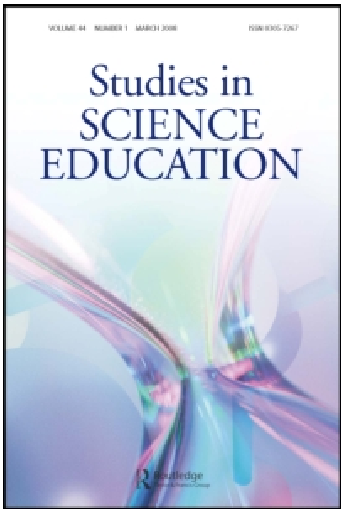


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# Critical appraisal of physical science as a human enterprise: dynamics of scientific progress

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# BOOK REVIEW

**Critical appraisal of physical science as a human enterprise: dynamics of scientific progress**, by Mansoor Niaz, Milton Keynes, Springer, 2009, 215 pp., £72 (hardback), ISBN 978-1-4020-9625-9

*Critical appraisal of physical science as a human enterprise: dynamics of scientific progress* by Mansoor Niaz is one of the recent books from the Science and Technology Education Library (Dana Zeidler, series editor). This 14-chapter book devotes 10 chapters to historical episodes of scientific discovery and theory development in the physical sciences. Topics and scientists include: kinetic theory/Maxwell; periodic table/Mendeleev to Mosley; atomic theory/Thompson, Rutherford, and Bohr; electrical charge/Millikan and Ehrenhaft; photoelectric effect/Einstein and Millikan; eclipse experiments/Einstein and Eddington; covalent bond/Lewis; quantum mechanics/Bohr to Bohm; wave-particle duality/DeBroglie, Einstein, and Schrødinger; and quarks/Peel. The thesis proposed by Professor Niaz, a member of the Epistemology of Science Group in the Department of Chemistry of the Universidad de Oriente, Venezuela, is that the study of the history of science, in general and as it applies to matters of science education, can be coordinated around a set of interpretive components from these episodes of science. These interpretive components and presuppositions he labels heuristic principles. Specifically, it is Niaz's position that heuristic principles can be used to guide the writing of science textbooks and teaching the nature of science (NOS).

In order to fully appreciate the contributions of this volume, one needs to consider how the arguments are placed in the sequence of twentieth-century developments regarding the philosophy of science. Niaz has grounded the monograph strongly in the 'historical turn' of philosophy of science, with frequent references to Thomas Kuhn, Imre Lakatos, Gerald Holton, and Stephen Brush. The strength of this volume for me is Niaz's elaboration of Kuhn's arguments in *Structures* that science education practices and the content of science textbooks have contributed to positivistic or received view images of science. In each of the 10 physical science episode chapters, Niaz includes discussion of the embedded heuristic principles therein and presents textbook content analysis research documenting the omission of these principles from science textbooks. In fact, this monograph has pulled together in one place Niaz's impressive research programme on the analysis of science textbooks. Thus, for students of history and philosophy of science (HPS) and science education, this volume reports on important physical science episodes in the application of HPS to science education.

Chapter 2 sets out the framework for the monograph, with the goal of the monograph being 'to demonstrate that various experiments and episodes in the history of science involved the confrontation between the quantitative imperative and the imperative of presuppositions' (p. 12). Niaz goes on to argue and illustrate with four historical episodes here in Chapter 2 and then in the 10 chapters that the imperative of

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presuppositions, more so than the quantitative imperative, 'played a crucial role in the dynamics of scientific progress' (p. 12). The review of historical episodes is an aspect of the monograph I find intriguing inasmuch as these provide concise narratives about progress in the physical sciences. Comprehension of the episodes requires sophisticated understanding of the complex physics being presented as well as a strong grounding in HPS. Thus, this volume is one more appropriate for scholars and advanced students and less so for beginning students.

By choosing to situate the heuristic principles framework in this one 'historical turn' period of HPS, Niaz has ignored the subsequent and currently embraced 'naturalistic turn' in philosophy of science. If one stops with the 'historical turn' episode of science, then one can, as Niaz does, embrace the idea that 'a certain degree of consensus has been achieved within the science education community and the nature of science can be characterized, among others, by the following aspects (Abd-El-Khalick, 2004; Lederman, 2004; McComus, Almazroa, and Clough, 1998; Niaz, 2008b; and Smith and Scharmann, 1999)' (p. 23). Eleven consensus statements are then listed, for example: different scientists can interpret the same experimental data in more than one way; scientists require accurate record keeping, peer review and replicability; and scientific progress is characterised by competition among rival theories. At the end of each chapter Niaz presents the textbook analysis research results and then discusses which of the 11 NOS heuristics can be addressed or demonstrated in studying this episode. The consequence is that while the interpretive components or heuristic principles of scientific knowledge can be used for documenting the growth of knowledge developments in the physical sciences, the extension in the last section of Chapter 2, and all subsequent chapters in the monograph, to the heuristic principles as frameworks for guiding science teaching about the nature of science is, I feel, problematic.

In very broad brushstrokes, twentieth-century developments in science studies can be divided into three periods. The first, *positivism*, with its emphasis on inductive logic and the hypothetico-deductive method, has been dominant. Second is the *historical turn* of philosophy of science that began with the work of Kuhn, Feyerabend, and Lakatos and third is the *naturalistic turn* with a focus on scientific practices within cognitive and social contexts.

Positivistic views of science held to several assumptions:

(1) There is an epistemologically significant distinction between observation language and theoretical language and that this distinction can be made in terms of syntax or grammar.
(2) Some form of inductive logic would be found that would provide a formal criterion for theory evaluation.
(3) There is an important dichotomy between contexts of discovery and contexts of justification.

In the 1950s and 1960s, various writers questioned these and other fundamental assumptions of logical positivism and argued for the relevance of historical and psychological factors in understanding science. Thomas S. Kuhn is the best known of the figures in this *historical turn* for philosophy of science, but there were numerous others, including Paul Feyerabend, Norwood Russell Hanson, Mary Hesse and Stephen Toulmin. Kuhn introduced the conception of paradigm shifts in the *Structure of scientific revolutions* and then replaced paradigms in the postscript to the 1970 second edition, introducing the concept of a disciplinary matrix. In the disciplinary matrix view of science, theories play a central role but they shared the stage with other elements of science, including social dimensions and commitments to methodology and instruments. The omission of the disciplinary matrix components from the consensus list is one example of the list's shortcomings.

Within the *historical turn* lies Niaz's commitment to scientists' presuppositions, interpretations or theory commitments as a major force in the *Dynamics of scientific progress*. Although Kuhn saw the scientific communities as essential elements in the cognitive functioning of science, his early work did not present a detailed analysis of precisely how the growth of scientific knowledge proceeds. Imre Lakatos and Larry Laudan are two early influential commentators who presented models of growth that sought to preserve the objectivity and rationality of theory development. The concept of heuristic devices used extensively by Niaz, though out the book, derives from Lakatos who described positive and negative heuristics respectively to distinguish episodes of science where scientific knowledge was building (e.g. Quantum Mechanics) from episodes where scientific knowledge was eroding (e.g. Ether Theory). The tone of the volume is decidedly one of a rational reconstruction approach to HPS.

At the same time as philosophy of science was taking the *historical turn*, much of philosophy was engaging in the *naturalistic turn*. The *naturalistic turn* in philosophy of science can be seen as filling in some of the gaps left by Kuhn's demolition of the basic tenets of logical positivism. This movement:

(1) emphasises the role of models and data construction in the scientific practices of theory development,
(2) sees the scientific community as an essential part of the scientific process and
(3) sees the cognitive scientific processes as a distributed system that includes instruments, forms of representation and agreed upon systems for communication and argument.

> 'Most philosophers started to accept as a serious constraint on their theorizing that both human mental processes and human modes of acquiring knowledge are *natural*, happening in accordance with causal laws as do all other events in nature and that philosophical attempts to achieve an *understanding of the nature of these processes should be seen as continuous with scientific inquiry*' (Carruthers, Stich, & Siegal, 2002, p. 3, emphasis added).

The continuous feature between NOS and scientific inquiry proposed by naturalised philosophy of science is embraced by some science educators (cf. edited volumes by Carruthers et al., 2002; and Duschl and Grandy, 2008) but contested by those science educators who embrace the 'degree of consensus' point-of-view for listing aspects of the nature of science and perceive 'doing science' as an obstacle to learning about the nature of science. For them, reviewing episodes and excerpts of history of science is the way to go. Niaz writes:

> A major difficulty in implementing NOS is the expectations that students will come to understand it by 'doing science'. … This is like assuming that students would come to understand photosynthesis just by watching a plant grow. In order to facilitate understanding of NOS, teachers need to go beyond the traditional curriculum and emphasize the difficulties faced by the scientists, and how the interpretation of data is always problematic, leading to controversies among contending groups of researchers. (p. 24)

Of course, Niaz's position hinges on what is meant by 'doing science'. When the 'doing' is engaging in investigations within discrete lesson units not sequenced around core ideas, then highlighting in texts or lessons where and when consensus list heuristic principles apply and align may be the way to go. An alternative being proposed by research in the learning sciences and in sciences studies (Duschl, 2008; Duschl & Grandy, 2008; Duschl, Schweingrube, & Shouse, 2007) is to situate science learning in weeks-long immersion units and months/years-long learning progressions that involve students in the 'difficulties' mentioned above by Niaz: problematising data and evidence, building and refining explanations, engaging in talk and argumentation and participating in modeling and representation. The NRC research review reports *Taking science to school* and the companion practitioner's volume *Ready, set, science!* include numerous research studies that demonstrate the importance of coordinating science education around the plethora of scientific practices that can contribute to learners' proficiency regarding (1) understanding the nature and development of scientific knowledge and (2) participating productively in scientific practices and discourse. These are two of the four 'Strands of Proficiency' around which the NRC reports are organised.

Niaz's heuristic principles could still have some sway in the design of the curriculum, instruction and assessment models that include historical controversies. Niaz himself has successfully used these in an INSET graduate course (i.e. with in-service teachers). The danger of the heuristic principles as defined here and as a goal for the field is to move science education beyond the learning of declarative statements about NOS to the engagement of learners in meaningful participation with the scientific practices involving the critique and communication of scientific ideas and information (Ford, 2008). As Allchin (2003) warns, 'Contrary to recent claims for reform, we do not need more history in science education. Rather we need different types of history that convey the nature of science more effectively' (p. 329).

In summary, the physical science episodes in *Critical appraisal of physical science as a human enterprise* convey but one episode and perspective of NOS, the *historical turn.* Many of the book's episodes focus on 'dense physics' and assume readers have a depth of knowledge about the *historical turn* in philosophy of science. There are frequent redundancies of long text passages, some in the same chapter, in the monograph. Given that the volume has drawn heavily from Niaz's previous journal publications, a more careful editing on the part of author, series editor or Springer would have been appreciated. The last chapter of the monograph presents a helpful overview of the major themes presented throughout. Niaz's monograph is a good source for gaining insights into how history of science influenced philosophy of science.



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