Quantum Computing from a CS Perspective: An Experience Report on Professional Development for Secondary CS Teachers

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Abstract

Recent innovations in quantum computing have initiated a discourse regarding its future relevance for K-12 computer science (CS) education. Gathering early experience on how to adequately prepare CS teachers for this complex field is important, yet remains a significant challenge. To this end, this experience report describes the design and evaluation of a one-day professional development (PD) workshop for secondary CS teachers. Central to the PD's design is a black-box approach intended to abstract from underlying physical principles and instead emphasize a computing-centric perspective on quantum computing. Based on a qualitative analysis of semi-structured interviews with four participants, we report on the feasibility of our approach, the suitability of the design, and the teachers' perspectives on if and how quantum computing should be integrated into CS curricula.

CCS Concepts

• **Social and professional topics** → **Computing education**; **K-12 education**; • **Hardware** → *Quantum computation.*

Keywords

Professional Development, K-12, Quantum Computing

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1 Introduction

As a dynamic discipline, computer science (CS) is characterized by regular innovations that must be examined for their relevance to general education and, where appropriate, integrated into K-12 curricula. A current example of such an innovation is the field of quantum computing (QC). While promising new possibilities in solving problems in simulation, optimization, or machine learning, QC also implies potential societal challenges, raising the question of how computing education must contribute to preparing students as informed citizens. Furthermore, the relevance of this topic is discussed from an economic perspective, particularly regarding the preparation of a 'quantum-ready' workforce [6]. As recent technological advancements are rendering the practical implementation of QC increasingly plausible, this has prompted initial explorations regarding connections to established frameworks such as computational thinking [36] and the identification of central concepts accessible for K-12 computing education [2, 11, 32].

Successfully integrating such innovations into school practice requires equipping teachers with the necessary content knowledge and pedagogical content knowledge [21]. This poses a considerable challenge: QC introduces a fundamentally new way of information processing, characterized by high conceptual complexity that can appear counter-intuitive [7–9]. Furthermore, the field is situated at the intersection with physics, and QC concepts are currently often explained by building directly upon physical principles [13, 31]. Moreover, established teaching concepts and classroom-ready materials are scarce.

Experiences with previous innovations emphasize the importance of addressing these challenges early on. In particular, the recent integration of Artificial Intelligence (AI) serves as a cautionary example: While AI is now becoming anchored in curricula around the globe [28], concepts for professional development (PD) were often developed and researched only after the technology had already significantly shaped our daily lives. Similarly, we argue that gathering practical experience in teacher training early is essential for QC – although it is still unclear when (or if) QC will influence our society. However, to date, PD offers for QC and the resulting

practical experience and research are largely confined to physics education.

To address this gap, we present the design of a one-day PD offer for secondary CS teachers and report on our experiences. Central to our PD concept is a "black box" approach, which abstracts from underlying physical principles to focus on a computing perspective on QC. Based on participant interviews, we evaluate the feasibility of this approach, the suitability of the design, and the teachers' perspectives on if and how QC should be integrated into CS curricula.

2 Related Work

In recent years, significant progress has been made in QC, both in hardware and algorithms. Key works include beyond-classical quantum advantage with verifiable computational outcomes across different quantum computers [1], as well as demonstrations of key components in quantum error correction [30]. These advances constitute important steps toward the practical application of quantum computers. While QC is therefore increasingly integrated into higher education curricula [22], the potential societal implications have also sparked the discourse on its relevance for K-12 education. In this context, however, QC remains an emerging topic in CS education [32]. A primary challenge remains the abstract nature of fundamental concepts like superposition and entanglement, which are inherently difficult to visualize [29]. Consequently, K-12 teachers have concerns about the high complexity associated with these topics [18]. Additionally, in a recent systematic review, Yusuf et al. [37] report a lack of empirical depth and identify the need for more educational studies and the development of age-appropriate teaching approaches that can effectively translate abstract quantum concepts for K-12 learners.

Existing teaching concepts have begun to address the pedagogical challenges inherent to QC by reducing complexity and focusing primarily on core concepts and basic algorithms [19]. Furthermore, they frequently rely on interactive digital simulations [20], digital games [15, 17], or unplugged activities designed to gamify quantum mechanics [3, 25, 33]. Other established approaches leverage physical implementations, such as the polarization of photons, which provide a tangible link to experimental physics [31]. This physics-centric approach is further supported by Ghimire et al. [13], who demonstrated through teacher surveys that activities exploring wave-particle duality and electron transitions can be successfully integrated into K–12 curricula while fostering student engagement. However, since these approaches often require a substantial physics background, there is a growing interest in pedagogical designs that lower entry barriers by abstracting away the hardware layer to prioritize a computer science perspective [2, 11, 32] – also reflecting the growing importance of computer science in the field of QC. In this context, Liu and Franklin [24] demonstrate that a visual-first spiral curriculum can successfully introduce quantum concepts by abstracting away traditional physics-heavy prerequisites. Their work indicates that learners can develop a robust conceptual understanding of qubits and gates through visual metaphors before transitioning to a more formal mathematical notation.

Concerning professional development, similarly, we see a focus on the physics perspective on QC, primarily targeting physics and STEM teachers. Sutrini et al., for instance, describe the integration of quantum concepts into the existing physics and mathematics landscape of Italian high schools, specifically for physics teachers [35]. Matsler and Lopez describe a "learn then practice" PD model targeting STEM teachers that combines workshops with immediate teaching experience to help them overcome cognitive overload and gain instructional confidence [26]. To this end, they build upon physical concepts such as waves or photons to explain QC. Similarly, Kelly et al. report on a 12-hour PD intervention for 51 secondary educators including CS teachers. While their findings show significant increases in participants' self-efficacy and knowledge of career pathways, they also prioritize the physical perspective by utilizing concepts such as photon polarization [23]. Practical experience regarding PD offers that focus on a computer science perspective and specifically address CS teachers remains limited. A recent exception is Gonzalez-Maldonado et al. [14], who report on a three-hour workshop for 27 K-12 teachers that used hands-on activities and pre/post surveys to measure gains in self-efficacy, enthusiasm, and confidence. Their findings suggest that even a brief intervention combining active learning with directly transferable materials can meaningfully lower barriers to teaching QC. We extend this work by addressing CS teachers specifically, in a full-day format with an explicit black-box design, evaluated qualitatively rather than via pre/post surveys.

In summary, despite the growing significance of the field, QC in K-12 education is characterized by a scarcity of both empirical research and practical field experience. Existing pedagogical approaches predominantly follow a physics-centric perspective on quantum technologies. This is notably even more prominent in the area of PD, showing a need for PD designs that successfully abstract the physical foundations to adequately address CS teachers and focus on the CS-perspective of quantum computing.

3 Design of the Professional Development Offer

Our PD is designed as a one-day workshop. It aims at providing CS teachers with the basic content knowledge (CK) required for a foundational understanding of QC. Furthermore, the workshop aims to build pedagogical content knowledge (PCK) to prepare participants to implement QC topics within extracurricular offerings, project days, or elective courses. Specifically, we address secondary CS teachers who, in our national context, typically possess a solid computer science background but have no previous experience with QC.

Central to our PD concept is a "black box" approach, which abstracts underlying physical principles to focus on a computing perspective on QC. Consequently, no prior knowledge of physics is required – even though a considerable subset of CS teachers in our context are also qualified to teach physics[1]. The selection of content is closely aligned with recommendations for QC in K-12, such as *Key Concepts for Future QIS Learners* [2] or core ideas for QC [32]. To this end, the PD was structured into two main phases: a morning session focused on the foundations of QC (such as qubits, superposition, entanglement and simple quantum circuits), and an afternoon session dedicated to advanced topics, including the use of real QC hardware, specific algorithms, and current research areas.

[1]In our national context, secondary teachers typically hold a Master's degree covering two (or, in some cases, three) subjects, ensuring a high level of content knowledge.

A key component of the PD was a workbook covering the morning session content. It is designed to be used directly in the classroom as a student workbook or as a self-study guide for educators. In the following, we first outline the workbook's pedagogical design, while sections 3.2 and 3.3 detail the practical implementation for the morning and afternoon sessions, respectively.

3.1 Underlying Workbook intended for the classroom

The workbook (see Fig. 1)[2] utilizes a narrative-driven approach, set in the year 2038, to contextualize QC within a relatable future society featuring fictional news reports and advertisements. Its design is guided by the following pedagogical principles:

- **Exploratory learning:** In the workbook, priority is given to learners' first-hand experience and active experimentation with quantum phenomena from a CS perspective. To this end, they engage in inquiry-based activities – such as using interactive simulators or unplugged activities – to explore QC concepts before formalizing the underlying theoretical principles.
- **Hybrid approach:** Integrated QR codes lead to a web-based, drag-and-drop quantum circuit simulator, allowing learners immediate practical experimentation without the need for complex software installation.
- **Connecting to prior knowledge:** The content bridges traditional CS topics – such as bits, logic gates, and complexity – with respective quantum counterparts, to leverage previous knowledge.
- **Abstraction:** The workbook avoids heavy mathematical formalisms in favor of structural analogies, to reduce the entry barrier and focus on the underlying concepts and principles.

The workbook was integrated throughout the morning session to link content knowledge (CK) with pedagogical content knowledge (PCK), while also providing participants with directly transferable materials for their own classroom. Consequently, the aforementioned design principles of the workbook also served as a pedagogical guidance for the PD session itself.

3.2 Morning session (pre-lunch)

The morning session focused on the foundations of QC from a CS perspective. Connecting to prior CS knowledge, the workshop moved from the inherent limitations of classical computing to the foundational concepts of QC.

Motivation and Complexity. The workshop began by exploring the physical and temporal roadblocks facing current computing paradigms. We utilized the unplugged "monkey puzzle" activity by [12] (see Fig. 2) to demonstrate the exponential scaling of specific problems, illustrating how they can rapidly become intractable for traditional systems. To show how alternative paradigms can fundamentally change runtime complexity for certain tasks, we contrasted classical sorting with the "spaghetti computer" model, where numbers are encoded into the length of spaghetti strands

[2]The workbook can be downloaded at https://computingeducation.de/proj-quanteninformatik/; an interactive English version is available at https://www.stefanseegerer.de/quantum-chronicle/?lang=en.

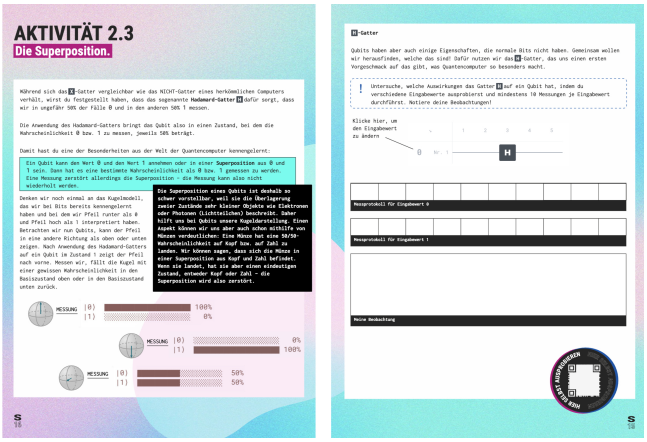


Figure 1: Excerpts from the workbook, showcasing parts with explanatory text such as the Bloch sphere (first image) and inquiry-based activities (second image).

to be sorted simultaneously [10]. This comparison served as an introductory analogy for QC, with its procedural steps—such as data encoding—acting as conceptual references throughout the PD.

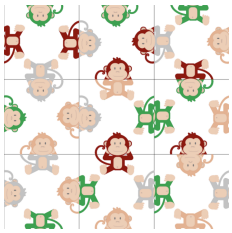


Figure 2: The Monkey Puzzle, an unplugged activity, serves as a tangible example for problems where verifying a solution is simple, but finding one classically requires exhaustive checking of exponentially growing permutations [12]

Circuits and Measurements. As a starting point for the transition to quantum circuits, the workshop continued by reviewing classical logic gates (specifically NOT, AND, and OR gates). Participants engaged with these concepts through a digital applet that enabled the construction and measurement of classical logical circuits. This grounding is essential, as it introduces measurement as a discrete action early on. Familiarizing participants with the measurement operation served as a critical bridge to QC, where repeated measurements are necessary to determine the probabilistic states of a system (see Fig. 3).

From Bits to Qubits. The transition from classical bits and logic gates to the quantum bit (qubit) was facilitated through direct interaction with a specialized digital applet. By experimenting with X and Hadamard (H) gates – specifically observing that applying the H gate twice consecutively restores the qubit to its initial state – participants discovered that neither classical bit definitions nor pure randomness sufficiently describe quantum behavior. Following this exploratory phase, the workshop introduced the Bloch sphere

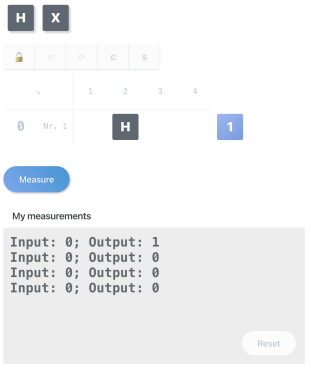


Figure 3: Interactive circuit applet: By clicking "Measure", participants experience state collapse as a discrete event (here following a Hadamard gate). This emphasizes measurement as an intentional action prior to statistical interpretation.

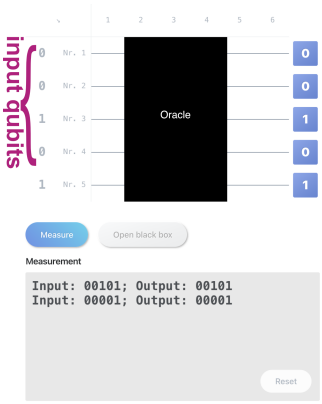


Figure 4: Participants can change the input on the left hand-side and observe the measurement output. The task is to retrieve the hidden code used by the oracle (Bernstein-Vazirani algorithm).

as a way to visualize qubit states, providing an explanatory model for understanding superposition. To further reinforce these ideas, the "Quantum Penny Flip" game [27] was utilized as an intuitive, classroom-ready entry point to demonstrate the practical application of these phenomena. This introduced the coin analogy, a second explanatory model.

Quantum Operations and Entanglement. As a next step, participants further explored quantum operations using the digital simulator, introducing T-gates to investigate the role of phase. This segment demonstrated how rotations around the z-axis, which are initially non-measurable, can be made observable by applying an H-gate. A pivotal milestone in the workshop was the introduction of **entanglement** via the CNOT (Controlled NOT) gate. By linking the states of multiple qubits, participants observed how the measurement of one qubit can instantly determine the outcome for its entangled counterparts. This concept was then used to discuss the exponential scaling of quantum information, highlighting the computational advantages of quantum systems over classical systems.

Initial Applications. Finally, the foundational concepts were applied through the Bernstein-Vazirani algorithm [4], which addresses the task of identifying a secret, unknown bitstring stored within an oracle [5]. This oracle is configured to invert an answer bit whenever it encounters a '1' in the hidden code and this specific input is guessed correctly. Using the circuit editor, participants first attempted to retrieve the secret code classically by systematically testing individual input bits (see Fig. 4). They then implemented a quantum solution by applying a Hadamard transform to the qubits, a process analogous to the technique used earlier to make T-gate effects measurable. This activity highlights the requirement to consider the collective state of all qubits. It is also a first algorithm that shows how this paradigm shift allows for identifying the hidden code in significantly fewer operations than required by classical logic.

3.3 Afternoon session (post-lunch)

While the morning session utilized the workbook to establish the fundamentals, the afternoon aimed at providing a glimpse into the 'real world' of current QC. To this end, the PD transitioned from conceptual understanding to the practical implementation of QC, inevitably introducing a higher level of complexity.

Grover's algorithm. This first segment focused on how quantum concepts such as superposition and entanglement can be leveraged for computation beyond the already discussed Bernstein-Vazirani algorithm. To this end, Grover's algorithm, a quantum search method for unstructured databases, was first introduced through its geometric interpretation [16]. Building upon this, the algorithm was translated into quantum gates before a Python-based coding tutorial was provided via Jupyter Notebooks. In contrast to the simulations used earlier in the day, this session provided the opportunity to interface directly with actual quantum computing hardware. Participants were given dedicated time to work through the tasks within the tutorial, which were then discussed collectively to ensure a shared understanding of the implementation.

Quantum Machine Learning. Following the programming tutorial, the afternoon session explored the intersection of machine learning and quantum algorithms. Both fully quantum models and hybrid quantum-classical models were covered. Given the topic's inherent complexity, this segment was delivered as a university-style lecture. It provided participants with a state-of-the-art overview of current application examples, offering a realistic perspective on scientific development and the contemporary landscape of the field.

4 Qualitative Evaluation

To evaluate the PD, we focused on qualitative feedback to better understand the teachers' perspectives. As an experience report, rather than measuring standardized metrics like self-efficacy, our goal was to capture their individual perception of the content and its presentation, as well as their assessment of how suitable the topic and materials felt for their own classrooms.

	Other Subjects	YoE	Background in QC
L1	Physics, Music	≈ 8	Occasional QC articles and talks
L2	Math, Physics	≈ 20	Pop-sci media and general interest
L3	Math, Physics	≈ 20	None
L4	Math, Physics	≈ 25	Occasional QC articles

Table 1: Overview of interview participants, including subjects taught, years of classroom experience (YoE), and prior background in QC.

4.1 Participants and Data Collection

The PD was conducted at TU Munich and attended by 18 secondary CS teachers (14 male, 4 female). Besides a strong background in CS, many participants also taught physics; their prior knowledge of QC was heterogeneous but overall limited. They were recruited through an official governmental platform, which facilitated formal recognition and accreditation of the PD; however, participation was entirely voluntary.

In the two weeks following the workshop, we conducted semi-structured interviews with four participants (L1–L4, see Tab. 1), selecting them based on availability while their memories were still fresh (convenience sample). The interview guideline covered professional background, an evaluation of the PD's pedagogical approach (specifically the black-box design), the classroom suitability of the materials, and the relevance of QC for secondary education. Data was analyzed using thematic analysis [34]. Interviews were transcribed and coded inductively by two of the authors. In addition, informal feedback was collected through observations and discussions throughout the day.

4.2 Experiences & Findings

Based on our informal observations throughout the day, all participants completed the workbook activities and contributed to group discussions during the morning session, indicating sustained involvement with the material. However, the afternoon proved to be challenging, in particular during the coding tutorials, where only a few participants were able to complete the tasks in full. Concerning the interview data, L1–L3 provided predominantly positive assessments of the PD, while L4 provided a valuable critical counter-perspective. In detail, our analysis yielded five primary findings:

QC Complexity and Exploratory Learning. A consistent theme across L1-L3 was the high level of satisfaction with the intuitive, hands-on morning session. L1 and L2 expressed strong satisfaction with the morning session, describing it as "very good"[3] (L1) and "totally great" (L2), reflecting the perceived accessibility of the hands-on approach. In contrast, L4 criticized the exploratory approach in the morning session as inefficient, arguing that a "consistent model" should have been introduced beforehand to allow participants to link their exploration directly to this model. During the more technical afternoon session, all participants reported experiencing cognitive overload at some point. L2 noted that the content felt "almost a bit over our heads because it was already super scientific". Similarly, L1 reported "dropping out" during the afternoon because the "algorithms and implementation were too complicated". L3 explicitly identified the programming tasks as "too fast", suggesting that an additional hour would have been necessary to adequately process the material. Despite these difficulties, participants explicitly noted that they found it rewarding "to be pushed to their cognitive limits once again" (L2), or even praised it as "finally a PD where one was actually challenged, and – quite honestly – also overwhelmed towards the end" (L3).

These observations suggest that while QC remains a highly complex subject, it is possible to facilitate foundational understanding, particularly through hands-on activities. This aligns with [14], who similarly find that full content mastery is not a prerequisite for teachers feeling empowered to introduce QC in their classrooms. However, the transition to advanced concepts, specifically implementing complex algorithms and their formalisms, remains a significant hurdle, even for CS teachers with a strong background in math and physics. Furthermore, the polarized feedback on the exploratory approach (L1–L3 valued inquiry, L4 favored direct instruction) indicates divergent preferences, which possibly also reflect individual teaching styles.

The CS Perspective vs. Underlying Physics Principles. The PD deliberately utilized a "black box" approach to abstract from physical details to focus on the CS perspective. Notably, all our interviewees also teach physics, which certainly influences their perception. L1 stated that the principle of treating the qubit as a given unit without delving into the underlying physics "actually works... especially in the morning it worked really well". L3 agreed that the concept "is working", though he admitted needing to "pull himself together" to avoid reverting to a physical mindset. L2 shared this view, but noted benefiting from prior physics knowledge, explaining that the concepts "seem less spooky, simply because you've gotten used to this spookiness". Conversely, L4 expressed reservations, arguing that "you also need to know a little bit about physics" to "really understand it." At the same time, he emphasized that this perception might be specific to him, as a physicist, stating that others "maybe [...] don't actually need to know the physics behind it."

This suggests that a black-box approach can successfully facilitate a CS-centric perspective. However, it interacts with established mental models of physics teachers: for some, prior physical knowledge might act as a stabilizing factor that reduces the "spookiness" of QC, while for others, the lack of hardware-level explanations can create barriers.

Explanatory models. Essential for teaching a complex topic such as QC are appropriate explanatory models and visualizations [32]. In our PD, we introduced the coin analogy and the Bloch sphere, which represent a small selection of common models we deemed suitable for our purpose and target group. Participants showed differing preferences regarding these models. For example, L2 stated: "I liked the coin." He primarily linked his preference to the Quantum Penny Flip game, noting that the model allows one "to put oneself in different roles". In contrast, L4 preferred the Bloch sphere model, stating that it "carries important information" such as "these rotations", "without having to know anything about the matrices or maths behind it". Regarding classroom implementation, L1 considered that "it [the sphere model] could be beneficial", but cautioned

[3]All quotes have been translated from German into English by the authors with minimal adjustments to improve comprehensibility.

that the Bloch sphere "goes deeper" and is therefore "relatively complicated". Opposing this view, L2 highlighted that every model used to explain QC phenomena is inherently "confusing" to a novice, and that a teacher must intentionally utilize multiple representations to clarify the abstract concepts for different learners.

In summary, the opinions on models are mixed, possibly also depending on the purpose – whether as an introduction for students or for establishing a consistent conceptual model for teachers in PD. We argue that this emphasizes the need for more research in this direction, specifically investigating the potential and limits of different models.

The Workbook. The workbook as teaching material received high praise for its aesthetic design and low barrier to entry. Even L4 described it as "high quality". Similarly, L2 characterized it as "very low-threshold", noting that the interactive digital elements and the initial "Quantum Penny Flip" game likely generate immediate student motivation. When asked if the material passed the "Monday Morning Test" (readiness for immediate classroom use), L3 confirmed that he would "take it directly" and use it "exactly as is". L1 echoed this, suggesting the material is suitable even for motivated elective courses in lower secondary education. However, some participants expressed skepticism about using the workbook as a purely self-directed learning format. L3 argued against letting students work through the workbook "completely alone [...] without accompaniment", asserting that "you need a teacher". This view was reinforced by L4, who maintained that the underlying quantum models are too complex for "explorative" learning and instead require "direct instruction" to be truly understood. To prevent students from becoming lost in technical execution, L3 recommended implementing intentional "breaks" after key milestones (such as logic gates or entanglement) to ensure students maintain "conceptual coherence".

This indicates that while the materials are perceived as highly motivating and *ready to use*, the teachers agree that the complexity of QC necessitates a scaffolded approach, balancing self-directed exploration with teacher-led conceptual checkpoints.

Curricular Integration. All participants agreed that quantum computing is a future-oriented topic warranting further investigation within computing education. However, opinions on its specific integration varied: L3 advocated for inclusion into the "mandatory [CS] curriculum". Similarly, L2 favored the comprehensive integration into secondary school curricula to ensure its permanence. In contrast, L1 and L4 took a more cautious position. L4 argued that "computing education must prepare for this [topic]" and therefore support "individual teachers to explore it in special courses". However, he noted that "real-world applications do not yet play a significant role". Similarly, L1 reasoned that "from an end-user perspective, quantum computing is not yet relevant", which "perhaps is an indication that it is not yet suitable for classroom teaching". Regarding the appropriate grade level, the participants favored upper secondary education (L2, L3), even though L1 noted that the workbook might work for a "motivated elective course at the lower-secondary level". Views on the main learning objectives also diverged. While L2 emphasized that students should engage with "spooky concepts" like entanglement to learn that one can effectively work with phenomena that may not be "100 percent scientifically understood", L4 argued that students must understand the topics' "operating principles" to demystify the technology and distinguish it from "magic or esotericism". L3 added that students should gain a "glimpse into the future", understanding both the potential of QC's way of information processing and its limitations to specific problem areas. Finally, L1 argued that QC should be analyzed from three distinct perspectives: technological fundamentals (e.g., superposition and logic gates), societal implications (e.g., encryption security), and the practical relevance for citizens.

In summary, the teachers acknowledge the future relevance of QC for CS in schools, locating it primarily within upper-secondary education. They emphasize that the main learning objectives should focus on "demystification" and high-level principles and concepts rather than in-depth technical details.

5 Conclusion

In this experience report, we presented a one-day PD workshop for secondary CS teachers on the emerging topic of quantum computing. While existing QC teaching materials and PDs often lean into the physics domain, we deliberately chose a "black box" design that abstracts from underlying physical principles to emphasize a CS-centric perspective. To evaluate our PD, we conducted qualitative interviews with four participants. While this small sample size does not allow for generalizable statements, our findings provide rich insights into the PD's perception. We found that the morning session was positively received by the majority of the interviewees, who especially valued the hands-on activities and the classroom-ready teaching materials. In contrast, the afternoon session proved to be more challenging, as the transition to advanced concepts and formalisms overwhelmed the participants at certain points.

Overall, the PD design offers a starting point for future PD programs in quantum computing for CS teachers. Our experiences suggest that hands-on, activity-driven formats represent a promising direction for QC teacher professional development. At the same time, the diverse feedback from the participants points out several avenues for future work. First, while the "black-box" design was generally well-received, it did not convince all interviewees. This highlights the need for further practical experiences and research into the necessity and role of physical foundations for QC – especially since all our interviewees were physics teachers. Second, our results indicate that the question of which explanatory models are best suited for specific purposes and target groups warrants further investigation. Third, the feedback from the teachers questions the balance between exploratory inquiry and scaffolded instruction for such a complex topic. Considering our national context, it is worth noting that our PD primarily reflects the experiences of teachers with a rather high level of CS content knowledge, which may limit their transferability to different educational systems.

While our teachers argued for a future integration of QC in upper secondary education, the topic has not yet been integrated into school curricula, and whether or when this will happen remains uncertain and depends on technological developments in the upcoming years. Nevertheless, this paper contributes early practical experiences to support the qualification of CS teachers, an area where empirical evidence remains scarce, which may inform future PD design for CS teachers.

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