The Meaning of Modelling and Modelling with Meaning

(supersedes the previous 'draft')

OED (1933) First (of 15 main meanings) given as 'representation of structure';

Oxford Concise (9th ed.): model … 2. (of 8):

'a simplified (often mathematical) description of a system etc., to assist calculations and predictions'

For example, 1667, John Milton *Paradise Lost* Book 8:

> ……
> Hereafter, when they come to model Heav'n
> And calculate the Starrs, how they will wield
> The mightie frame, how build, unbuild, contrive
> To save appearances, how gird the Sphear
> With Centric and Eccentric scribl'd ore,
> Cycle and Epicycle, Orb in Orb:
> …….
> …….

The phrase here 'save [the] appearances' is of ancient origin and remains important in the philosophy of science. It appears likely that Ptolemy, among many others, had no intention of suggesting that the planets 'really' move on cycles and epicycles – only that such geometric devices accurately predicted their movements.

There is a vast range of sources of (often very different) material, and views, on modelling. For example:

(i) a 'standard' philosophical story (e.g. Max Black, Mary Hesse) of 1960's;
(ii) a business story (e.g. Pidd, Robinson);
(iii) an engineering story (e.g. Hargreaves, Bissell & Dillon);
(iv) a mathematical story (typically for non-mathematical subjects, e.g. Beare)
(v) a traditional logical story (e.g. Tarski, Kemeny, standard logic textbooks)
(vi) a modern logic story (e.g. Huth & Ryan)
(vii) a modern philosophical story (e.g. Elizabeth Lloyd);
(viii) a modern scientific story (e.g. Morgan & Morrison)
(ix) a computational science story (e.g. Humphreys)
(x) a cognitive science story (e.g. Gardner, Crane)
(xi) a phenomenological story (e.g. James, Gendlin)
(xii) an Empirical Modelling story (e.g. Beynon, Russ & McCarty)

Black (as below, Ch.13) gives a brief but detailed summary of five types of model: scale, analogue, mathematical, theoretical and a very general notion of what he calls 'archetypes'. The major emphasis is on 'theoretical models' in science. The great value of his work lies in the succinct exposition of a very diverse field and the strong links identified with his own analysis of metaphor.

Both Black and Hesse recount a controversy over the role of theoretical models beginning in early 20C in which Duhem attacked the use of models as 'a prop for feeble minds', they were not built he says, 'for the satisfying of reason, but for the pleasure of the imagination'. In fact Duhem regards the predilection for models as characteristic of the 'visualizing, imaginative, incoherent mind typical of the English'. Indeed, Lord Kelvin (William Thomson) had famously said, 'I never satisfy myself until I can make a mechanical model of a thing. If I can make a mechanical model, I understand it. As long as I cannot make a mechanical model all the way through I cannot understand…' (reference below p.270).

Both Braithwaite and Black maintain that models do, at least sometimes, 'play a distinctive and irreplaceable part in scientific investigation'.

The controversy continues today as it is closely connected with the 'realist' versus 'instrumentalist' debate. That is the debate over whether a model, or a theory, describes how the world 'really' is, or whether it merely acts as an instrument for prediction of phenomena, i.e. merely indicates that the world works 'as if' the model was a faithful representation.

In so far as EM models are sometimes, at least, analogue models they can serve the mechanical role that Kelvin favoured and offer genuine insights through construction and use (e.g. the planimeter model).

Note that at first sight Black seems to omit mention of two kinds of model that are especially important in Empirical Modelling: personal models made 'in our heads', and computer models. (It is characteristic of EM that these two kinds of model – normally distinctly sequential – are developed together, the computer thereby being used for personal expression.) There is in fact at least a passing reference to both. The experiential modelling materials of EM – namely observables, dependencies, agency – are candidates for what Black calls 'archetypes' and Pepper calls 'categories': fundamental means of describing a new realm by analogical extension. And under 'analogue models' he explicitly mentions the 'use of electrical circuits in computers' (p. 222). It was characteristic for Black that analogue models involve a 'change of medium' but preserve the (abstract) structure of the original. It would be hard for any computer user in 1962 to experience anything but abstract (symbolic) structure, but technologies have allowed us to appreciate, and take advantage of, structural similarity at the interactional, visual and aural levels as well.

It seems to me fruitful to think of EM models as analogue models in which there are many levels of similarity. The similarities themselves are on a spectrum of those that are easily shared and widely agreed (e.g. Newton's law in the cruise control model), those that are easily shared but only a hypothesis (e.g. the mechanism for ant navigation by landmarks in Keer's model), those that are personal views with very limited behaviour (e.g. various restaurant models). Of course there is typically a range of similarities displayed within a particular model, It is interesting, and unusual but supportive of the EM perspective, that Lloyd highlights the insight of Wartofsky that the human modeller plays a crucial role in the establishment of the similarities constitutive of a model: she writes, 'Fundamentally, to be a model is to serve in a triadic relation: a *person* takes *something* as a model of *something else*…'. Notice that there is no suggestion in Black that his kinds of model are exclusive. Indeed he

suggests that mathematical models are themselves a kind of analogue model in which the modelling medium is abstract.

It may be useful to group the above (rather random) collection of 'stories' as follows.

The Concept of a model
Only (i) and (vii) purport to explain the concept of model and classify some of the different kinds. Note (vii) is only three pages.

Practical modelling
The stories in (ii) – (iv) are typical samples from a huge literature and widespread practice. Here models, often standardized as part of a 'library', are used to aid decisions or solve problems. They are clearly 'goal-oriented', practical and often a vital part of the normal working of a business or enterprise. (Cf. From front page of Guardian 25/11/06: 'Scientists are trying to use computer models, based on analysis of Mr Litvinenko's urine, and the apparent damage to his organs over the last three weeks, to work out when he may have been poisoned.') In the context of this module it may be more helpful to think of such models as 'programmed models' (rather than computer models). The Bissell and Dillon paper is excellent on engineers' use of models for 'conversation and stories' and how their way of thinking contrasts with that of mathematicians.

Scientific and theoretical modelling
The important story of (viii) is perhaps only found in the Morgan & Morrison source – especially its Chapters 1 and 2 where the idea of models as lying 'in between' theories and the world, but partially independent of both, a position that allows them to function as 'mediating instruments' for us to explore and learn about both theories and world. This tool, or instrument, role for scientific models leads the authors to put forward models as a technology in their own right.
The story (ix) is put forward by Humphreys where 'computational science' is – he claims - a 'new kind of scientific method' adding to the traditional experiment and theory through the use of computational models and computer simulations. See his elaborate definition of computational model at p.102 of the reference below.

Models in logic
Models in logic (v) and (vi) are rather different from others. They are part of the formal semantics for a given formal language. A theory is a set of sentences in the given language and a model is a structure with a mapping (an interpretation) between the language and the structure such that all sentences of the theory hold true in that structure. The model itself is treated as a formal object. Typically attention was given in the first place to the theory because of its significance in the world (e.g. parts of geometry, arithmetic).

Human modelling
The story of (x) in cognitive science is relevant but largely theoretical. More practical (xi) are the 'philosophers of life' (e.g. William James) and psychologists and artists who have emphasised experience. This is a huge diffuse area, not generally called 'modelling', but includes thinking in general, imagination, creativity, and the making of sense. It includes the 'conceptualisation' of a domain (Fetzer's term) that is necessary prior to the development of use-cases, requirements and specification of

software. It also includes the ‘identification’ process referred to in the *Rethinking Programmin*g paper (Beynon, Boyatt, Russ) and the mental processes necessary to develop an LSD account of a domain of interest. Note that this heading refers to the modelling that humans in fact do themselves, not to the extensive interest of AI and ‘computationalism’ in using computers to model the things that humans do (including, presumably, the modelling that they do).

So much for the meaning of modelling. Now to consider the way that humans, in the course of their own ‘mental’ modelling do that modelling with meanings.

Black’s book ‘Models and Metaphors’ is subtitled ‘Studies in Language and Philosophy’. It contains an important chapter (3) on metaphor including his own ‘interaction view’ of how metaphor operates. He suggests, lightly, in Ch.13 that the use of models is ‘similar to’ the sustained and systematic use of metaphor. ‘A memorable metaphor …[uses] language directly appropriate to the one [domain] as a lens for seeing the other; … Metaphorical thought is a distinctive mode of achieving insight, not to be construed as an ornamental substitute for plain thought’.

Metaphor primarily refers to a use of language. It is far more pervasive than commonly thought (to be convinced of this peruse the early chapters, and chapters 16, 17 of Lackoff & Johnson). This suggests that meanings have a kind of life of their own in blending and interacting within the minds of individuals and in complex ways through communication. The Jamesian phrase ‘one experience knows another’ obviously applies to metaphor but importantly suggests application beyond (or before) language, for example, in the realm of images or icons. This is happening when we correlate in our mind the experience of a display, and our interaction with it, (e.g. the railway animation) with experience of, and interaction with, ‘real’ railways.

It is this power of metaphor and, by extension, of modelling, to bring two realms of meanings into fruitful interaction that is fundamental to the idea of ‘modelling with meaning’. Human modelling may be hard to distinguish from simply ‘thinking’ in the sense of developing our ideas about some topic or domain, a disciplined use of the imagination, raising and resolving questions, making distinctions, making sense through all means possible. This theme is best taken in conjunction with the ‘human computing’ lecture (cf the first Licklider quote there). Note here the ‘cognitive layering’ approach adopted in some EM models (OXO, racingGardner etc) in which each layer corresponds to new meanings being introduced in the model.

It is a commonplace to say that putting thoughts into writing helps to clarify our thoughts. Even more so is it the case with modelling - putting our ‘imaginings’ into a construction helps to clarify the meanings. In the case of ‘programmed modelling’ it is necessary to have the meanings clear in advance of construction. In the sort of ‘modelling with meaning’ that EM allows and encourages, the computing environment becomes an environment for the human to clarify meanings and, in the same continuous construction, to compose and create models with those meanings.

Selected Bibliography * = *'core' material*

Most of these items are easily available in the Library or from the Web.

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