# Summer schools on QT for students as a long-term educational strategy

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**Abstract**: In this contribution we describe the summer schools for students which have been organized with significant mutual collaboration at the University of Pavia and CNR-IFN Como. These schools can constitute examples of good practices for a long-term strategy of development of QT education.

Until the first decade of the XXI century there was practically no attempt in the physics education community, or coming from other sources, to bring topics related to the second quantum revolution to secondary school students. Then, around 2010, also under the drive national and international projects on QT with an interest on education, research started to move in such direction, recognizing the importance of raising awareness of the potential impact of such technologies also for younger students. At the beginning of the 2020s, CNR-IFN Como and the Department of Physics of the University of Pavia started organizing summer schools for secondary school students (17-18 year old) aiming both at orientation for future career choices, and at disseminating the core concepts of QT, with the help and support of methods and strategies coming from educational research. These schools, which have seen a significant mutual collaboration between the two institutions, have now several years of history, a robust record of encouraging results both in terms of student appreciation and conceptual understanding, and may form the basis for a more widespread and long-term educational strategy in the future.

At CNR-IFN Como, the different editions of the student schools (September 2020, April and September 2021, April 2022, June 2023 and June 2024, June 2025) aim to provide students with an introduction to the key concepts of Quantum Mechanics in connection with the latest applications in the field of quantum technologies. The course is based on the idea that it is possible to construct a didactic course that is both accessible to students and formally correct. To this end, we select a number of core concepts (the axioms of Quantum Mechanics) within a two-state approach in order to simplify the mathematical description with the Dirac notation. The working tool is the qubit, the basic building block of quantum information, and the transformations of the qubit states are approached from the computational point of view using quantum logic gates. The relevant properties of physical systems, such as electron spin or single-photon polarisation, as physical realisations of qubits. The methodology includes lectures, experiments (both simulated and in the laboratory), quantum algorithms with the IBM-Q interface and quantum games.

At UNIPV, the summer school on QT [1-3] has been held for three editions (September 2022, 2023, 2024) and its main content is a teaching-learning sequence covering from basic quantum physics with a two-state approach based on photon polarization, to quantum information science and quantum communication.The course has been developed in the framework of the Model of Educational Reconstruction [4], and relies on an integrated perspective on the different disciplines involved (physics, mathematics, information science), that includes a clarification of the information processing phase of quantum algorithms, identifying functional processes and connecting them to the structure of the quantum theory. Students are engaged in discipline-based epistemic practices, such as theoretical and experimental modelling, as well as lab activities, by leveraging optical qubit implementations (polarization and which-path). The conduction of these activities is assisted by the interplay of multiple representations, such as the introduction of the “optical circuit”: a diagrammatic representation of the experimental design of a logic circuit by encoding properties of one photon. The course was evaluated and monitored by several means: learning outcomes of modelling activities from student worksheets, a final test, pre-post questionnaire on common misconceptions and false information about quantum, and a satisfaction survey. The results, largely positive in all areas, will be presented at the congress.

## References

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