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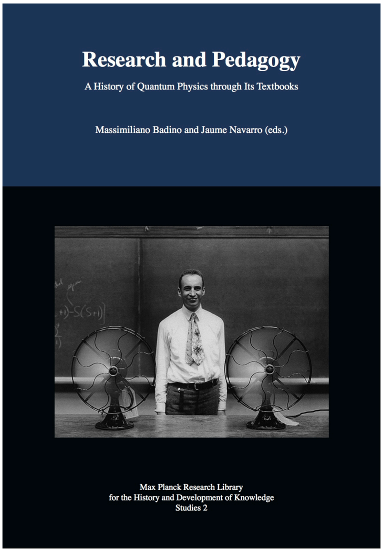
*David Kaiser:*

Epilogue: Textbooks and the Emergence of a Conceptual Trajectory

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# Chapter 12
# Epilogue: Textbooks and the Emergence of a Conceptual Trajectory

*David Kaiser*

Of what use are scientific textbooks? To scientists and their students, textbooks can inspire admiration and nostalgia, but also a sense of limits, of being far from the intellectual frontier. After all, research in the physical sciences long ago ceased to be a bookish affair. For at least a century and a half, the most important developments have been communicated in journal articles and cognate forms such as conference talks and preprints (Frasca-Spada and Jardine 2000; Gross, Harmon, and Reidy 2002). The British scholar and statesman C. P. Snow—who spent much of his career trapped in a superposition, both physicist and novelist—observed in his famous lecture on *The Two Cultures* that "perhaps not many [scientists] would go as far as one hero who, when asked what books he read, replied firmly and confidently: 'Books? I prefer to use my books as tools.'" Snow continued with a flourish: "It was very hard not to let the mind wander—what sort of tool would a book make? Perhaps a hammer? A primitive digging instrument?" (Snow 1959, 14)

At the same time that Snow offered his observation, Thomas Kuhn elevated scientific textbooks to a central position in his analysis of scientific change. He declared, for example, that "The single most striking feature of this education [in the natural sciences] is that, to an extent totally unknown in other creative fields, it is conducted entirely through textbooks." (Kuhn 1977, 228). Yet Kuhn was clearly ambivalent. Scientific textbooks "may be the right place for philosophers to discover the logical structure of finished scientific theories," he explained in a 1961 article, but "they are more likely to mislead than to help the unwary individual who asks about productive methods"—not least, Kuhn insisted, because "science textbooks do not describe the sorts of problems that the professional may be asked to solve." (Kuhn 1977, 180, 229). In the end, Kuhn concluded, textbooks "are the unique repository of the finished achievements of modern physical scientists" (Kuhn 1977, 186): mausoleums for yesterday's achievements, where creative ideas went to die.

Snow's and Kuhn's dour views did little to inspire close historical scrutiny of the ways in which scientific textbooks have been composed, produced, or utilized. In recent years, however, historians of science have rediscovered the textbook, and with good reason. The general incorporation of perspectives from cultural history has encouraged attention beyond the elites of scientific practice and the seemingly placeless march of ideas. The rise of interest in pedagogy and training on the one hand, and in histories of the book and material reading practices on the other, have rightly refocused interest on textbooks' production, circulation, and appropriation. Kuhn's at-once exaggerated and dismissive assessment of the roles of scientific textbooks will no longer suffice.[1]

[1]For recent historiographical reviews, see (Warwick and Kaiser 2005, 393–409; Bensaude-Vincent 2006, 667–670; Olesko 2006, 863–880; Mody and Kaiser 2007, 377–402; Vicedo 2012, 83–87).

If Snow and Kuhn downplayed the usefulness of textbooks to scientists, nowadays few can question these books' value for historians. One usage is to add textbooks to the source-base of materials to be sifted for clues about the chronology of conceptual developments, alongside research articles, unpublished correspondence, notebooks, and oral histories. Chapters in this collection by Clayton Gearhart, Domenico Giulini, Michel Janssen and Charles Midwinter, Helge Kragh, and Don Howard exemplify the richness that scientific textbooks can offer for this kind of study: How did practitioners at the time think about particular ideas, such as Einstein's light-quantum hypothesis or the challenge of quantizing systems with multiple degrees of freedom? How did textbook authors read or cite one development alongside another? As Massimiliano Badino and Jaume Navarro make clear in their introduction, early textbooks on quantum theory are especially valuable for such historical investigations, since the books date from a time of tremendous conceptual uncertainty. Quantum theory as we know it had yet to congeal at the time that many of these books were published. Given the relative length of textbooks as compared to research articles, and the textbook authors' clear intention to impose order on recent, scattershot developments, these textbooks offer detailed documentation of how moments of rapid conceptual change appeared to physicists at the time.

We might liken this historical use of textbooks to physicists' uses of test-bodies when marking out an invisible field. Like pith balls charged with slight static electricity or tiny iron filings sprinkled near a bar magnet, early textbooks on quantum theory might help to delineate a clearer path, enabling historians to chart a conceptual trajectory during times of unusual variation. How did the physics community move from early hints about black-body radiation, specific heats, and the photoelectric effect to a full-blown armory of state vectors, Hilbert spaces, and Hermitian operators? Surely textbooks composed at intermediate steps along the journey are invaluable resources for reconstructing that path.

The pith-ball approach assumes that textbooks reflect underlying conceptual developments, but do not affect them: there existed a genuine conceptual trajectory, and textbooks help to reveal it. Yet many chapters in this collection suggest reasons to reconsider such an assumption. Consider the range of books produced in short order by physicists working at the same university, for example: quite a gulf separates George Birtwistle's *The Quantum Theory of the Atom* (1926) and *The New Quantum Mechanics* (1928) from Paul Dirac's *Principles of Quantum Mechanics* (1930), even though (as we learn from Jaume Navarro's and Helge Kragh's chapters here) all three books emerged from courses taught at Cambridge University, often during the same semester.[2] More generally, if we take seriously the notion that research in quantum theory often unfolded hand-in-hand with teaching for many physicists at the time—as documented so clearly in the chapters by Massimiliano Badino, Michel Janssen and Charles Midwinter, Michel Eckert, Domenico Giulini, Jaume Navarro, and Helge Kragh—then why should we assume that a research-oriented conceptual trajectory existed prior to or independent from all these pedagogical exertions? See also (Warwick 2003; Kaiser 2005; Seth 2010).

In place of the pith-ball analogy—which, after all, hearkens back to the era of classical physics—we might turn to John Wheeler's evocative metaphor for quantum theory, his "Great Smoky Dragon." Wheeler introduced his metaphor to try to capture what it means for quantum particles not to possess sharp trajectories through space and time, such as when

[2] These distinctions are similar to the contrasts drawn by Andrew Warwick in the teaching of special relativity at Cambridge a decade earlier: see (Warwick 2003, chap. 8).

moving through a double-slit apparatus. The tail of the dragon could often be pinned down with accuracy, Wheeler argued; that corresponded to the source that emitted the quantum particles. Likewise the dragon's fiery mouth could usually be found: that was the place, past the screen with two slits, where a detector registered the particle's position. But in between those two spots, nothing definite could be said about the particle's location as it traversed the apparatus—the body of the dragon dissolved into a puffy cloud of smoke.[3]

Much like Wheeler's smoky dragon, what had once been taken to be a relatively clear conceptual trajectory for early quantum theory no longer appears so sharp. Recent scholarship has highlighted the striking heterogeneity—even cacophony—of competing assumptions, approaches, and interpretations during the early years of quantum theory, even among physicists who worked closely together and whose views had earlier been considered synonymous (Beller 1999; Howard 2004, 669–682; Camilleri 2009; Carson 2010). The wide array of textbooks sampled in this volume only reinforces the point. Indeed, we might well wonder whether any coherent conceptual trajectory connected, say, Planck's publications in 1900 with Heisenberg's, Born's, Jordan's, Schrödinger's, or Dirac's papers in the mid-1920s. Did quantum theory itself follow a path as indeterminate as Wheeler's Great Smoky Dragon?

With hindsight, of course, physicists, historians, and philosophers have drawn and redrawn various candidate trajectories for the conceptual history of quantum theory. Indeed for a long time the history of modern physics seemed almost indistinguishable from the history of quantum theory, given the great mass of work published on the topic. Moreover, though significant challenges of interpretation remain open even to this day, the range of approaches and techniques to quantum theory has surely narrowed compared to the turmoil and tumult of the period from 1900 through 1930. Some shadow of a conceptual trajectory appears to have emerged from all the dust and smoke.

We might therefore pose some new questions, inverted from the type that animate pith-ball historiography. Among the wide range of possible (and competing) efforts at the time, through what means did a narrowing of approaches and interpretations occur? What work was required for something approximating a conceptual trajectory to emerge? These last questions suggest yet a third analogy, alongside the pith-ball and smoky dragon: decoherence and the emergence of classical behavior from quantum systems. An influential line of thought among contemporary physicists suggests that classical behavior—such as the possession of a sharp trajectory through space and time—might emerge from quantum objects' interactions with the environment. Repeated scatterings between a quantum particle and the flotsam and jetsam of its surroundings can cause the strange superpositions endemic to quantum theory effectively to get washed out. Even inside the tyrannical box, Schrödinger's cat might well have been all-alive or all-dead the whole time, never caught in a ghostly superposition of both states at once (Zurek 1991, 36–44).

In addition to providing hints of competing approaches or supplying fodder for adjudicating priority claims, scientific textbooks like the ones examined throughout this volume can be used to chart just those interactions with the "environment"—pedagogical, institutional, intellectual—by means of which something approximating a conceptual trajectory emerged. Rather than assume that the textbooks and ancillary pedagogical efforts from the time reflect an underlying trajectory, we might train our attention on the means by which

[3]See, e.g., the interview with John Wheeler in (Davies and Brown 1986, 58–69, on 66–67).

books like these helped to reduce the ever-multiplying possibilities, producing what would later appear to be a recognizable conceptual path. The detailed and revealing chapters in this volume provide an excellent resource with which to pursue just such an investigation. As quantum physicists learned not so long ago, sometimes a little decoherence can be a very useful thing.

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