

Hands-on experiences for quantum physics dissemination and education: interactive tools for engagement and understanding

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Abstract: Within the Italian Quantum Weeks project, we developed an exhibition exploiting visual analogies and tools (cubes and coins, polarization, cards) to convey quantum concepts. These tools enable accessible and scalable outreach and educational activities.

In recent years, the rapid development of quantum technologies has stimulated a growing number of dissemination initiatives in Quantum Physics (QP) [1,2], together with proposals for innovative didactic approaches [3,4]. In informal education, a key challenge is to bridge the gap between complex quantum concepts and public understanding without falling into oversimplification. Entanglement is a paradigmatic example: attempts to avoid mathematical formalism often result in vague or misleading descriptions [5]. To overcome these issues, simulations and games have been proposed to make entanglement and other fundamental QP concepts more accessible [6,7].

Within the Italian Quantum Weeks project [8], we have designed and tested a set of outreach activities targeting the general public, as well as secondary school students and teachers. A central outcome is the exhibition “Quantum-Dire l’indicibile,” where QP concepts are introduced through visual analogies, ad hoc demonstrators, and interactive staging activities. The approach relies on tangible objects and embodied interaction to enhance engagement, conceptual understanding, and memory retention.



Fig. 1 (a) Quantum Cubes and color measurement apparatus; (b) Quantum Cards.

Key analogies include colored “quantum” cubes and coins to represent classical states and superposition, and tokens combining different colors and shapes to model incompatible observables and non-commuting measurements. Polarized light experiments, using polarizers, optical rotation in sugar solutions, and birefringent plastics, provide intuitive access to state preparation, measurement bases and state evolution. More advanced topics are addressed through “Quantum Cards,” a card-based toolkit enabling hands-on exploration of the BB84 quantum key distribution protocol and the CHSH Bell inequality.

These activities are modular and adaptable across contexts. Notably, the same demonstrators and narrative developed for the exhibition have been successfully implemented in educational settings, including summer schools for students and teacher training, where they support inquiry-based learning and discussion. The professional production and distribution of the demonstrators, supported by NQSTI, have enabled broad dissemination across Italian institutions, contributing to scalable and research-informed practices in QP outreach and education.

References

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