfrey-Smith and Weisberg consider models as almost isolated structures that are invented or picked up without serious coordination from one case to another. They do not analyze sequences of models, systems of models, model evolution. I think, this is how they could arrive at their general conclusion about the inherent indirectness of modeling.

However, let us consider the cognitive opposite of ADR - a situation when some successful theoretical construct cannot be observed even in principle - such as, for example, quarks. Do quarks "really exist", or are they only an "indirect" entity introduced by physicists? For the current purposes, this construct works fine, but will this situation continue in the future? If not, quarks will be removed from the picture like as flogiston and aether were removed. But what if quarks will be retained as a construct in *all* future physical theories? Do physicists need more than this kind of *invariance* to claim the "real existence" of quarks and believe in having a "direct representation" of them?

Thus, if we consider modeling not as a heap of contingent structures, but (where possible) as evolving coordinated systems of models, then we can reasonably explain as "direct representations" even some very complicated model-based cognitive situations. Scientific modeling is not as indirect as it may seem. "Direct theorizing" comes later, as the result of a successful model evolution.

Karlis Podnieks
Computer Science, University of Latvia