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From Experiments to Concepts, from Theories to Experiments: Toward a Circular and Historical-Epistemological Didactics of Contemporary Physics

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In Italian upper secondary schools, especially in techno-scientific courses, contemporary physics topics such as special relativity and quantum mechanics are often treated superficially as late-stage additions rather than integral components of the curriculum. This is mainly due to structural limitations but also to resistance to methodological innovation. Yet in today's world, permeated by relativistic and quantum technologies, awareness of their conceptual and historical foundation has turned into a key competence.

This contribution proposes an alternative didactic model with a circular approach. Starting from hands-on experiments (adapted to school settings and focused on a few indispensable notions) students can actively engage in inquiry-based learning. From these experimental foundations, the physics curriculum can then expand toward rigorous but accessible theoretical conceptualizations, framed within their historical-epistemological contexts, in order to reconstruct the importance of such experiments.

Specific examples (black-body radiation, the photoelectric effect, the double-slit experiment, and the Michelson–Morley interferometer) will be provided, alongside a didactic version of the Aspect–Clauser–Zeilinger experiment on Bell's inequality violation and quantum entanglement, recently adopted by the Liceo M. L. King in Genoa.

One aim is to demonstrate the feasibility of teaching contemporary physics at Italian techno-scientific high schools, in connection with student training in laboratory practice and in some advanced but still accessible mathematics. The other is to foster students' effective learning and critical understanding of 20th-century physics, with direct links to nowadays cutting-edge issues like quantum computing and cryptography.

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