A gender-sensitive approach to high school education in quantum computing.

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Topic

"Education and training in Quantum Technologies"

Background

We are now in the middle of what is termed the 'Second Quantum Revolution', where noisy quantum devices can be built and controlled with high precision. Even though there are a lot of challenges to overcome, quantum devices are expected to be used in the near-future for communication and computation purposes [1]. The topic of quantum information is however considered impenetrable for many, and this could hinder the appropriate understanding and usage of this new technology in the future. It is therefore important to introduce the subject to young audiences, in order to demystify the topic and trigger interest in the field at an early stage. High-school students possess the necessary tools for understanding the basics of quantum information [2]. While teaching material at that level exists in English, there are unfortunately no resources available in some other European languages, e.g. in German, which is the second most spoken language in the EU (after English) [3].

In quantum information, similar to all Science, Technology, Engineering and Mathematics (STEM) fields, there is a significant lack of women. This is an important current issue in the EU, since addressing it could help increase employment and productivity of women, reduce occupational segregation and lead to economic growth [4]. To tackle this problem, we strongly believe that actions at the early stages of education are necessary, so that women do not obtain a sense of exclusion from specific domains. Furthermore, the recent pandemic experience has intensified the use of Online Educational Resources (OERs), and therefore any effort to increase the number of women in STEM, should also target audiences that commonly use the internet for educational purposes.

The goal of the joint project QuExplained between TU Berlin and the HTW Berlin is exactly to address all the above, by developing and practising material in German with a gender-sensitive approach. Within this project, several workshops with high school students have been organised and online material is currently being developed. The surveys conducted during these events aim to evaluate the effectiveness of the methodology and dissemination measures.

Presentation

In this talk we will present the content of the organised workshops, which were conducted on various occasions with more than 100 participants, approximately 60% of which were girls. We will also present the results of a survey filled by the participants before and after two main events, the Girls' Day 2021 and the Quantum Hackathon 2021. Both events lasted for four hours and the participation was voluntary.

The organised workshops consist of two parts that can be implemented in an arbitrary order and they both require that the participants work on their computers in digital labs. These hands-on digital experiments give participants the opportunity to successfully accomplish challenges without significant prior knowledge in mathematics or physics. The topics covered are quantum physics leveraged by quantum computers and the basics of quantum computing. The "Quantum Physics" part of the workshop introduces the concepts of superposition, entanglement and polarization through the digital *Quantum Flytrap* lab [5]. The "Quantum Computing" part of the workshop introduces quantum gates and quantum circuits and discusses superposition, entanglement and measurements using the digital lab *Quantum Composer* of IBM [6]. The two main experiments 'Quantum Hello World' and 'Quantum Coin Toss' are built step-by-step, and the workshop concludes by running the quantum circuits not only on a simulated quantum computer, but also on a real quantum computer in IBM's cloud platform ([7], [8]).

In total, 39 students participated in the events and responded to the survey. A total of 35 declared that they knew more about quantum computing than before the workshop. 32 students said they would like to learn more about quantum computing in the future, and 35 said the same about quantum physics. Thus we can see that the vast majority of the students left the workshop wanting to learn more and with significantly more knowledge on the field. The increased confidence in the students' knowledge is also reflected in the answers when asked if they knew what superposition and entanglement were after the workshop. At the Girls' Day event all of the 23 participants answered with yes to both questions. In the following figures we see how the students increased their knowledge during the workshops, when asked to rate their familiarity with the respective field.

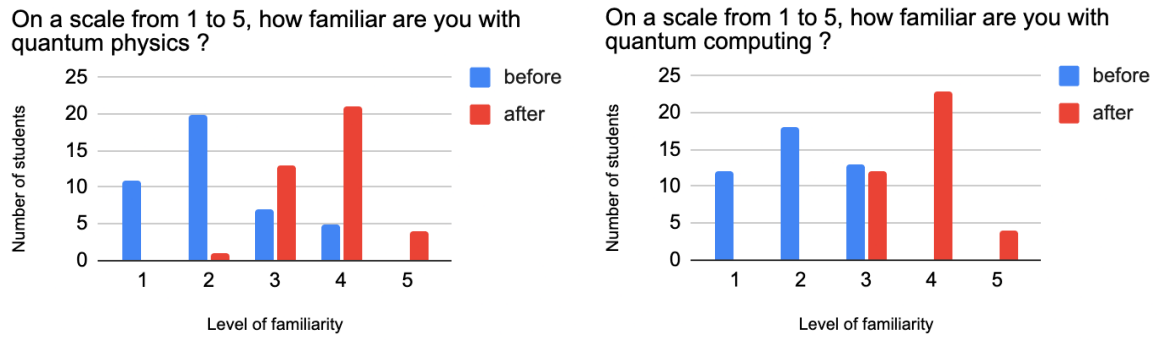

Figure 1: The left (right) plot shows the familiarity the students have with quantum physics (computing); 1 corresponds to "no familiarity at all" and 5 stands for "very familiar with the subject".

References

[1] J. Preskill, “Quantum Computing in the NISQ era and beyond,” *Quantum*, vol. 2, p. 79, Aug. 2018.
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