# 邁向技術取向的方法論和科學哲學

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## 摘要

過去數十年來，諸如 Hacking 和 Giere 等哲學家在討論科學哲學時，已不再專注於科學理論本身，而是從實驗操控和建造模型等方面來進行論述。就催生實作和技術取向的科學哲學而言，不管是 Hacking 的實驗主義或是 Giere 的模型論都貢獻良多。本文要論證的是，科學哲學和工程技術學科的方法論兩者之間其實可以彼此借鏡而相互受益。此外，不同的方法論進路也有必要整合成一個更普遍的詮釋架構理論，而實作-理解-認知乃是被詮釋和觀點所形塑而成的。

**關鍵詞：**

工程技術學科的方法論，實作取向的科學哲學，詮釋架構理論，理解

# Towards a Technologistic Methodology and Philosophy of Science


## Abstract

For the past several decades, philosophers of science such as Hacking and Giere, instead of focusing attention on scientific theories and seeing them as just linguistic entities, have been thinking about philosophy of science from the standpoint of experimental manipulation and model-construction. Both Hacking's experimentalism and Giere's modelism have played a great part in giving birth to an action-oriented and technology-shaped philosophy of science. In this paper, it is argued that philosophy of science can benefit from the technological approach and correlatively, the methodology of general technology might profit from taking into consideration the refinements and novel developments of philosophy of science. It is argued, besides, not only that different methodological approaches have to be integrated into a rather general theory of scheme-interpretation, but also that action-"grasping"-knowledge is shaped by interpretations and by perspectives.

**Keywords:**

Methodology of technology, action-oriented philosophy of science, theory of scheme-interpretation, grasping

# Towards a Technologistic Methodology and Philosophy of Science

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Regarding the topic "philosophy of science and technology" there are of course debates and contributions for more than 30 years regarding the different approaches in the philosophy of science (cf. Lenk - Moser, Eds. 1973). The main question was whether or not the traditional philosophy of science applies also to technology and engineering disciplines, whether or not engineering science would exist as an autonomous discipline to be separated from natural science and whether or not engineering disciplines have to be embedded in social science and systems-theoretical perspectives or even in an extra theory of technology and technological action. The necessity of multi-disciplinary mutual influences was already stressed in the mentioned discussion regarding the philosophy of science of engineering disciplines (ibid.).

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In this paper, however, I am not going to deal with philosophy of science of technology and engineering science proper, but I would like to address other important aspects of the mentioned mutual influence or even interaction between both philosophy of science and technology which to my mind will play a much greater role in the future. The idea is that philosophy of science in general might profit from technology-oriented methodologies and the respective interactions and action perspectives mentioned in connection with an action-oriented reorientation of the concept of knowledge and what can be called "grasping" in a wider sense (cf. my 2003, in press). I think that the concept of "grasping" implies several components, namely on the one hand the activistic element that knowledge would not just be mirroring real things and structures, but does on the other hand figure as a genuine constructive activity. Therefore, grasping is not only to be interpreted in the literal sense as "gripping something" ("some thing"), but also in the figurative sense as "understanding", "knowing" and "getting inside". Knowledge in this sense is a kind of activity or even interactivity in between certain partial systems and it also does rely on agents, be they even, amongst others, "software agents". This does not apply only to knowledge in the traditional sense, but all the more and to a fast growing extent even to scientific knowledge and to gaining such knowledge.

In the last decades there has been quite an interesting new accent in the philosophy of technology and philosophy of science amounting to the so-called school of "New Experimentalism" as initiated by Gooding, Pickering and others. This approach aims to develop a variant of philosophy and history of science dealing mainly with the development of instruments and experiments as well as the respective technologies and potentialities opened up by the progress and development of ever-improving measuring instruments and procedures etc. In particular, I think of the approaches by Ian Hacking (1983) and Ronald Giere (1988). Those authors have convincingly shown, that scientific work and progress is not just the claim of theories (as, e. g., analytic philosophy of a traditional provenance would have it), but would essentially also rely on the development of experimental techniques and development of instruments as well as on the "embedding" of these instruments in the respective scientific and experimental contexts.

Primarily one could think of Hacking's idea, that theoretical entities which are postulated or hypostatized to begin with are in a certain sense set only by instruments, experimental appliances and measuring devices, etc. into a quasi "direct" experimental relation to reality. (Think of the atoms at the time of Ernst Mach, later on of electrons and even much later of the W-boson or the top-quark as instances of postulated theoretical entities which could only much later be experimentally "discovered" or "confirmed" by sophisticated experimental arrangements.) Let me illustrate Hacking's thesis by using the example of electrons: By using electron rays and electrons in our experimental and measuring instruments to a large scale in order to solve other problems, e. g. to prove the existence of the

Z-boson or the top-quark or whatever, it is clear that this technological "embedding" into the respective apparatus in the context of experiment leads to the hypostatization of electrons as "*real*"; they so to speak change their status from being just theoretical entities to becoming real "instruments", i. e. technologically effective real entities.

Ronald Giere developed this idea in the form of a sort of theory and philosophy of science of models and their role in science. In science not theories are primarily at stake, but models: "Look for the models" (he writes without of course thinking of fashion shows and the respective models there!). Giere (1988, 85f) understands a theory as a set of models connected by different hypotheses with one another and with important types of real systems and the world. Important is the relation of similarity between the models and the identified real systems and again model-bound representations of these. "There is ... no direct relationship between sets of statements in the real world. The relationship is indirect through the intermediary of a theoretical model." (ibid., 82) – and by technological instruments and experimental arrangements. "A real system is *identified* as being similar to one of the models" (ibid., 86). According to Giere (ibid., 106) "the notion of *similarity* between models and real systems provides the much needed resource for understanding approximation in science" and "it is technology that provides the connection between our evolved sensory capacities and the world of science" (ibid., 138) for: "Scientists' knowledge of the technology use and experimentation is far more reliable than their knowledge of the subject matter in their experiments" (ibid., 139).

This is even true for theoretical entities like electrons, protons, elementary particles etc. To quote Giere again with an example (ibid., 140):

"The proton was once among the most theoretical of particles. Scientists had real questions about the reality of any such thing. Now the proton has been tamed and harnessed to the equipment used to investigate other particles and structures: Quarks, gluons, and the shell model of the nucleus. Thus some of what we learn today becomes embodied in the research tools of tomorrow." Thus, "at least some background knowledge is better thought of as *embodied knowledge* (than as traditional *propositional knowledge*, H. L.). It is embodied in the technology used in performing experiments".

Giere talks of a "*naturalistic constructive realism*" as "a *restricted* form of realism in the sense that theoretical hypotheses are interpreted as asserting a similarity between a real system and some, but not necessarily all, aspects of a model" (ibid., 97, 94).

Theories are but "a set" or "a family" of models or "still better, a family of families of models" (ibid. 80) which indirectly by fitting and connecting the models with the respective system of the real world (by instrumental and technological means) (ibid., 85) is connected with reality. Theories in such a sense are not any more linguistic entities or just frameworks of formulae, but heterogeneous sets of in part abstract constructs (the theoretical models) and in part hypotheses (formulated of course in ordinary language) about the fitting of these models and their similarity to reality depending on degrees and perspectives. Again: "A real system is *identified* as being similar to one of the models. The *interpretation* of terms used to define the models does not appear in the picture; neither do the defining linguistic entities, such as equations" (ibid., 86). (To note, there seem to be projective model applications involved.) "When approaching a theory, look first for the models and then for the hypotheses employing those models. Don't look for general principles, axioms, or the like" (ibid., 89). In contradistinction to Nancy Cartwright's thesis in *How the Laws of Physics Lie* (1983) according to Giere "the general laws of physics, such as Newton's laws of motion and the Schroedinger equation, cannot tell lies about the world because they are not really statements about the world. They are ... part of the characterization of theoretical models, which in turn may represent various real systems. But (they are) only part of the characterization" (ibid., 90).

In connecting theoretical models and the real systems to be grasped or met now technology plays a decisive role. Like Hacking's also Giere's constructive realism sees in the applied techniques dealing with formerly just theoretical entities (e. g. protons or electrons) a proof of their reality and an instigation to develop and capture new models. If we routinely use electron rays (cathode rays and beams) in an electron-microscope successfully in order to solve other scientific tasks and problems the formerly theoretical entities as the postulated electrons in this technological set-up are now scientific-technological *real* entities. If electrons and protons are by now completely manipulated and controlled in technological measuring instruments even in big science experimental set-ups in order to prove the existence of other elementary particles and structures like gluons, quarks etc. then these electrons and protons are indeed "*real*" (Hacking 1983). "Again, thus, some of what we learn today comes embodied in the research tools of tomorrow" (Giere 1988, 140).

Giere thinks that scientists are more or less successful constructive realists who essentially by using technological instruments intervene into reality and despite all just theoretical constructions disseminating in the scientific community arrive at an experimentalist-realist interpretation of models in the sense of relative (not necessarily "optimum") satisficing (after H. A. Simon). We would not maximize the fit of models but *optimize* it (in a relative sense) in order to get at a satisfying result for experimental and the degrees of fit of the models to be used. Scientists are according to Giere "satisficers" or "optimizers", but no absolute "maximizers" regarding the degree of similarity of the models with reality. In fact, basically it may even be several models which fit in a certain sense; one need and could not talk of *the* unique optimum theory alone, but we have to deal with a certain kind of fit or fitting – i. e. "satificing" – of the models of which perhaps several ones might fit equally and relatively well to fulfill the required function of explanation, prediction etc.

After having called such a model-oriented indirect realism a sort of "constructive realism" as mentioned, Giere had later on changed this label because of the danger of confounding his constructivism with the so-called constructivism or even the "strong constructivism" in psychology, social science and the so-called "radical constructivist" approach. He rejected the name "constructivism" without eliminating the role and whole idea of construction and reconstructing or constructing in connection with the building and establishing of models. In his new book *Science Without Laws* (1999) he talks instead about a "*perspectival realism*" (1999, 79f, 105, 240f).

The main features of this kind of realistic perspectivalism is: "First, there is no total or universal perspective, or, alternatively, there is no perspective from nowhere or from everywhere at once. All perspectives are partial relative to the objects. Second, each perspective is a perspective of the building. There is something real that each perspective is a perspective of. So perspectivalism is *prima facie* a form of realism, not relativism or constructivism" (ibid., 80). This is not only true for radical perspectives, but "the existence of scientific instrumentation provides a further extension of the metaphor:

"Radio telescopes, for example, may be said to provide us with a perspective from which we view the heavens. It is a different perspective from that provided by more ordinary optical telescopes. Without this technology the kinds of outputs provided by such instruments would not exist. Yet radio telescopes do provide us with information about aspects of the universe that may not be accessible in other ways. Similar comments apply to the infrared detectors aboard the Hubble Telescope..." (ibid., 80).

Instead of just talking of models Giere now involves an analogy ("not too great an analogical leap") of going "from maps to the kind of models one finds in many sciences": "The fit between a model and the world may be thought of like the fit between a map and the region it represents" (ibid., 82).

Thus, perspectival realism Giere thinks "is a later development of constructive realism. The constructive element remains as before": "The categories we use are to some extent constructed by us. Nevertheless, scientists can sometimes legitimately claim similarity between their logical constructs and aspects of reality ... our theories do not ever capture the totality of reality, but provide us only with perspectives on limited aspects of reality. Scientific knowledge is not absolute, but perspectival" (ibid., 150). Nevertheless:

"The result is a kind of realism regarding the application of models to the real world, but it is a realism that is perspectival rather than objective or metaphysical. The sorts of general principles operative in some sciences provide a perspective within which particular models may be constructed. When, through observation or experimentation, these particular models are judged to be well-fitting, we are justifiably confident that the world itself exhibits a structure similar to that of our models. Realism need not require that we be in possession of a perfect model that exactly mirrors the structure of the world in all respects and to a perfect degree of accuracy" (ibid. 241).

The decisive difference between constructive realism of the earlier stage and perspectival realism is that different model perspectives are now possible at the same time even for perception and interpretation of science and formulae etc. An analogous insight is also relevant and valid for theories insofar as different approaches from different perspectives may allow and lead to different answers without denying that an external reality with 'structures of its own' lies behind.[1]

With all of this, we are at the point of reaching an approach which I had developed since three decades by now, namely a realism of what I call methodological interpretationist provenance or methodological scheme-interpretationism. In short we may say: We conceive of the world as being real, hypostatize it, for practical and theoretical reasons, as real: The world is real, but any grasping of it or of parts of it or entities in it is always impregnated by or bound to interpretational perspectives, i. e. is interpretational, interpretatory, or interpretative, schematized, theory-bound or "theory-impregnated", "theory-laden" or what have you as rather common descriptions of the shaping role of theories or perspectives in the building of scientific insights and knowledge. Any "grasping" (in the double sense mentioned) whatsoever is to be understood from a scheme-interpretationist approach and is beyond that to a large extent

[1] The talk of structures in reality might be a little bit misleading: We should rather say that reality has a certain kind of constitutedness which we can more or less successfully describe by our perspectival model concepts and concepts of structures etc.

also shaped and structured by actions, action-forms, or presuppositions. This is the main idea.

I think it is very important for a philosophy of science to stress this. The same certainly is true for Giere's experimentalism and modelism in philosophy of science.

However, Giere's provocative title "Science Without Laws" seems to lead too far insofar as it insinuates a disjunctive "either ... or" instead of a more reasonable "both ... and". We indeed do not only use and need models instead of theories and laws, but *both* theories *and* models. It is certainly right to stress that models and experimental models are very important in science. (This is also emphasized in the so-called structuralism in philosophy of science à la Sneed and Stegmüller.) But in any case as important is the insight, that we need knowledge and action as well as experimentation and that we know that knowledge or gaining knowledge is a sort of action, at times an higher-level activity, namely e. g. indeed exactly the acting with models, preparations or experimental arrangements (think of quantum theory and the measurement problem in it): To be sure, we need constructions, we know that all our "graspings" are structured, schematized, to a large extent "constructive" indeed, but it is equally true that knowledge and insights in experimental science are not but constructions and interpretations or interactivities at will just fitting to arbitrary models whatsoever, but as Giere rightly stresses the models and their fit are *not* relativistic or arbitrary. Indeed, they are bound to strict and stringent requirements of experimentation, objectivity, repeatability, etc., according to the traditional rules and norms of "good" scientific practice. This is the element of realism in the otherwise rather perspectival and constructivist model-making and theory-building activity of the scientist or group of scientists frequently described by using a certain Kuhnian "*paradigm*". As I stressed time and again, e. g. also in my *Introduction to Theory of Knowledge* with the subtitle "Interpretation, Interaction, and Intervention" (1998) gaining knowledge, constructing, acting and intervening as well as interpreting go necessarily together. Instead of misleadingly just introducing and highlighting models and falling victim to some kind of dichotomizing strategies, philosophy of science has to take seriously the insights that we need models and laws *as well as* theories. It is then certainly an interesting problem to analyze and discuss how these analytic differentiations hang together with the real world or the respective evidences or resistances or make-ups ("preparations") in the situation of experiments. I think indeed that the idea raised by quantum mechanics that the initial preparation is of very much import, may even be or feature as *the* rather *general case*, i. e., there usually is a certain kind of interplay generally not to be neglected between questioning, preparing experiments and relevant perspectives in order to deal with experimental reactions from a perspectival approach (see my 2003, in press).

Generally speaking the approaches by Hacking and Giere are not only explicitly action-oriented, but they are in a certain narrower sense a technology-shaped philosophy of science, notably affected by (the existence and development of) measuring instruments and measuring technology. These however are the vehicles of the respective interactions and interventions into nature and reality as such. Insofar we can even talk about a *technologistic* or *technology-oriented philosophy of science* in that sense. Technology (technological instruments, measurement appliances, technological approaches and models as well as technical procedures, processes and artifacts) would shape the scientific possibilities of knowledge and gaining knowledge in a decisive degree. This is not only true in the narrower sense, as the above mentioned New Experimentalism in philosophy and sociology of science would say, but in a far more general and larger sense as entertained by methodological scheme-interpretationism and also (although still narrowly restricted in scope) by Giere's modelism and Hacking's technological realism. In the future, certainly such interactions between approaches of a rather technologistic and action-theoretic provenance with philosophy of science analyses will reach center stage in philosophy of science debates. Thus, the indivisible connections between knowledge (gaining knowledge), experimenting and action-orientation will lead the way (as I emphasized in my 1998). Insofar Giere's approach regarding the connection between scientific models and real systems by the vehicle of technology, technological manipulation and intermediary instances like measuring instruments and machines has to be extended by the action-theoretic interpretation. This would even be interesting for construction engineers and design theorists as well as the design of software models and respective computer simulations of theories in addition to or instead of the full-fledged analytic theory in the traditional style. With regard to the traditional approaches of philosophy of science it is true, that usually the propositional approach wrongly interpreted theories and hypotheses as well as models as just linguistic entities. In a similar vein the pure axiomatic or even the so-called structuralist approach suffered from too formalist a meaning understanding theories and their structures exclusively as mathematical structures. It is true that the philosophy of science and sociology of science of the so-called New Experimentalism like the pragmatic-technology-oriented direction of the approaches by Hacking and Giere as well as the action-theoretic interpretation is a route to avoid such one-sided exaggerations or even dichotomizations rendering the refined relational interpretation of the interplay between cognitive models, intended models of theories, technological realizations and action- or operation-theoretical sequences of operations and experiments. In such a way the theoretician may relate his or her methodology or meta-methodological conceptions of operative principles of the conceptualization of theories, concepts and hypotheses rendering them rather independent of absolute truth claims in order to rely on relativized concepts as, e. g., the degree of fitting, functional requirements or optimizing (notably satisficing) plurifunctional conditions which are typical for designs, plannings, constructions of all kinds. With this, certainly a normative component is taken into account, thus rendering a normative part or element within the make-up of the rules and principles of philosophy of science. As such a pragmatic philosophy of science can learn much from technological and action-theoretic approaches, likewise also the methodology of engineering disciplines or even what might be called a "general technology" may gain much methodological stature by considering the refinements and novel developments of philosophy of science under the auspices of general methodologies including theories of action. In addition, these methodological approaches have still to be integrated into a rather general theory and methodology of scheme-interpretation (the author's 1993, 1995, 1998, 2002) covering also the "grasping" of real systems from a methodologically and epistemologically determined perspective or set of perspectives, employing teleo-functional requirements, theoretical approaches and practical action-routines as well as social conventions and institutional rules and at times specific institutionalizations. A new "unity" of the sciences and technologies might well evolve and cover the access to the world by action and action-orientation by applying theoretical and interpretive as well as experimental models. This approach will excel on a meta-theoretic level characterized not only by general methodological requirements of any active "graspings" of external or mental entities, but also by certain "ideal" structures, constructions, etc. Action, "grasping" and knowledge as well as the designing and normative shaping of world versions is in that sense shaped by interpretations, ways of "graspings" and by perspectives – in short, by action-oriented and perspectival preparations. (Again the analogy to the preparation problem in quantum theory regarding its measurement problem springs to mind.)

Theories, generally speaking: methodical and methodological concepts as well as normative structurings of actions and procedures are guided by interpretations and schematizations. The methodological scheme-interpretationism as developed by the present author (since 1991) is indeed a higher-level methodological and epistemological conception covering from a methodological point of a meta-theoretical provenance the special cases of scientific theories, technological developments and designs, procedures of structuring in everyday knowledge and perception as well as all kinds of action-forming and mental representation. Interpretations are always constructions – as any knowledge whatsoever. Theories are interpretative constructs claiming, as substantive theories (after Bunge 1967, vol. II), validity or even truth – that is to say approximative truth, or verisimilitude, or, as operative theories, methodical or methodological validity. Norms and values are also interpretational constructs, standardized by social or cultural conventions, traditions or, largely, by language.

It was Henry Ward Beecher who ironically called a theory but "the skin of truth, propped and stuffed". However, theories are more than that: They are complex interpretational constructs consisting of many subordinate schemata or schemes and interpretations, embedded in procedures, actions, and techniques and constructive models, selective world representations and methodological models as well as meanings in the form of mental entities or ideal constructs etc. – far beyond just the requirement and role of truth orientation. Philosophy of science is permanently changing and much more now than ever. It grows much more practice-oriented and experimentalist by now. In the future it will necessarily have to be even more strongly action- and interaction-oriented on the one hand and technology-bound on the other. The cooperation between philosophers of science and philosophers of technology as well as philosophers of action theories should and will, I think, set the stage for future developments in philosophy of science proper.

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