Nordic-Estonian Quantum Computing e-Infrastructure Quest

Academic Perspectives on HPC-Integrated Quantum Computing:

Insights from a Survey

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NordIQuEst is a project of the Nordic e-Infrastructure Collaboration (NeIC).
NeIC is an organisational unit under NordForsk.

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January 13, 2025

Abstract

This executive summary provides an overview of key findings from a survey conducted among 40 individuals within academia, representing a relatively small sample size. The survey aimed to understand the experiences and perspectives of participants regarding HPC access to quantum computers. A notable observation is that only 35% of respondents have teaching experience, suggesting a predominant focus on research activities within the surveyed group. Additionally, 50% of participants have not utilized a quantum computing framework, with Qiskit being the most commonly used framework, followed by PennyLane.

Surprisingly, almost 80% of respondents have not used a quantum computer for teaching purposes, highlighting a significant gap in practical exposure to this technology in educational settings. Of those who have incorporated quantum computing into teaching (9 individuals), half believe that quantum computers are beneficial for educational purposes. The survey reveals a strong consensus among respondents regarding the importance of access to quantum hardware, with 90% considering it vital or potentially useful for their work. Interestingly, only a small percentage prefer on-site access, suggesting a preference for remote access or simulators.

The primary us of quantum hardware and software, as reported by the respondents, is for research purposes. Approximately 50% believe that fewer than 50 qubits are sufficient for their work, while the rest are either unsure or express a need for up to 10,000 qubits. Notably, no participant indicated a desire for more than 10,000 qubits. Participants emphasized the importance of tutorials with examples for state-of-the-art algorithms, an easy simulator setup, and access to real hardware for quantum computing via High-Performance Computing (HPC).

In conclusion, these findings offer valuable insights into the current landscape of quantum computing in academia, underscoring the need for increased practical exposure, diverse access options, and tailored resources for research purposes within this field. However, it is worth mentioning that roughly half of the surveyed individuals had heard of NordIQuEst, suggesting a potential internal bias for the survey.

Introduction

The field of quantum computing is rapidly evolving and gathers users from both academia and industry. One way to respond to the increased demand is to provide access to quantum computers via HPC platforms like is done in NordIQuEst. HPC-integrated quantum computers can leverage powerful classical computing resources for hybrid computing, as well as benefit from well-developed existing HPC tools and workflows. To further continue developing the quantum computing and HPC ecosystem, it is important to understand the experiences and future perspectives of the user base. This report presents the findings from our survey targeting 40 academic participants, offering insights into user demographics, experiences of the current platform, software preferences, and future expectations. The survey helps to identify what kind of features the users would like to have implemented, and how to improve the current ecosystem to make it more suitable for the most popular use cases.

Results

Figure 1

Among all survey participants (40 participants), most of them don't have experience of teaching in quantum computing.

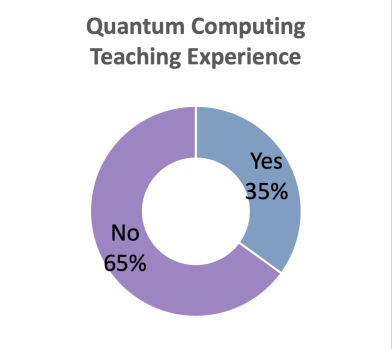

Figure 1: "Do you teach quantum computing at any level?"

Figure 2

There are even fewer people (23% of all participants) who have experience teaching with quantum computers. Around 80% of people with such experience find quantum computers useful for teaching.

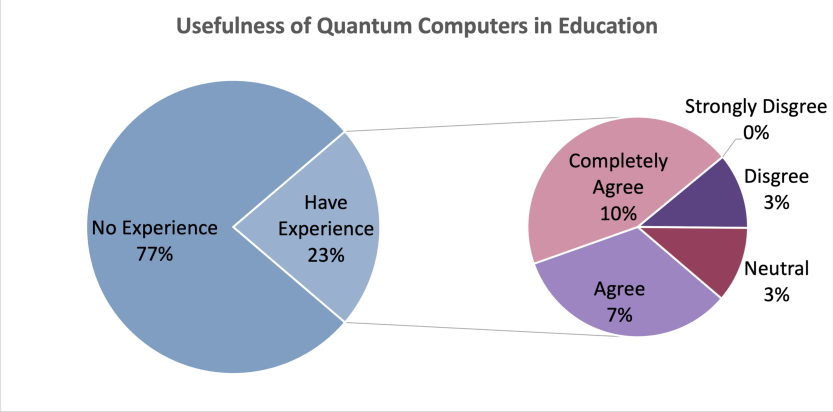

Figure 2: "Have you ever used quantum computers for teaching?" and "Are quantum computers useful for teaching?"

Figure 3 and Figure 4

Among participants experienced in using quantum computing tools, some of them have used multiple types of tools before. The majority of them have the experience of using Qiskit. For participants (5 participants) with experience with other tools, 4 of them mentioned the Google QC stack, such as Cirq. They also mention pyQuil and some tools for synthesis and language simulation/translation.

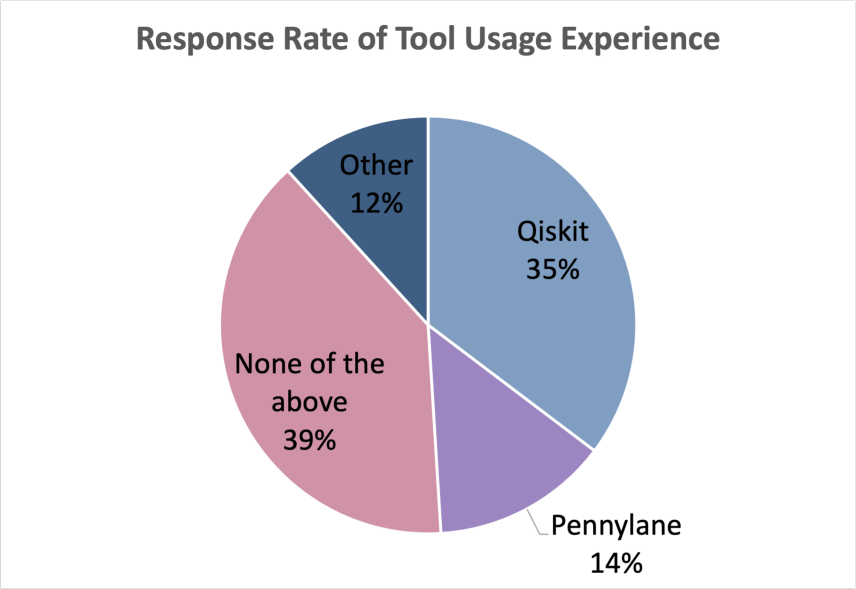

Figure 3: Response rate for "Which tools have you used before?"

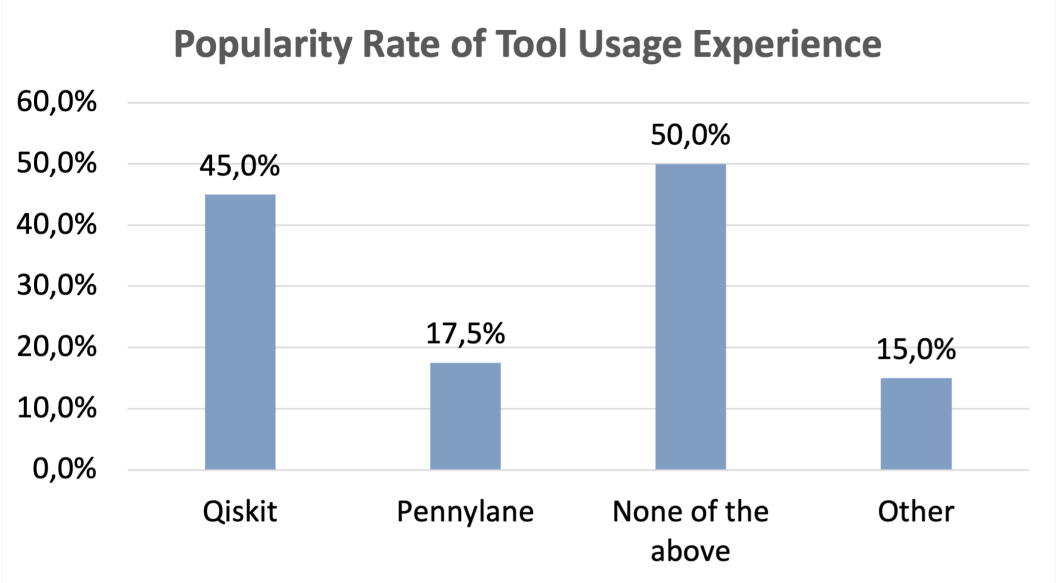

Figure 4: Popularity rate for "Which tools have you used before"

Figure 5

In the following question, we collect information on the importance of quantum computers to participants, comparing between simulator and hardware. Results show that more than half of participants think quantum computers can relate quantum computers to their work. Also, 25% of participants are interested in playing around with quantum computers. There is no large difference between answers for simulators and quantum computers.

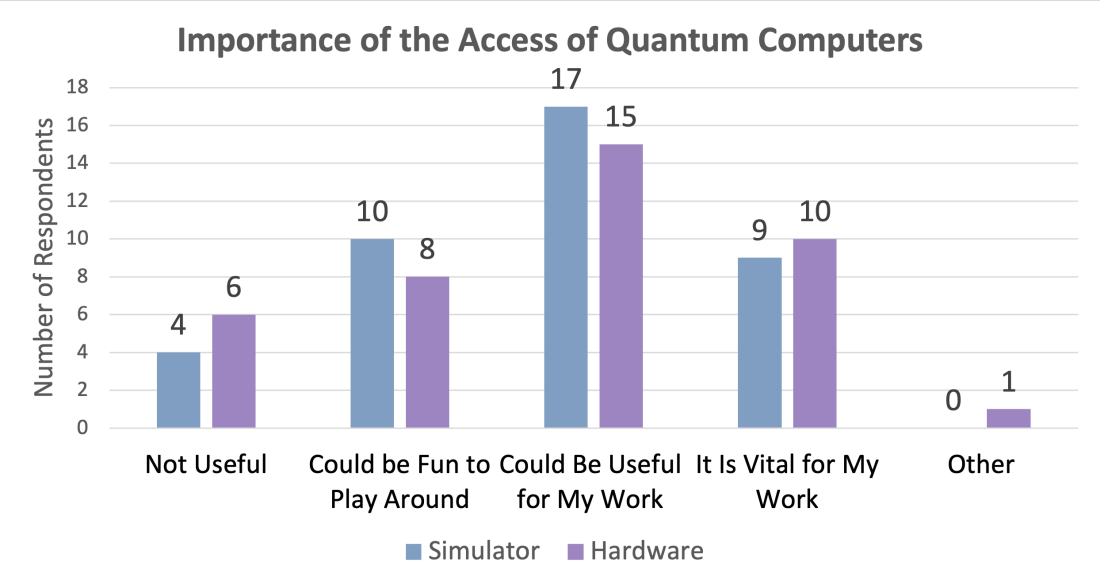

Figure 5: "How crucial is the access of quantum computer (simulator and hardware) to you?"

Figure 6 and Figure 7

For the question "if access to real quantum hardware is useful, what kind of access do you need?" There are 24 participants among 40 find it useful and specified in the question. More than half of them choose gate-based level quantum computers. Also, around half of them consider pulse level and cloud quantum computers are useful to them. There is one comment specify that his field is fluid mechanics, he needs on-going programs for fluid dynamics simulations in quantum computers.

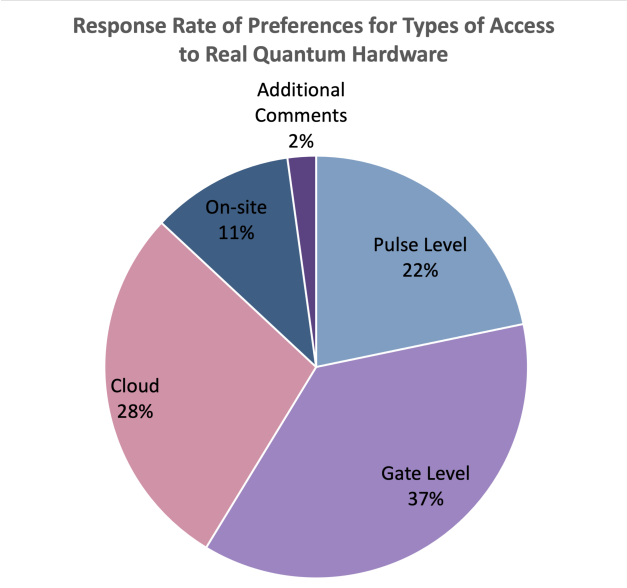

Figure 6: Popularity rate for "If access to real hardware is useful, what kind of access do you need?"

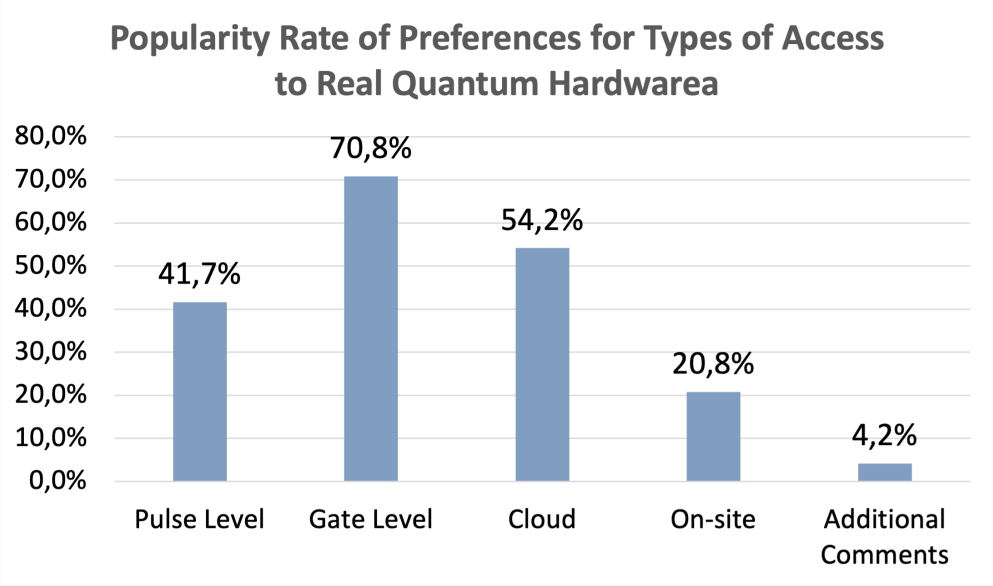

Figure 7: Response rate for "If access to real hardware is useful, what kind of access do you need?"

Figure 8

In the following question, we ask about the main purpose of using quantum techniques. Most of the participants answered by doing research. Also, some of the participants choose education and training. One participant specifies that they use QC through the cloud to train employees. Another participant specifies that he would like to help spread awareness of the benefits of quantum technology to sectors and various stakeholder groups, and he is more concerned with reaching out to people with not much knowledge of quantum computing.

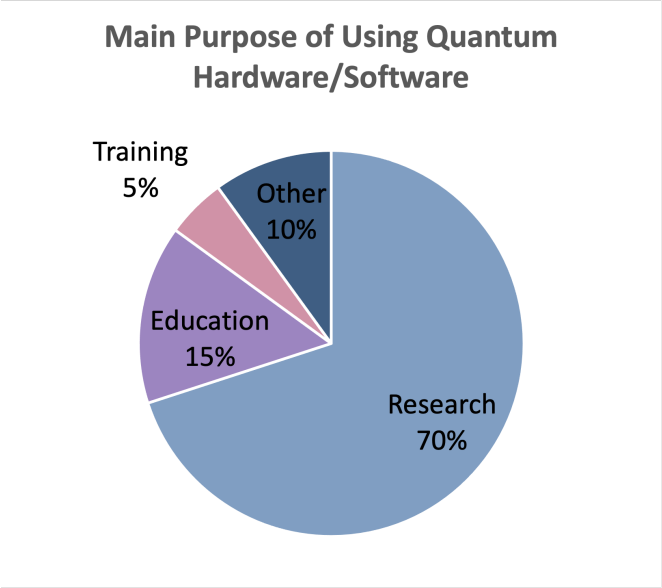

Figure 8: "What is the main purpose of using quantum hardware/software for you"

Figure 9

In this question, we would like to know the number of qubits (i.e., no matter physical, logical, and simulated) required to make the quantum computers "useful" to participants. Half of the participants chose qubits from 10 to 50. A large number of qubits in quantum computers is not necessary to the majority of participants. Also, some participants don't have a clear answer to this question. Some think it depends on the problems they need to solve. Some believe that working with quantum technology is an iterative process and that learning to gradually work with an ever-greater number of qubits is useful.

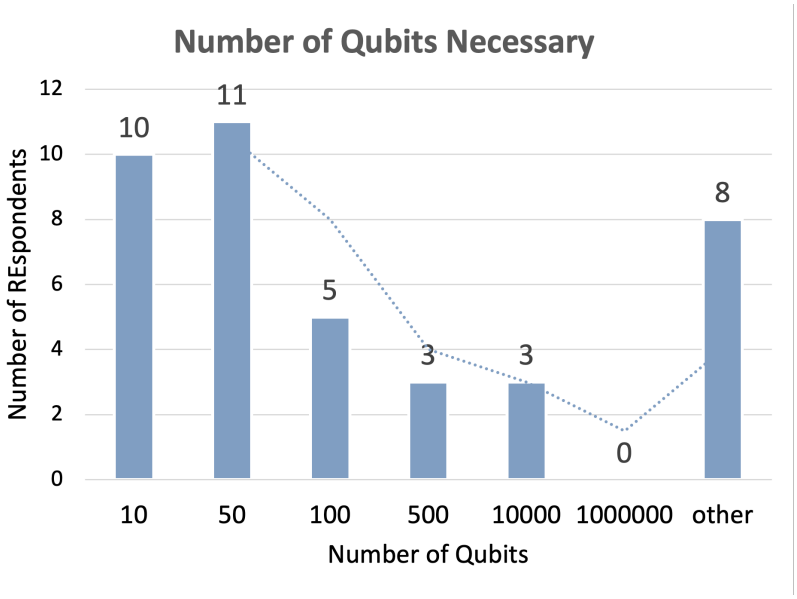

Figure 9: "In order to be useful, I would need at least this many qubits"

Figure 10 and Figure 11

In this question, we did a survey on useful features for a quantum computing platform via HPC. The rate of selecting three choices (i.e., "tutorial of algorithms", "easy setup for simulators", and "easy setup for accessing real hardware") is rather high. Some people also have the following expectations:

- Fined-detailed control, such as calibration and diagnostics of the hardware
- Well-written and updated tutorials. All API functions are rigorously documented.

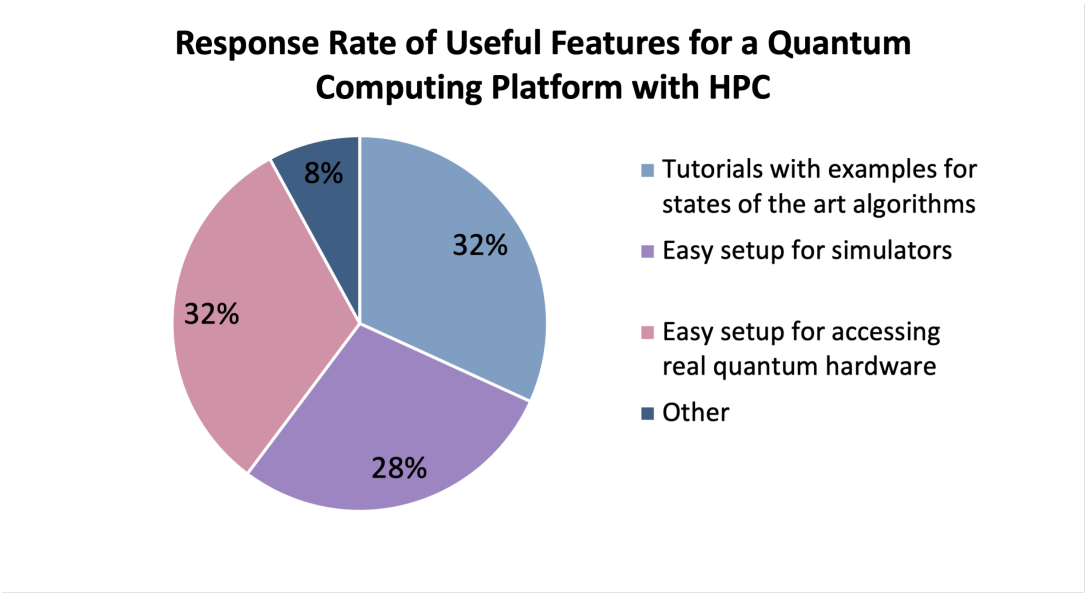

Figure 10: Response rate for "Which features should a quantum computing platform via HPC have to be useful"

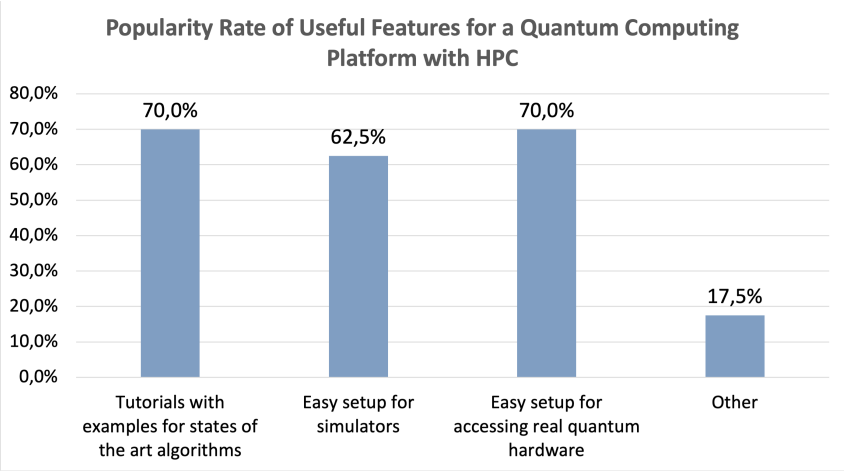

Figure 11: Popularity rate for "Which features should a quantum computing platform via HPC have to be useful"

Figure 12

In this survey, about half of the participants have heard about NordIQuEst project before.

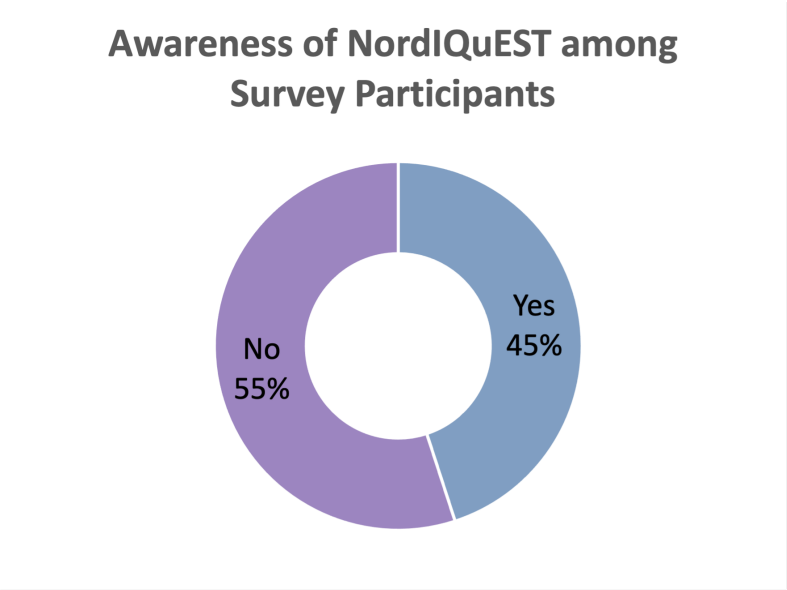

Figure 12: "Did you hear about NordIQuEst"

Conclusions and next steps

The survey contains 40 academic professionals in quantum computing, where approximately half had heard of NordIQuEst before. The results show that 70% primarily use quantum computing for research, with limited use in teaching. Only 35% have teaching experience in quantum computing, and even fewer use real quantum computers in teaching. However, those who do find access to quantum computers highly beneficial. The usefulness might depend heavily on the field, e.g. lectures in physics, computer science, and mathematics have different needs. A majority of participants consider access to quantum computers or simulators essential to their work. Qiskit stands out as the most popular programming tool, used by 35% of respondents. Participants prioritize access to real quantum computers with 10–100 qubits, favoring cloud-based, gate-level programming and, to a lesser extent, pulse-level access. Simulators and thorough documentation are also deemed important.

A key takeaway is the significant potential to expand quantum computing education. Providing easy access and availability of real quantum hardware is crucial, as exposure to real systems is widely viewed as valuable. The anticipated qubit capacity of near-term cloud quantum platforms aligns well with users' needs. This growing demand highlights the necessity for user-friendly services and comprehensive documentation, especially for newcomers to quantum computing.

Based on this analysis, NordIQuEst's planned activities could greatly benefit educational users. Training initiatives, such as the Quantum Autumn School 2023 and 2024, offer participants hands-on access to real quantum computers. Expert-led tutorials and knowledge-sharing sessions can further develop participants' expertise. Additionally, the NordIQuEst Application Library, featuring a diverse collection of algorithms and documentation, provides valuable resources for exploration. Expanding and maintaining these activities is strongly recommended

Looking ahead, NordIQuEst will explore opportunities in the industry sector. Another survey is planned to identify industry needs and deliver customized services for new users.