Philosophy of Science

Idealization and Scientific Models: Reducing the Information Content

In the last two decades it has become commonplace that idealization is an important aspect of scientific practice. Largely due to the work of Mcmullin (1985), Suppe (1989), Nowak (1980), Cartwright (1983) and others, we have come to realize that idealizations enter in a variety of different ways in the formulation of scientific laws and scientific theories, in the construction of scientific models, in thought experiments, and in experimental design. Idealization in scientific models, in particular, has received the most attention largely because idealizing assumptions enter in the construction of models, the latter are constructed in order to represent physical systems, thus questions about idealization are linked to questions about scientific representation, and hence an analysis of idealization as it enters in scientific modelling affects the ways questions of epistemological nature could be addressed. Most philosophers would agree that 'idealization', 'model' and 'representation' are strongly coupled notions. In order to make sense of scientific representation we must address questions about the nature of scientific models, and in order to illuminate the notion of model we must address the character of idealization.

In this paper I focus on the character of idealization, particularly regarding its use in scientific models. More specifically, I try to analyze the ways idealization enters in scientific modeling from the perspective of the reasoning process involved. Much can be said about scientific models in order to shed light on the notion. The various kinds of models that are encountered in scientific practice, as well as the different ways by which scientific models are constructed and the wide variety of their functions has been the subject of inquiry of a growing number of philosophers in the last three decades. Although there is no agreement among philosophers neither regarding the function of models nor regarding the nature of their relation to their target systems, there is no dispute about the fact that models present simplified descriptions of their targets. Simplification in modelling is not, of course, confined to idealization. Scientists also simplify by the use of approximations, by the use of ideal limit case scenarios and possibly by other means. I shall not concern myself with the latter kinds of simplifications herein.

I argue that the core feature of the reasoning process behind scientific modelling is the systematic omission of information, which leads to reduction of information content in models. By relying on an analysis of the reasoning process as omission of information regarding the characteristics of target systems, three general ways by which information content is reduced are distinguished: idealization by undelimitation, by isolation and by decomposition. These three kinds of idealizations are explained and an attempt is made to demonstrate their usefulness in making sense of a variety of characteristics exhibited by models.

Undelimitation involves the omission of natural bounds on the possible values of parameters that correspond to characteristics of the target system that are retained in the model description. For example, in the classical simple harmonic oscillator the size of the bob and the amplitude of oscillation of the bob are parameters whose actual lower bound values have been omitted. The information lost in such cases is about particular characteristics of parameters that are retained in the model description. The bob, that is, is present in the model and its size has magnitude. However, by omitting the information that there is a natural limit to how small it can be in the actual world we are able to construct a description in which it is considered to be infinitesimally small; because this kind of simplification does not violate certain theoretical principles and leads to tractable equations. Generally, undelimitation leads to theoretical assertions that would hold for states of affairs in which the values of parameters have been allowed to be stretched beyond their natural limits.

The second way by which information content is reduced, isolation, is by the omission of characteristics of factors that are influential to the behavior of the system. This kind of reduction of information amounts to omitting relevant characteristics of influencing factors or entirely omitting the presence of the latter from the model description. In the example of the simple harmonic oscillator we entirely omit the influence of factors such as buoyancy, rotational motion, stretching, motion of the support, and the damping of the medium. Idealization by isolation, just like undelimitation, leads to assertions about states of affairs that do not seem to obtain in the actual world because we have never encountered such systems in nature, and not because theory precludes the possibility that such systems obtain. I choose to call the result of this kind of idealization *isolation* (Maki 1992), because it is a description of states of affairs that ostensibly hold for a system that would be screened-off from influencing factors.

The above two kinds of idealization have been analyzed from various perspectives by a number of philosophers. Some blend the two into their notion of idealization, and others refer to the first as idealization and to the second as abstraction. The dubbing of the notions is not however an issue of concern in this paper. More importantly, for my purposes, I wish to highlight the difference between the first two kinds of idealization from the third kind. The third way by which information content is reduced in scientific models, idealization by decomposition, has not received much attention in the literature. Decomposition (which is most common in Quantum Mechanical modeling) consists in setting apart various clusters of influencing factors. The result of decomposing-idealization, is a description that involves distinct clusters of factors thought to be acting in tandem to produce the particular behavior of the system. Idealization as decomposition is the result of setting apart, within our model description, clusters of factors that we assume to influence the behavior of the target system. What is omitted in decomposition is the information that the behavior of the system is the result of a convoluted complex natural mechanism.