

Quantum Table: A Tangible Quantum Circuit Demonstrator

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Abstract

Quantum computing has considerable potential, but its abstract nature often intimidates beginners, and existing quantum circuit simulator interfaces can be overwhelming for them. To address this accessibility issue, we have developed an intuitive simulator that integrates the principles of a tangible, collaborative tabletop workbench with quantum circuits. This simulator allows users to manipulate circuits through physical interaction, providing real-time visual feedback. The use of tangible user interfaces (TUIs) in complex systems has been shown to improve the user experience by allowing users to control and represent data flows through physical objects. Inspired by the tangible workbench's use of dynamic visual cues, our system employs similar techniques to help users understand quantum operations through direct manipulation and visual representation. The integration of tangible interaction with quantum circuit simulation is a novel approach to making quantum computing more accessible and engaging.

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1 Quantum Table

The way computations are performed on a quantum computer is drastically different to how we think intuitively. Quantum physical concepts such as entanglement, the superposition of states and the measurement process, which are key elements for quantum computing, frequently present a significant challenge for understanding. A plethora of training material is available online, from free books [2] to drag-and-drop quantum circuit simulators such as Quirk [1]. However, these can quickly become overwhelming [4]. Our goal was to lower the entry barrier for a broader audience by designing and implementing a tangible way to interactively explore quantum computing while hiding many details about the theoretical foundations of quantum circuits as well as the physical realization of quantum computers.



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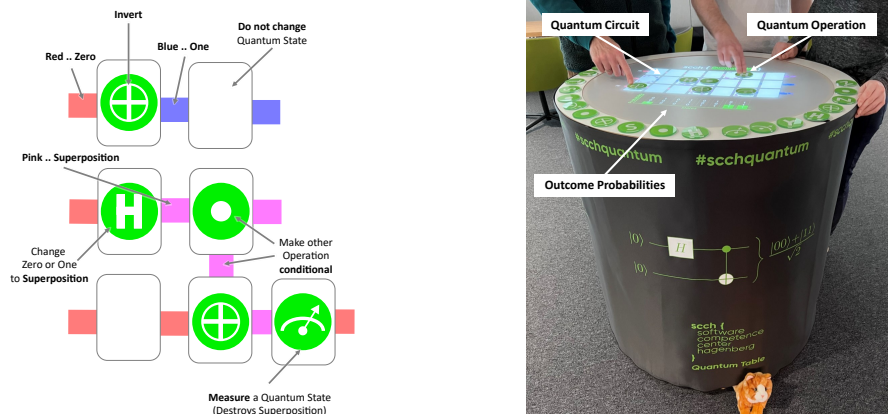
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■ **Figure 1** Visualization of the basic elements in a quantum circuit (left) showing a subset of possible operations (green circles) and quantum states (red, blue and pink lines). Collaborative use of the Quantum Table (right).

We built a tangible quantum circuit simulator in form of a round table offering a playful way to engage with people interested in quantum computing, from students and school children to the technically interested public. The Quantum Table shows a plain quantum circuit grid on its surface where users are invited to physically place blocks that represent quantum operations, which trigger immediate feedback by simulating and visualizing the resulting effects. This solution also includes the sense of touch into the learning experience. The setup is based on the reacTable and reacTIVision frameworks [3], which were originally designed for collaborative live music performances. The Quantum Table uses image recognition to classify the tangible objects placed on it and map them to the corresponding quantum operations. Figure 1 shows a visual explanation of the function on the left and a photo of the physical realization, with a diameter of about 90 cm, on the right.

Preliminary laboratory study. We presented the quantum table to two school classes, an industry delegation and at a teachers' symposium. Each session began with a short introduction to quantum computing, covering its basic principles and operations. After an introduction to the Quantum Table, participants were given the opportunity to interact with the table themselves.

Questionnaire responses from participants indicate that they found the tangible quantum table useful for understanding quantum circuits. The hands-on experience made abstract quantum mechanics more accessible and engaging, with immediate feedback reinforcing the learning process and deepening conceptual understanding. The tangible interface was preferred to web or touch screen applications because of its immersive and interactive nature, and the feedback system clarified the behaviour of the circuits and their outcomes. Participants also recognised the potential for such technologies in wider STEM education, particularly in schools, to enhance learning through physical interaction.

In future work, we plan to extend the quantum table with interactive “challenges”, such as asking users to prepare a particular quantum state or to identify misplaced tangible blocks within a circuit. We also plan to conduct a larger and more structured user study. To ensure equal opportunity and comparable conditions for all participants, we will prepare resources to help standardise prior knowledge and enable a more universal and equitable test environment where each participant starts with a similar understanding.

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