MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2026, 22(8), em2875
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/18980

The "quantum" exhibition: Communicating quantum physics through demonstrators and staging activities

Valentina De Renzi [1,2*], Maria Bondani [3]

[1] Dipartimento di Scienze Fisiche, Informatiche e Matematiche, Università di Modena e Reggio Emilia, Modena, ITALY
[2] CNR Istituto Nanoscienze, Modena, ITALY
[3] Istituto di Fotonica e Nanotecnologie, Como, ITALY

Received 21 December 2025 ▪ Accepted 09 June 2026

Abstract
In recent years, the rapid development of quantum technologies and the increasing research activity in quantum science have prompted a growing number of dissemination initiatives aimed at enhancing public understanding of quantum physics (QP). Within the framework of the Italian Quantum Weeks project, we have developed, over the past four years, an exhibition that introduces visitors to fundamental concepts of QP through visual analogies, purpose-built hands-on demonstrators, and interactive staging activities. In this paper, we focus on the design, implementation, and educational use of two of these demonstrators, namely the quantum-dice and the quantum-cards. We also present preliminary visitor feedback, indicating that these low-tech interactive demonstrator materials can effectively engage a general audience, stimulate curiosity, and foster an understanding of abstract quantum concepts without requiring prior background knowledge.

Keywords: quantum physics, exhibition, demonstrators

INTRODUCTION

In recent years, the emergence of quantum technologies and the intense scientific activity in quantum science have led to a growing number of initiatives aimed at disseminating knowledge of quantum physics (QP) and enhancing quantum awareness in society, as for instance qtedu (https://qtedu.eu/) and qplaylearn (https://qplaylearn.com/). Moreover, the need to strengthen quantum literacy at both undergraduate and high school levels has fostered educational research focused on assessing existing approaches (Krijtenburg-Lewerissa et al., 2017), as well as developing and testing innovative teaching methodologies addressing the foundations of QP and quantum technologies (Albert et al., 2025). As reported in Donhauser et al. (2024), most recent studies primarily focus on introductory quantum mechanics and modern quantum technologies, predominantly relying on digitally mediated tools, with school-level interventions often emphasizing visualization and conceptual understanding, while university-level studies more frequently address formal and mathematical aspects.

Beyond formal education, several recent studies have examined informal outreach and community-engaged efforts to build quantum literacy (Angara et al., 2022; Bondani & De Renzi, 2025; Bondani et al., 2022; De Renzi et al., 2025a, 2025b; Darienzo et al., 2024; Foti et al., 2021). Informal initiatives—including public lectures, science festivals, and online resources—aim to engage broader audiences and raise public interest in quantum science, though their educational impact is less frequently assessed through systematic research. Additionally, educational games have emerged as promising tools to promote interactive learning and curiosity about quantum phenomena in informal environments, with evidence indicating positive effects on engagement and conceptual understanding (Bondani et al., 2024; López-Incera & Dür, 2019; López-Incera et al., 2020; Seskir et al., 2022).

A preliminary version of this paper was presented at the GIREP 2025 Conference.

✉ vderenzi@unimore.it **(*Correspondence)** ✉ maria.bondani@uninsubria.it

Contribution to the literature

- This study proposes an exhibition-based framework for introducing and explaining fundamental QP concepts to non-expert audiences through visual analogies, interactive demonstrators, and staging activities.
- It contributes two original and replicable demonstrator designs (quantum-dice and quantum-cards), developed and tested within the "Quantum" exhibition.
- It provides preliminary empirical evidence of the potential of low-tech demonstrators to support engagement and conceptual accessibility in quantum outreach settings.

In both formal and informal education, interest has recently grown in the use of demonstrator materials (DM), both digital and haptic. A recent review (Folkers et al., 2026) surveyed and analyzed publications on DM for QP, highlighting various strategies and offering pedagogical insights. While available DM for topics such as entanglement, quantum cryptography, and quantum computing are mostly simulation-based and rely on standard optics experiments, considerable opportunities remain to develop and expand demonstrators, particularly those incorporating tactile and haptic elements (Weisberg & Newcombe, 2017).

Over the past four years, as part of the Italian Quantum Weeks project, we have developed and tested outreach activities focused on QP for both the public and secondary school students and teachers. Since 2022, we have designed and showcased four editions of exhibitions in various Italian cities, introducing foundational concepts of QP and quantum technologies. A distinctive feature of these exhibitions is a collection of specially designed objects and activities that help visualize abstract and unfamiliar quantum concepts. Rather than relying on computer simulations or complex illustrations, these tangible objects serve as interactive demonstrators to engage visitors directly.

We believe these objects can be of significant interest to the quantum education community, offering practical and adaptable aids for teaching quantum concepts. Due to their simplicity and affordability, these demonstrators can be easily reproduced and tailored to diverse educational settings, ranging from large public exhibitions to smaller classroom activities. This paper focuses on the design and use of these demonstrators, providing a brief overview of the exhibition as a whole and a detailed description of sections directly related to their implementation. Additionally, we present results from a satisfaction survey, analyzing audience characteristics and outcomes of the exhibition.

THE "QUANTUM" EXHIBITION

The 2025 edition, titled "Quantum", has been held in several Italian cities throughout the year, with its inauguration taking place in Modena in March 2025. The exhibition includes informative panels, key experiments, hands-on demonstrations, and interactive activities, all led by expert guides, such as researchers, postdoctoral fellows, and PhD students in physics. It aims to introduce the fundamental principles of quantum mechanics from scratch, using analogies and visual tools – rather than mathematical formalism – to help understand the new rules that govern the quantum world. In this way, it also becomes possible to provide a meaningful glimpse of quantum technologies and their applications. Within the context of informal education, our scope is to design QP-activities able to bridge the gap between complex scientific truths and public understanding, accepting the challenge of simplifying quantum concepts without diluting their essence, avoiding the pitfalls of oversimplification and inaccuracy.

The exhibition is briefly outlined below, without providing a full description, which would be beyond the scope of this paper. The narrative begins with a brief historical introduction motivating the need for a new theory to explain experimental evidence from the microscopic world, in particular discussing those phenomena—such as emission and absorption lines in atomic spectra—revealing the quantization of energy exchange between matter and the electromagnetic field. Before entering this new quantum framework, we recall how classical physics describes the state of a system, its deterministic evolution, and the origin of probability—concepts that remain foundational but acquire new meanings in quantum mechanics. To illustrate this point, we use the example of satellite motion. In classical physics, the state of a system is defined by observables such as position and velocity. If the initial state and the interactions are known, the future evolution can be predicted exactly, and the dynamics is deterministic. Probabilistic descriptions—such as weather forecasting—arise only from incomplete knowledge of initial conditions or interactions.

The principles of quantum mechanics—such as superposition, measurement, and incompatible observables—are then introduced using the DM described in the next section, namely the quantum dice (Q-dice) and the quantum cards (Q-cards). An explicit comparison between the classical and quantum cases highlights analogies (the definition of a physical state in relation to observables, and the deterministic evolution of the state) and differences (the intrinsic origin of probability, and the impossibility of measuring all

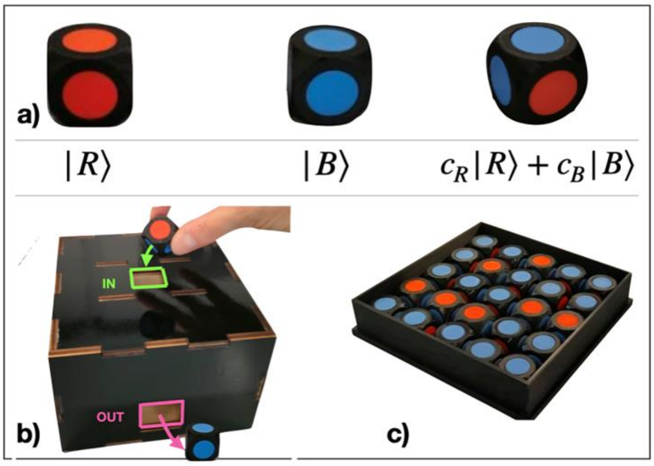

Figure 1. Q-dice representing eigenstates (red and blue) and one among different possible superposition states (a), the "magic" black box used to simulate measurement collapse (b), & the dice ensemble (c) (the authors' own work)

observables simultaneously). These concepts are further explored by introducing the electron spin and examining the Stern-Gerlach experiment. The focus then moves to atomic systems and the double-slit experiment, illustrating the wave function as the position representation of superposition. A subsequent section focuses on simple experiments and demonstrations exploiting the analogy between light polarization and two-state quantum systems, which allows the concepts previously introduced with Q-dice and Q-cards to be revisited and reinforced.

Finally, a section devoted to quantum technologies discusses quantum cryptography, quantum computing, and quantum algorithms, illustrating their basic principles through activities on the BB84 protocol and quantum walks (Bondani & De Renzi, 2025; De Renzi et al., 2025a). In parallel, the exhibition includes a section on entanglement, with activities on Bell inequalities and the experiments demonstrating their violation, as described in detail in our recent paper (De Renzi et al., 2025b).

The Quantum Dice

The rules governing quantum systems are introduced axiomatically by means of a fictitious but tangible system represented by a die, whose faces are colored either red or blue, as shown in part a in **Figure 1**). The observable defining the state of the system is the color, and a measurement is operationally defined as throwing the die and observing the color of the upper face. If all six faces have the same color (red or blue), the measurement outcome is certain, and the die is said to be in an eigenstate of the color observable. If the die has both red and blue faces, the outcome cannot be predicted deterministically. In this case, the state of the die is described as a superposition of eigenstates (i.e., a linear combination of the red ($|\mathrm{R}\rangle$) and blue ($|\mathrm{B}\rangle$) eigenstates),

$$|C\rangle = c_R\,|R\rangle + c_B|B\rangle \text{ with } |c_R|^2 + |c_B|^2 = 1. \quad (1)$$

When the state of the die is known, the probabilities of the outcomes (P[R]) and (P[B]) can be predicted and correspond to the fractions of red and blue faces, respectively

In the formal analogy, these probabilities are associated with the coefficients of the state vector, $P(R) = |c_R|^2$ and $P(B) = |c_B|^2$.

A further postulate is then introduced: state reduction as a consequence of measurement, namely the assumption that a measurement forces the system out of the superposition and into the eigenstate corresponding to the observed outcome. To make this abstract rule more concrete, a "magic" measuring black box is presented, as shown in part b in **Figure 1**). The box takes a die as input and produces as output a new die that is either entirely red or entirely blue (in practice, two such dice, a red one and a blue one, are hidden inside the box). The "trick" consists in pretending that the initial die has changed its state as a consequence of the measurement. The mechanism behind the box is deliberately simple and immediately transparent: its purpose is not to simulate a physical process, but to provide a visual and tangible representation of state reduction. This deliberately naïve implementation helps emphasize that the device is merely a representational aid for an abstract postulate, rather than a realistic model of a quantum measurement.

The Q-dice tool thus offers a simple and effective way to introduce the axioms of quantum mechanics, with several features worth discussing:

- The Q-dice are inexpensive, concrete, and closely connected to everyday experience with probabilistic outcomes. Crucially, the probabilistic nature of the outcomes is presented as intrinsic, rather than arising from ignorance of the state. Within the analogy, knowledge of the quantum state (i.e. of the number of red and blue faces) exhausts the information that can, in principle, be obtained[1]. The probabilistic behavior can be further explored using the demonstrator shown in part c in **Figure 1**), where an ensemble of 25 dice, prepared in the same state, is measured. This helps clarify the relation between relative frequency and probability, connecting to concepts—such as the law of large numbers—that are usually familiar to the public.

[1] Within this analogy, probability amplitudes and phases cannot be introduced. While central to QP, these concepts require mathematical formalism that may hinder initial understanding for a general audience; they are addressed later in the exhibition, for example in the discussion of Feynman's experiment.

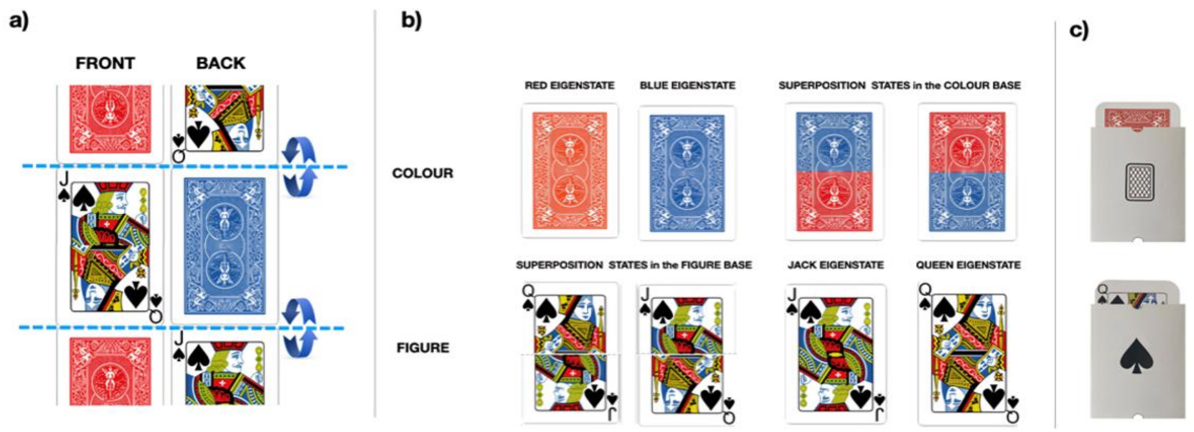

Figure 2. Q-card is made of a main body (Blue on the back, half-Queen half-Jack on the front), to which are attached two flipping half-cards (both Red on the back, either half-Queen or half-Jack on the front) (a), examples of eigenstates of one observable ($|B\rangle$ on the left, $|Q\rangle$ on the right), corresponding to superposition states of the other (b), & cards in the envelopes, illustrating the measurement procedure (c) (the authors' own work)

- The assumption of a finite and discrete set of possible outcomes is introduced ad hoc but can be readily accepted as part of the "rules of the game". Similarly, the operational definition of measurement—considering only the upper face or the outcome of the magic box—naturally connects to the broader notion of observables defined through measurement procedures.
- We should observe that the die is not a quantum object itself, but rather a concrete representation of a quantum state. The earlier discussion of the notion of state in classical physics supports this distinction between a physical system and its state description. While this difference may be difficult to articulate fully in an exhibition setting, it is relevant in a more formal discussion.
- Mathematical formalism is not required. Depending on the audience, one may omit equations entirely while still conveying the core ideas or introduce mathematical expressions to deepen understanding. Likewise, the fact that the coefficients are, in general, complex numbers may be mentioned or left implicit.

The Quantum Cards

Non-commuting observables are a central concept in QP and a key focus of our exhibition. To illustrate this idea, we developed a novel educational tool—the Q-cards—which represents a system characterized by two distinct, dichotomous observables: color (Blue or Red), displayed on the back of the card, and figure (Jack or Queen), displayed on the front. As shown in part a in **Figure 2**), the Q-cards resembles a standard playing card, with two attached, independently flipping halves. Depending on how these halves are flipped, the card can be prepared in different states, as illustrated in part b in **Figure 2**). As with the dice, the cards can be prepared in a color eigenstate ($|B\rangle$ or $|R\rangle$) or in a super- position $\frac{1}{\sqrt{2}}(|B\rangle + |R\rangle)$. With the introduction of a second observable—the figure—the state may equivalently be described in the figure basis, either as a figure eigenstate ($|Q\rangle$ or $|J\rangle$) or as a superposition $\frac{1}{\sqrt{2}}(|Q\rangle + |J\rangle)$[2]. These two representations correspond simply to observing the back or the front of the card.

Crucially, the card is designed so that an eigenstate of one observable corresponds to a superposition on the basis of the other, and vice versa; the two observables are therefore non-compatible. During the guided tour, visitors can interact directly with the card, compare its properties with those of standard playing cards—where both observable outcomes can be defined simultaneously (e.g., a red Queen or a blue Jack)—and discover this non-compatibility for themselves. The measurement procedure is also explicitly defined. As shown in part c in **Figure 2**), the card is first placed inside an envelope—playing a role analogous to the black box used for the die—and one half is then randomly extracted, analogous to observing only the upper face of a die. In this way, a single outcome (Red or Blue, Jack or Queen) is obtained, regardless of the card initial preparation. State reduction following measurement is simulated by fully extracting the card and flipping one half, accordingly, thereby inducing the collapse. Allowing visitors to manipulate the card, perform measurements themselves, and openly revealing the underlying mechanism helps make the abstract concept of non-commuting observables concrete and accessible.

After their introduction and visitors' exploration of the Q-card's properties, the cards are used throughout the exhibition. For instance, they serve as an aid during

[2] In this version of the card, the analogy is not extended to include relative phases of the coefficients. We are considering introducing a distinction between $|+\rangle$ and $|-\rangle$ states in future versions.

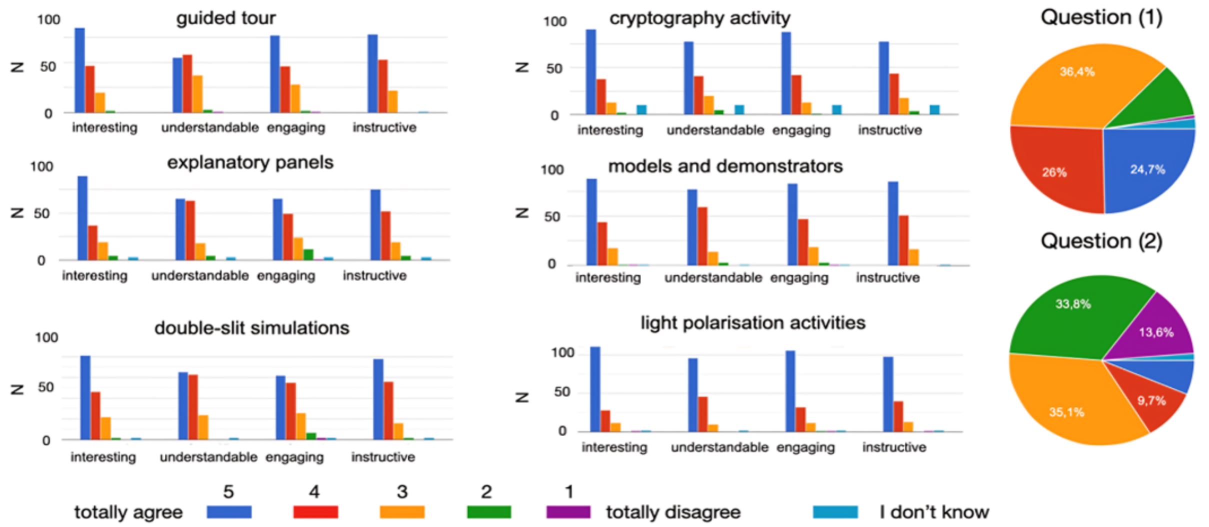

Figure 3. Results for selected key survey questions are presented (visitor responses were measured on a 5-point Likert scale, ranging from "totally agree" to "strongly disagree;" "I don't know" (light blue) was also always available as a response option; the histograms show visitors' opinions regarding different parts or aspects of the exhibition, expressed in statements such as "I found the guided tour interesting/understandable/engaging/instructive;" & the pie charts refer to question (1) and question (2), as described in the text) (the authors' own work)

the presentation of the *gedankenexperiment* based on a Stern-Gerlach sequence, which provides a concrete example of genuinely non-compatible physical observables, namely the z- and x-components of spin. Moreover, the Q-cards play a central role in the BB84 activity, which is proposed in the part of the exhibition devoted to quantum technologies. This activity, described in detail elsewhere (Bondani & De Renzi, 2025; De Renzi et al., 2025a) actively involves the public in staging the BB84 protocol for secure key distribution and introduces the basic concepts of quantum cryptography. In this context, the Q-cards play the role of polarized photons, with the color and figure bases corresponding to polarization bases rotated by 45° with respect to each other.

VISITORS' SURVEY RESULTS

In this section, we briefly present the results of a survey designed to gauge participant interest and satisfaction. While rigorous assessment of learning outcomes is difficult in an informal exhibition setting, levels of engagement and appreciation can be more readily explored.

We first report basic information on the participants' educational background and then summarize the main survey results concerning interest and overall satisfaction with the exhibition activities.

The "Quantum" exhibition held in Modena attracted approximately 700 visitors, including about 300 high-school students (13 classes). The visitors took part in guided tours lasting about 90 minutes having master and PhD students as moderators. The survey was conducted to all visitors immediately after the event as an online questionnaire accessible via mobile devices. Due to limited local Wi-Fi connectivity, only a subset of attendees completed the survey (N = 157), including high school students and independent visitors, the majority of whom were adults. Among adult visitors, 44 % of the respondents had a STEM background, only a minority (19%) were physicists, while a substantial fraction (30%) studied humanities or economics. Most visitors reported having very limited prior knowledge of QP, mainly derived from television, cinema, or the web. This result, together with the fact that most respondents (147 out of 157) would recommend the exhibition to friends and relatives, suggests that the exhibition is accessible to a general audience and effectively engages visitors without requiring specific prior preparation.

Figure 3 presents visitors' evaluations of specific components of the exhibition—namely the guided tour, the explanatory panels, and the simulation of Feynman's double-slit experiment[3]—across four dimensions: interest, understanding, engagement, and perceived educational value. Overall, all components received highly positive ratings. Activities involving demonstrators and direct visitor participation achieved the highest scores across all dimensions, particularly in understanding and engagement. The highest ratings were observed for the polarization activities and for the cryptography activities based on the Q-cards.

Furthermore, visitors' perceived difficulties were specifically addressed. Respondents indicated their level of agreement on a 5-point Likert scale for two questions: (1) "I found the exhibition easier to follow than I expected" and (2) "I found it difficult to understand the

[3] Note that this simulation was used by the guides during explanations and was not experienced independently by visitors.

topics presented in the exhibition." Slightly more than half of respondents scored 4 or 5 on question (1), while 46% scored 1, 2, or 3 on question (2). The Pearson correlation between the two sets of responses was found to be -0.95, indicating a strong anticorrelation, as expected. Moreover, for question (1), the percentage of respondents scoring 4 or 5 is similar among those with higher education (graduate and PhD; 62%) and those with a diploma (58%), but lower among high-school students (38%). In contrast, perceived difficulty (percentage scoring 4 or 5 on question 2) is higher among adults (35% for graduates and 26% for diploma holders) than among pupils (16%).

DISCUSSION AND CONCLUSION

While the survey results do not provide a formal assessment of learning outcomes, they clearly indicate strong public appreciation in terms of engagement and understanding, suggesting that the exhibition successfully balances conceptual depth with accessibility. Notably, this balance is not achieved through sophisticated digital technologies, but rather through intentionally low-tech activities grounded in direct manipulation, embodied interaction, and material experience (Weisberg & Newcombe, 2017). This design choice appears to be pedagogically significant.

All components received positive evaluations, with most responses in the top two categories of the 5-point Likert scale (5 and 4). Guided tours received particularly positive feedback, especially regarding engagement and interest. However, some variability emerged in the dimension of perceived understanding. This variation may reflect differences in guides' communicative clarity, pedagogical strategies, and responsiveness to visitors' questions. From a didactical standpoint, this highlights the importance of mediator training: even well-designed materials require coherent and adaptive facilitation to fully support conceptual comprehension. The explanatory panels and non-interactive simulations were also evaluated positively and regarded as informative and interesting. Nonetheless, they were rated slightly lower in engagement and understanding. One plausible interpretation is that these elements rely more heavily on verbal explanation and abstract reasoning. Without embodied or manipulative components, visitors may experience greater cognitive load, particularly when encountering counterintuitive quantum concepts. In contrast, the most highly rated activity across all four dimensions was the exploration of light polarization properties. This finding aligns with our observations during the visits: this part of the exhibition was the most playful and surprising, and likely also the easiest to understand. Its success may be attributed to several didactically relevant features: clear cause-effect relationships, visible transformations, opportunities for prediction and testing, and a relatively low threshold for conceptual entry. In other words, polarization may function as an effective "conceptual anchor," allowing visitors to ground abstract ideas in concrete perceptual experience.

Notably, both the DM and the related cryptography activity, which simulates the BB84 protocol, received very high scores—almost comparable to the most engaging activity, polarization. This indicates that visitors appreciated the interactive manipulation of the Q-cards despite the cognitive effort required to understand all phases of the protocol.

Taken together, these results highlight the central role of demonstrators in facilitating visitor engagement and understanding. Activities involving direct interaction with demonstrators consistently received the highest ratings, indicating that guided explanations and hands-on participation are key to making complex quantum concepts accessible while maintaining a playful and engaging experience.

Currently, these demonstrators and activities are being adapted for use in more formal educational contexts, including secondary education and teachers' training. Future research will focus on systematically investigating their impact on conceptual understanding, epistemological beliefs about science, and long-term retention. In particular, comparative studies between informal exhibition settings and classroom implementations could clarify how contextual factors influence learning processes.

In conclusion, the exhibition provides promising evidence that complex quantum concepts can be communicated in ways that are simultaneously rigorous, playful, and accessible. By integrating embodied interaction, guided mediation, and cognitive challenge, the project offers a transferable didactical framework for addressing quantum concepts in both informal and formal learning environments.

Author contributions: VDR & MB: conceptualization, data curation, formal analysis, investigation, methodology, writing – original draft, writing – review & editing. Both authors agreed with the results and conclusions.

Funding: Funding from the Italian Ministry of University and Research through the Piano Lauree Scientifiche program and from the University of Modena and Reggio Emilia under the Bando PE 2023-2025 is gratefully acknowledged.

Acknowledgments: The authors would like to thank L. Lusoli (bachelor's student, Unimore) for assistance in setting up the exhibition, as well as in the design and analysis of the survey and M. G. A Paris for the many insightful and wide-ranging discussions.

Ethical statement: Ethics approval was not required for this study, as it involved only anonymous questionnaire responses and did not collect identifiable personal data. Participation was voluntary, and all responses were collected and analyzed anonymously.

AI statement: Generative AI tools were used only for English language editing. The authors reviewed all outputs and remained fully responsible for the content of the manuscript.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Albert, C., Förster, M., & Pospiech, G. (2025). Developing a quantum physics curriculum for lower secondary education: Insights into the design of a spin first teaching concept and first empirical findings. *EPJ Quantum Technology, 12*, Article 132. https://doi.org/10.1140/epjqt/s40507-025-00436-0

Angara, P. P., Stege, U., MacLean, A., Müller, H. A., & Markham, T. (2022). Teaching quantum computing to high-school-aged youth: A hands-on approach. *IEEE Transactions on Quantum Engineering, 3*, Article 3100115. https://doi.org/10.1109/TQE.2021.3127503

Bondani, M., & De Renzi, V. (2025). Formal and informal approaches to quantum mechanics using quantum cryptography. In *Proceedings of the GIREP-EPEC 2025 Conference*.

Bondani, M., Caprara, S., Chiarello, F., Dabbicco, M., Hamma, A., Malgieri, M., Marzoli, I., Nazzaro, M., & Paladino, E. (2024). QTris: A quantum game. In F. Baboux, V. D'Auria, & T. Bienaimé (Eds.), *Proceedings of SPIE, vol. 12993, quantum technologies 2024*. SPIE. https://doi.org/10.1117/12.3029532

Bondani, M., Chiofalo, M. L., Ercolessi, E., Macchiavello, C., Malgieri, M., Michelini, M., Mishina, O. S., Onorato, P., Pallotta, F., Satanassi, S., Stefanel, A., Sutrini, C., Testa, I., & Zuccarini, G. (2022). Introducing quantum technologies at secondary school level: Challenges and potential impact of an online extracurricular course. *Physics, 4*, 1150-1167. https://doi.org/10.3390/physics4040075

Darienzo, M., Kelly, A. M., Schneble, D., & Wei, T.-C. (2024). Student attitudes toward quantum information science and technology in a high school outreach program. *Physical Review Physics Education Research, 20*, Article 020126. https://doi.org/10.1103/PhysRevPhysEducRes.20.020126

De Renzi, V., Cavazzoni, S., Forghieri, G., Ragazzi, G., Paris, M. G. A., & Bondani, M. (2025a). Walking in the quantum world: The Italian Quantum Weeks Exhibition 2024. *Il Nuovo Cimento C, 48*, Article 250. https://doi.org/10.1393/ncc/i2025-25250-7

De Renzi, V., Paris, M. G. A., & Bondani, M. (2025b). From staging to insight: An educational path to understanding Bell's inequalities. *EPJ Quantum Technology, 12*, Article 122. https://doi.org/10.1140/epjqt/s40507-025-00415-5

Donhauser, A., Bitzenbauer, P., Qerimi, L., Heusler, S., Küchemann, S., Kuhn, J., & Ubben, M. S. (2024). Empirical insights into the effects of research-based teaching strategies in quantum education. *Physical Review Physics Education Research, 20*, Article 020601. https://doi.org/10.1103/PhysRevPhysEducRes.20.020601

Folkers, B., Castenmiller, C., Brinkman, A., & Stadermann, K. (2026). An analysis of demonstration materials in quantum physics education. *EPJ Quantum Technology, 13*, Article 6. https://doi.org/10.1140/epjqt/s40507-025-00460-0

Foti, C., Anttila, D., Maniscalco, S., & Chiofalo, M. L. (2021). Quantum physics literacy aimed at K12 and the general public. *Universe, 7*(4), Article 86. https://doi.org/10.3390/universe7040086

Krijtenburg-Lewerissa, K., Pol, H. J., Brinkman, A., & van Joolingen, W. R. (2017). Insights into teaching quantum mechanics in secondary and lower undergraduate education. *Physical Review Physics Education Research, 13*, Article 010109. https://doi.org/10.1103/PhysRevPhysEducRes.13.010109

López-Incera, A., & Dür, W. (2019). Entangle me! A game to demonstrate the principles of quantum mechanics. *American Journal of Physics, 87*(2), 95-101. https://doi.org/10.1119/1.5086275

López-Incera, A., Hartmann, A., & Dür, W. (2020). Encrypt me! A game-based approach to Bell inequalities and quantum cryptography. *European Journal of Physics, 41*(6), Article 065702. https://doi.org/10.1088/1361-6404/ab9a67

Seskir, Z. C., Migdal, P., Weidner, C., Anupam, A., Case, N., Davis, N., Decaroli, C., Ercan, I., Foti, C., Gora, P., Jankiewicz, K., La Cour, B. R., Malo, J. Y., Maniscalco, S., Naeemi, A., Nita, L., Parvin, N., Scafirimuto, F., Sherson, J. F., … Chiofalo, M. (2022). Quantum games and interactive tools for quantum technologies outreach and education. *Optical Engineering, 61*(8), Article 081809. https://doi.org/10.1117/1.OE.61.8.081809

Weisberg, S. M., & Newcombe, N. S. (2017). Embodied cognition and STEM learning: Overview of a topical collection in CR:PI. *Cognitive Research: Principles and Implications, 2*, Article 38. https://doi.org/10.1186/s41235-017-0071-6