

Beyond disciplinary frontiers: The value of the history of science in teaching

M. FORTINO(*)

Liceo Classico “Bernardino Telesio” - Cosenza, Italy

received 31 January 2023

Summary. — “The legitimate, safe, fruitful method, capable of preparing a mind to accept a physical hypothesis is the historical one”, argued the French theoretical physicist Pierre Duhem, in *La théorie physique: son objet et sa structure* (1906). Starting from this position of thought, with this contribution we want to broaden our gaze to try to briefly outline an “overall conception” of the history of science, in the light of its possible declinations and its epistemological implications, beyond the disciplinary frontiers, to foster a true education of the mind or, better, to understand, according to the French style, the formative value of a philosophical history of science.

1. – History of science and teaching

This paper is an opportunity to reflect on the value of the history of science for the teaching of Physics at school. In school textbooks the history of science is rather irrelevant. The history of science as a discipline was born in France during the Third Republic, in the season of positivism. In this environment it is not separate from the philosophy of science. As early as the second lesson of the *Cours de philosophie positive*, philosopher Auguste Comte (1798–1857) recognised the importance of knowledge of the history of science (see [1] p. 67). This knowledge has philosophical significance, is very influential in French culture between the 19th and 20th century, and its importance must be recognised even today. Of extreme interest are the insights around the method (*methodos*) of teaching Physics discernible in the *Théorie physique: son objet et sa structure* of Pierre Duhem (1861–1916), a theoretical physicist, historian and refined philosopher of science, and scholar of Thermodynamics. For Duhem “the legitimate, sure, and fruitful method of preparing a student to receive a physical hypothesis is the historical method [...]. It is forbidden to be purely and completely logical in teaching” (see [2] pp. 268, 269). Duhem did not neglect the genesis, cultural context, philosophical reflection on the value of knowledge and, from a logical point of view, the relationship between theory and observation. The critical reflection on the relationship between theory and observation will lead to his holistic thesis. Indeed, he confirms this thesis with the history of science, for instance with Léon Foucault’s experiment concerning the choice between the Newtonian corpuscular hypothesis and Fresnel’s wave hypothesis.

(*) Former teacher of Philosophy and History. E-mail: mirellaafortino@gmail.com

2. – Peculiarities of the historical method

Duhem first points out that in the teaching of physics, unlike in geometry, where demonstrative rigour is didactically essential, it is permissible to make use of abbreviations and efficient syntheses. Here are some peculiarities of the historical method, the importance of which he emphasises.

2'1. *Denial of the history of science as erudition.* – Despite being the author of erudite works, Duhem believes that the history of science in the teaching of physics should not coincide with erudition. What counts much more is the genesis, the conceptualisation, the how of hypotheses and theoretical choices. It is no coincidence that the historical-critical itinerary of the *Système du monde* and the $\Sigma\Omega\text{ZEIN TA } \Phi\text{AINOMENA}$ which winds its way from the Pythagoreans, Greco-Latin science, the Arabs, the Christians and the Jews up to the age of the Renaissance, is never a narrative detached from logical analysis.

2'2. *Interweaving physics and philosophy.* – In the monumental *Système du monde*, the boundary between philosophy and celestial physics is not visible because their interrelation is strong. The Platonic origin of the phenomenalist dogma *to save the phenomena* and Aristotelian philosophy occupy numerous pages. The value of the history of science in educational terms thus takes on a special significance: by investigating the genesis of theoretical hypotheses, the boundaries between scientific and philosophical ideas are broken. Philosophical ideas, aesthetic ideas, influential metaphysics, Thomism, Neo-Platonism, ancient values such as simplicity, for example, and mathematical elegance are motives for choosing and justifying theoretical hypotheses along the path of history. In this regard, it is worth mentioning the ancient philosophical dogma of the circularity and uniformity of celestial motions, which is defended until Kepler's ellipse.

2'3. *From common sense illusions to concepts and critical thinking.* – The history of science makes visible the vicissitudes through which we have moved from common sense and naive thinking to the abstract notions that are the subject of the teaching and learning process in Physics. For Duhem “it is [...] altogether illusory to wish to take the teachings of common sense as the foundation of the hypotheses supporting theoretical physics. By going that way, you do not reach the dynamics of Descartes and Newton, but the dynamics of Aristotle” (see [2] p. 264). The teachings of common sense are not detailed and precise. The laws of common sense, based on the immediate data, are the result of intuition and not analysis. Analysis and relationships between symbols nurture critical thinking and give cognitive value to physical theory.

2'4. *What does common sense have to do with the history of science.* – By following the vicissitudes that introduced the theoretical hypotheses, on the level of understanding the student will see in the abstract formulae the outcome of a long journey of the human spirit, and will avoid a learning made up only of abstract formulae. The history of science is precious: the teacher, by combining the history of a physical principle and the logical analysis of it, makes the student learn to emancipate himself from naive thinking, from bogus analogies. The conceptualisation of notions such as *force*, *energy* and *entropy* (*entropé*, a term coined by Clausius that “has a meaning only in the language of the physicist” (see [2] p. 260)) thanks to the history of science, will not be a leap in the dark.

3. – Truth is revealed by time

There is a privileged place where the boundaries between the history of science and philosophy break down and it is the region of *alètheia* or truth. Tracing the history of science means: identify ideas that will turn out to be false; seeing that several equally plausible theories (theoretical underdetermination), which are the subject of choice and

decisions, may correspond to a given phenomenon; avoid the presumption that theories are definitive. Along the thread of history, scientific reason becomes aware of its own non-absoluteness and the evolutionary power of theories. “To retrace the transformations through which the empirical matter accrued while the theoretical form was first sketched; to describe the long collaboration by means of which common sense and deductive logic analyzed this matter and modelled that form until one was exactly adapted to the other; that is the best way, surely even the only way, to give to those studying physics a correct and clear view of the very complex and living organization of this science” (see [2] pp. 268, 269). This translates into an antidote to dogmatism and scepticism and the formation of an authentic “intellectual culture”. Duhem expressly recognises that “the history of science alone can keep the physicist from the mad ambitions of dogmatism as well as the despair of Pyrrhonian skepticism” (see [2] p. 270). In its becoming also made up of errors and “false evidence”, physical theory offers reasons, for Duhem, to believe that it is not a technique but a natural classification that reveals the ontological order of the world. The search for truth, which is the source of authentic moral values, is not betrayed.

4. – In the French milieu, the history of science as the history of civilization

It is now necessary to highlight the interest, for teaching purposes, of the critical perspective that in the French *milieu*, between the 19th and 20th century, exalts the value of a “general history of science”. In *La théorie de la physique chez les physiciens contemporains* (1907), the philosopher and historian of science Abel Rey (1873–1940), high school teacher and later, from 1919, professor of History of Philosophy in its relationship with science at the Sorbonne, affirmed the irreducibility of the history of science to inventory, to “*histoire enregistrée*”. He asserts the integration of philosophy in its relations with the sciences, conceiving philosophy as the exaltation of a scientific spirit that is at one with the history of civilization. If it is true that the historical genesis of theories gathers a harvest of philosophical ideas as a prerequisite for discoveries, the link between the history of science and philosophy can now be said to be even more tightly knotted: science and philosophy are one and the historian of science is also the true philosopher. It is no coincidence that Gaston Bachelard, the philosopher of science successor to Rey in the chair to Sorbonne and his doctoral student, argued that philosophy is instructed by science in evolution, by ever-renewing thought. This renewal treasures history which is always “history judged” according to values of truth and not simply recorded. For Bachelard, the history of science, marked by epistemological obstacles and ruptures, is a history of rectifications that are never definitive, thanks to which an *evolution of the spirit*, indeed a progress of humanity, takes place. But it is necessary, he says, to integrate scientific culture into general culture. It should not be overlooked that for Rey “there is a direct continuity between science and philosophy, both through the methodological critique that scholars undertake, and through the general hypotheses that are the most valuable instruments, the specific instruments, of its methods” (see [3] p. 7 ⁽¹⁾).

A not insignificant link between science and philosophy is affirmed by Paul Langevin (1872–1946). Langevin was a physicist who supported Relativity in France, while also engaging in historical and philosophical reflection on science. The history of science for Langevin is the history of ideas that, in the dialectical unfolding of a process based on the conflict between thesis and antithesis, leads to superior syntheses that are never definitive. Thus, in teaching, the history of science encourages the development of critical thinking

⁽¹⁾ English translation of the quote is ours.

and avoids the fall into dogmatism. The history “complements and enlightens neighbouring teachings. Its influence on philosophy is undeniable since, to a large extent, this is based on science itself” (see [4] p. 209 ⁽¹⁾). The philosophy was prompted by physics, which between the 19th and 20th century presented itself as an anti-substantialist and relationalist science, examples of which are Relativity, non-Euclidism. In this regard, it is worth emphasizing the interest of philosophical thought in 20th century physics, which does not neglect the problem of time (the *arrow of time*), the irreversible changes, which rational mechanics on the contrary ignored. Let us now recall that Duhem, author of the *Traité d'énergétique ou de thermodynamique générale* (1911), recognizes the great value of qualitative physics, the importance of the Aristotelian notion of movement understood not only as a change of place in space, but, in a broader sense, also as a movement of alteration, generation and corruption. This qualitative physics, which concerns the transformation of material things, is Thermodynamics (see [5] pp. 55–89 and [6]). It is worth noting that philosophy draws strength from research on irreversible processes.

In the face of today's challenges of complexity, the history of science can promote an authentic critical awareness of the relationship between man and nature, of the processes of evolution and degradation. It is significant to note that general history, according to Langevin, “must take into account the influence of successive scientific conceptions on the course of civilization and the structure of societies and governments” (see [4] p. 210 ⁽¹⁾). The history of science is therefore intertwined with sociology. According to this critical horizon, the history of science is the history of civilization.

5. – Conclusions

For an intellectual culture, it is necessary in education pay attention to genesis of concepts, of the theoretical connection between different disciplines (physics, mathematics, philosophy, history of civilizations). If the history of science, as an expression of the evolution of human intelligence, is inseparable from the history of civilization, if the influence of scientific thought on the structure of societies and governments is to be taken into account, it must not appear as a second-hand element in today's teaching. This is important for bridging the gap between humanities and science disciplines, for citizenship, the formation of the integral men, to keep interest in the scientific disciplines alive. The history of science, being the history of scientific thought in the making, is always “young and current”. By integrating it into the general culture perhaps today's detractors of scientific rationality will become aware of the “humanising power of scientific thought” (see [7] p. 148 ⁽¹⁾). Thus Physics, not separated from its history, which is above all the history of method and civilization, is an educator of the human spirit.

REFERENCES

- [1] COMTE A., *Cours de philosophie positive*, in *Oeuvres d'Auguste Comte* (Editions Anthropos, Paris) 1968–1969, Vol. I (1968).
- [2] DUHEM P., *The Aim and Structure of Physical Theory* (Princeton University Press, Princeton, New Jersey) 1954.
- [3] REY A., *La théorie de la physique chez les physiciens contemporains* (Alcan, Paris) 1907.
- [4] LANGEVIN P., *La valeur éducative de l'histoire des sciences*, in *La pensée et l'action* (Les Éditions Français Réunis, Paris) 1950, pp. 194–211.
- [5] BRENNER A., *Duhem. Science, réalité et apparence. La relation entre philosophie et histoire dans l'œuvre de Pierre Duhem* (Vrin, Paris) 1990.
- [6] DUHEM P., *Rev. Quest. Sci.*, **XL** (1896) 463.
- [7] BACHELARD, G. *L'actualité de l'histoire des sciences*, in *L'engagement rationaliste* (Puf, Paris) 1972, pp. 137–152.