NTNU DidactiQC

Funded by
The Research
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WORKSHOP PROGRAMME / TRONDHEIM

Teaching and Learning of Quantum Computing

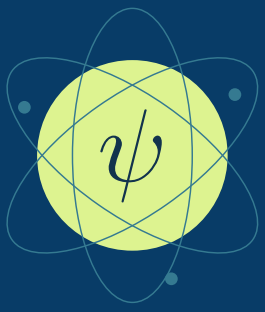
What should the next generation learn?
And how should we teach it?

OCTOBER / 2026

05–09

NTNU • Room G108
Trondheim, Norway

EDUCATION × RESEARCH × INDUSTRY



01 / A SHARED QUESTION

Building quantum competence, together.

How can universities prepare people to understand, use and teach quantum computing?

This DidactiQC workshop brings educators, researchers and industry representatives to NTNU to exchange experiences in quantum computing education. The programme connects university teaching with emerging workforce needs, teacher education, outreach and future collaboration.

VENUE

Room G108
NTNU, Trondheim, Norway
Open the room location in MazeMap

LUNCH

12:15–13:45, Monday–Friday.
Friday's sessions finish at 12:00.

MEET THE COMPANIES

Wednesday, 16:00–18:30.
Limited seats; registration is required. Coffee and waffles are advertised for Industry Day.

WORKSHOP ENQUIRIES

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02 / THE WEEK AT A GLANCE

Five days. Shared perspectives.

05 MONDAY

Workshop opens p. 4
Teaching and learning of quantum computing at NTNU.
10:30–16:00

06 TUESDAY

Quantum computing education p. 7
Experiences across Norway and a life-sciences perspective.
09:30–16:00

07 WEDNESDAY

Industry Day p. 10
Industry, research institutes and workforce development.
Meet the Companies: 16:00–18:30. Dinner: 19:30.
09:30–16:00 / 16:00–18:30

08 THURSDAY

Teacher education and outreach p. 13
Teaching, didactics and public engagement.
Special teaching-tools sessions: 15:00–16:30.
09:30–16:30

09 FRIDAY

Future directions p. 16
Final morning: didactics, roundtable, vision and discussion.
09:30–12:00

EVERY DAY / ROOM G108

Official detailed schedule • Workshop webpage

03 / MONDAY 5 OCTOBER

The workshop opens.

10:30–16:00 / NTNU PERSPECTIVES

10:30–11:00	Intro / Institute leaders - Marius Thaule
11:00–11:30	DidactiQC
11:30–12:00	Franz Luef
12:15–13:45	Lunch
13:45–14:30	Jeroen Danon
14:30–15:00	Gunnar Taraldsen
15:00–15:30	Torbjørn Smedshaug
15:30–16:00	Discussion

11:00–11:30

Kurusch Ebrahimi-Fard, Yael Fleischmann, Alexander Schmeding

IMF, NTNU

DidactiQC: Teaching and learning quantum computing at NTNU

We will report on our experience with introductory courses in quantum computing and quantum machine learning at NTNU in 2025–2026. A central question is how to offer a common introduction that is accessible and relevant to students across STEM, while preparing them for different paths of further study. We will describe our teaching formats and discuss the ambition of DidactiQC to develop a didactics research project in quantum computing and related topics in linear algebra. DidactiQC also includes a teacher education perspective, exploring how future teachers can engage with these topics and introduce them to their students. The aim is a continuing exchange between teaching and research: classroom experience informs the research questions, while findings about students' learning feed back into course design and teaching practice.

11:30–12:00

Franz Luef

IMF, NTNU

Harmoniq: From signal analysis to quantum computing

In this talk, I present the story behind the quantum data augmentation protocol, Harmoniq, a recently developed method in quantum machine learning (in collaboration with K. Kirova and R. Kueng from JKU Linz, and M. Doerfler from Uni. Vienna). This work is a result of research activities jointly with master's and PhD students at the Department of Mathematical Sciences at NTNU, where we have developed quantum versions of methods

and notions from signal analysis and transferred them to the setting of quantum information and computing. In the process, some of our master and PhD courses have been adapted to reflect this new focus on mathematical methods with relevance for quantum technology, sometimes called Quantum Mathematics, and how this fits into the new study direction “Quantum Technology” in our civil engineering study program, as well as our experiences in supervising and teaching our master and PhD students in this emerging field.

13:45–14:30

Jeroen Danon

Department of Physics, NTNU

Quantum Tech education at IFY

14:30–15:00

Gunnar Taraldsen

IMF, NTNU

The Art of Guessing - AI, statistics, quantum mechanics and quantum computers

An AI critic: “AI merely reads documents and guesses the right answer. It cannot be trusted.” That objection is dead by now. With enough information the uncertainty is negligible. Uncertainty is present in every answer, and statistics is the discipline whose main subject this is. In quantum physics the uncertainty is built in and is not merely due to lack of knowledge. Moreover, quantum mechanics requires a generalisation of Kolmogorov’s probability theory to non-commuting variables. In quantum computers all of this meets, and 0–1 states are replaced by qubits. The talk elaborates on this, using as an example a student project in which quantum algorithms were applied to the bandit problem. This is one of many examples where quantum computers are, in theory, expected to enable solutions beyond the reach of classical computers.

Mathematics Subject Classification (2020): 62A01 (foundations and philosophical topics in statistics), 60A05 (axioms; other general questions in probability), 46L53 (noncommutative probability and statistics), 81P05 (general and philosophical questions in quantum theory), 81P16 (quantum state spaces, operational and probabilistic concepts), 81P68 (quantum computation), 68Q12 (quantum algorithms and complexity), 62L05 (sequential statistical design), 68T05 (learning and adaptive systems in artificial intelligence).

Keywords: the art of guessing; uncertainty; Kolmogorov’s axioms; noncommutative probability; von Neumann’s postulates; qubit; quantum Monte Carlo; the bandit problem; reinforcement learning; artificial intelligence.

13:45–14:30

Torbjørn Smedshaug

IØT, NTNU

QC for Optimization

Optimization is one of quantum computing’s promising applications. The large state spaces of quantum computers can naturally accommodate the large problem sizes of combinatorial optimization, and hopefully also realistically model the stochastics of macro-scale processes which complicate the solution of realistic optimization problems. This talk aims to introduce the concept of quantum optimization, and give a quick overview

of the state of the art in this moment. Furthermore, we discuss how to introduce the concepts of quantum computing to students from the perspective of the curriculum of IØT, which do not have physics or theoretical mathematics as apart of the study programme.

04 / TUESDAY 6 OCTOBER

Teaching quantum across Norway.

09:30–16:00 / UNIVERSITY EDUCATION

09:30–10:00	Makoto Yamashita
10:00–10:30	Sølve Selstø
10:30–11:00	Discussion
11:00–11:30	Gunnar Felix Lange
11:30–12:00	Dennis The
12:15–13:45	Lunch
13:45–14:30	Berit Bungum
14:30–15:00	Klaus Mayer
15:00–15:30	Hans Heum
15:30–16:00	Discussion

09:30–10:00

Makoto Yamashita

UiO

Quantum information science education at Department of Mathematics, University of Oslo

I will report on what we learned from teaching Quantum Computation (Bachelor) and Quantum Information Theory (Master) courses. We started these courses in 2020 and 2022 respectively, as elective courses mainly for students in mathematics, physics, and informatics, and they are now integrated into the new Quantum Science and Technology program.

10:00–10:30

Sølve Selstø

OsloMet

Quantum literacy: Some experiences from OsloMet

Over the years, a lot of effort at Oslo Metropolitan University have been made to make students quantum literate. This applies to all levels, from Bachelor via Master and PhD level to lifelong learning. In virtually all cases, with the possible exception of PhD students, the students do not have the traditional physics or mathematics background. This introduces challenges and opportunities in teaching quantum sciences. I will address some of these and share experiences from our attempts on dealing with them.

11:00–11:30

Gunnar Felix Lange

UiO

Quantum computing with minimal mathematics?

Can we teach quantum computing without or with very little mathematics? Should we? How much understanding can be obtained from this? In this talk I will share from my experience from outreach talks, lectures at the University of Oslo and at Kristiania University College, which aimed to teach quantum with minimal mathematics. I will share some strategies and reflect on what I have learned from these experiences, and whether I believe that this is something we should aim to do.

11:30–12:00

Dennis The

UiT

Quantum Computing at UiT

This talk provides an overview of quantum computing education at UiT The Arctic University of Norway, including current course offerings and future plans in quantum information science.

13:45–14:30

Berit Bungum

NTNU

Quantum physics for quantum computing education: What are students' challenges?

Quantum physics breaks fundamentally with how we are used to see the world, and students encounter a range of challenges. This contribution presents what physics education research can tell us about the challenges different groups of students in secondary school and university encounter in learning quantum physics. The talk will point forward to a discussion on what they will need to know about quantum physics in order to develop, understand or use quantum computing.

14:30–15:00

Klaus Mayer

University of Applied Sciences Northwestern Switzerland, School of Life Sciences

Summer School "Quantum Computation in Life Sciences" – Teaching QC to non-experts

Since 2024, we offer this summer school to our 2nd & 3rd year BSc students. The aim of the summer school is to acquaint the students with the basic concepts of quantum computing and to show them possible use cases in the Life Sciences. I will present our teaching concept, comprising basic mathematics, physics and programming skills (Qiskit) required to gain a first understanding of gate-based QC. The course is very hands-

on, with many practical exercises. Students apply their learnings in a final project, where they implement a Hamiltonian simulation of a molecular NMR spectroscopy experiment, which is a natural use case from their field of studies. Finally, I will show a teaser of an online course we are currently building as supplementary material to the school.

15:00–15:30

Hans Heum

Simula, Bergen

Tools for Building Quantum Intuition

Students and researchers in informatics who want to learn quantum computing are faced with a high learning curve, with much specialised notation and terminology that must be internalised. As a result, they may find their classical intuition difficult to port to the quantum setting, even in cases where the analogy is exact. My view is that this is at least partially a failure of the formalization. I have therefore developed a quantum pseudocode, defined on quantum registers, which allows us to write algorithmic pseudocode and interaction diagrams that closely mirror their classical counterparts. Each operation is also defined in a primal (computational-basis) and dual (Hadamard-basis) domain, which makes dual domains the quantum feature with no classical counterpart. With these elements in place, we find that we can express several historically important algorithms and protocols in only a few lines of pseudocode, including quantum teleportation, Deutsch–Josza, Berstein–Vazirani, and Simon's and Grover's algorithms. I will then demonstrate how the expressive power of the notation enables much easier porting of classical intuitions when designing a quantum circuit.
I will conclude with a short overview of the main complexity classes, and how they map out the various problems relevant to quantum computing, at the level that I would want to introduce them to a class of fresh-minded quantum informatics students, to be used as a central contextualizing framework for the various quantum algorithms.

05 / WEDNESDAY 7 OCTOBER

Industry Day.

Industry, research institutes and workforce development

09:30–10:00	Maria Bartnes / DNV
10:00–10:30	Håvard Terland / d-fine
10:30–11:00	Lars Nordbryhn / IBM
11:00–11:30	Antoine Jacquier / Quanteam & Imperial College London
11:30–12:15	Discussion / break
12:15–13:45	Lunch
13:45–14:30	Steinar Brede / Innovation Norway
14:30–16:00	Discussion / Public/private partnership
16:00–18:30	Meet the Companies (next page)
19:30	Dinner

09:30–10:00

Maria Bartnes

DNV

The Quantum Countdown

The timeline for the PQC transition is tight, while migration will take years. The challenge is not just a technical one, it is just as much about organizational barriers and changes. If we manage to turn quantum urgency into controlled action, we are on the right path. In addition, we need to prepare for the age of quantum in more ways than the transition of cryptographic algorithms.

10:00–10:30

Håvard Terland

d-fine

Quantum Computing at d-fine

d-fine have participated in more than 15 different projects within quantum computing. In this talk, an overview of our efforts in the quantum computing industry and the opportunities and concerns that our clients see in the space will be presented.

10:30–11:00

Lars Nordbryhn

IBM

Building a quantum computing ecosystem

Building a thriving quantum computing ecosystem requires more than advancing hardware. It demands collaboration across industry, academia, government, and startups to develop skills, algorithms, applications, and a quantum-ready workforce. IBM's approach brings together researchers, developers, educators, and technology partners through shared access to quantum systems, open-source tools, and joint innovation programs. By fostering collaboration and knowledge exchange, IBM aims to accelerate the practical adoption of quantum computing and unlock real-world value across science, business, and society.

11:00–11:30

Antoine Jacquier

Quanteam & Imperial College London

Quantum Computing: a new toolbox for computations

Quantum hardware and quantum algorithms are being developed in parallel. This is both exciting and challenging as hardware evolves and some algorithms may thus quickly become obsolete. The goal of this talk is to emphasise the need for greater collaboration between industry and academia, to understand what types of algorithms are required, for what types of hardware and what skills are required to develop them and move them to production.

13:45–14:30

Steinar Brede

Innovation Norway

TBA

05 / WEDNESDAY / SPECIAL EVENT

Meet the companies.

16:00–18:30 / STUDENTS AND COMPANIES

An afternoon connecting students with companies and the people behind them.

16:15 / QUANTUM COMPUTING INTRODUCTION

Dennis The

UiT The Arctic University of Norway

Beyond the Hype: What is Quantum Computing?

Quantum computing promises to solve certain problems beyond the reach of today's computers. Governments and industry are investing billions in the development of quantum technologies and the pursuit of quantum advantage. But beyond the headlines and the hype, what is quantum computing actually all about? This talk offers an accessible introduction to the strange and fascinating world of quantum information. We will explore how qubits differ from ordinary bits and examine three central ideas of quantum computing: superposition, measurement, and entanglement. We will see how these ideas lead to new possibilities for computation and cryptography, while separating realistic expectations from common misconceptions. No prior background in mathematics or physics is required, only curiosity.

AFTERNOON / INDUSTRY PRESENTATIONS

Company presentations follow in the afternoon programme; individual times and speakers are not supplied.

06 / THURSDAY 8 OCTOBER

Into the classroom.

09:30–16:30 / TEACHER EDUCATION AND OUTREACH

09:30–10:30	Megan Wawro
10:30–11:00	Discussion / break
11:00–11:30	Max Hoffmann
11:30–12:15	Discussion
12:15–13:45	Lunch
13:45–14:30	Thora Storm
14:30–15:00	Davor Horvatić
15:00–15:45	Jörg Gutschank / Quantum Computing in STEM Education
15:45–16:30	Jörg Gutschank / Calculating on Real Quantum Computers

09:30–10:30

Megan Wawro

Virginia Tech, USA

Student Understanding of Linear Algebra in Quantum Settings

Quantum information science and engineering (QISE) is necessarily an interdisciplinary field, drawing from areas such as physics, computer science, mathematics, and engineering. With the global rise of QISE across a spectrum of forefronts, an important challenge in university education is understanding how students make sense of and leverage the foundational interconnectedness of mathematics in QISE. In this talk, I will share from my current research program that investigates how students reason about linear algebra concepts in coordination with quantum computing concepts across disciplinary settings. I will also integrate some relevant findings from my prior work on student understanding of linear algebra in quantum mechanics.

11:00–11:30

Max Hoffmann

Paderborn University

Making Sense of $\alpha|0\rangle + \beta|1\rangle$ with School Students – Ideas for a mathematical route to the qubit

Understanding quantum computing includes understanding what a qubit is and how one works with it. A qubit is a mathematical object, so even with school students the task is not to avoid the mathematics but to make it accessible through sound basic ideas. I sketch a suggestion for a possible route: from oscillations and their

superposition, via phasor diagrams, to the qubit, a coin gate and a quantum walk, and finally to the Bloch sphere. The talk shows anchor activities, points where students might stumble, and questions for discussion.

13:45–14:30

Espen Sjetne

Thora Storm High school, Trondheim

Quantum computing in upper secondary school in Norway

How are quantum topics taught in Norwegian upper secondary school today? Drawing on my experience teaching mathematics and Physics 2, I will outline our framework and current practice, and discuss what teachers need in terms of materials, professional development and collaboration to give pupils the competence they will need in the future.

14:30–15:00

Davor Horvatić

University of Zagreb, Croatia

Three Routes to Teaching Quantum Computing

Quantum computing is increasingly entering university curricula through different disciplinary routes. At the University of Zagreb, dedicated courses already exist within mathematics and electrical engineering/computer science, while the Department of Physics is currently considering how quantum computing should be introduced into the physics curriculum. Rather than designing such a course in isolation, we first examined the existing approaches and discussed prerequisites, expectations, and possible learning trajectories with colleagues from mathematics, computer science, and physics. These discussions highlighted both a substantial common core and the importance of discipline-specific entry points. For physics students, we argue that the common language of qubits, gates, circuits, entanglement, measurement, and basic quantum algorithms should be continuously connected to the underlying physical systems. A physics-oriented trajectory should therefore place particular emphasis on state preparation and control, physical measurement, decoherence and noise, experimental realizations of qubits, and the feasibility and limitations of implementing idealized computational operations in real devices. The aim of this contribution is to present the Zagreb context and to discuss how such a physics-centered learning trajectory might complement existing mathematical and computational approaches.

15:00–15:45

Jörg Gutschank

Science on Stage Germany / Leibniz Gymnasium Dortmund, Germany

Quantum Computing in STEM Education: From Open Teaching Material to a German Abitur Subject

Despite their growing importance, the fundamentals of quantum technologies are rarely taught in European secondary schools. Quantum computing offers a highly engaging, genuinely multidisciplinary context to change this, spanning Physics, Computer Science and Mathematics, yet schools seldom have room to explore

such topics across subjects over an extended period of time. In the project "Quantum Computing in STEM Education", twenty teachers from fifteen European countries collaborated over more than two years to develop open teaching material addressing exactly this gap. Working in international teams, the teachers designed, tested and refined the material in their own classrooms, continuously improving it through feedback and exchange with colleagues, supported by coordinators and scientific experts. The result is a teacher-driven, classroom-tested collection of hands-on experiments, worksheets, interactive resources and direct access to real quantum hardware, usable in established subjects, but also, and especially, for interdisciplinary project-based learning. This is exactly what we are now putting into practice at Leibniz Gymnasium, Dortmund International School: starting with the 2030 cohort, we offer "Quantum Computing" as an interdisciplinary project course, a mandatory, graded component of the Abitur curriculum that can also serve as students' fifth examination subject, built on this material. Students work toward proficiency level A2 (in two of three areas) of the European Competence Framework for Quantum Technologies (DOI 10.5281/zenodo.6834598). Mathematically, the course draws heavily on vectors, matrices and probability to describe qubits, gates and measurement, and we make active use of Qiskit not only to access real quantum hardware, but also as a computer algebra system in its own right, which simplifies these calculations considerably and lets students focus on the underlying ideas rather than the arithmetic. Teaching quantum computing in secondary school is about early literacy and fair access to the knowledge needed to participate in a future shaped by quantum technologies. This talk presents both the material and its first concrete implementation as an Abitur subject. Project materials: science-on-stage.eu/quantumcomputing

15:45–16:30

Jörg Gutschank

Science on Stage Germany / Leibniz Gymnasium Dortmund, Germany

Calculating on Real Quantum Computers

Quantum computers are no longer a distant vision, several are already accessible online and ready to be programmed. Yet hands-on experience with real quantum hardware rarely reaches secondary school classrooms, let alone teacher training itself. In this hands-on mini-workshop, participants connect to a real quantum computer at IQM, a Finnish company, and run programs written with Qiskit, the open-source quantum computing framework from IBM. Working in small groups on prepared Raspberry Pis, participants create an account, obtain an API token, and telecontrol real quantum hardware directly: measuring a single qubit, then letting the quantum computer add 1 and 1 for them. Time permitting, we take a first look at Deutsch's algorithm, the simplest example of a quantum computer outperforming a classical one. This workshop grows out of "Quantum Computing in STEM Education", the Science on Stage project in which twenty teachers from fifteen European countries developed open teaching material to bring quantum computing into secondary school classrooms. Project: science-on-stage.eu/quantumcomputing

PROJECT MATERIALS

science-on-stage.eu/quantumcomputing

07 / FRIDAY 9 OCTOBER

Future directions. Shared questions.

09:30–12:00 / FINAL MORNING

09:30–10:30	Nathan Lombard
10:30–11:00	Roundtable
11:00–11:30	Vision
11:30–12:00	Discussion
12:15–13:45	Lunch

09:30–10:30

Nathan Lombard

University of Nantes, France

New technology, old pedagogy? On the didactic transposition of quantum computing

An online search rapidly shows many courses and books on quantum computing are designed the usual way: Chapter 1, Section A, such theorem, such principle, such algorithm. In particular, they rarely address a specific question (coming either from research, industry or curiosity) in any other way than rhetorical. This observation can be related to broader phenomena, well identified by didactic research on inquiry-based teaching and learning. However, this may sound strange when it comes to quantum computing, which frequently involves approaching a problem in a novel way. How come new technologies are taught relying on old pedagogies? But, to what extent could quantum computing be transposed in an inquiry-based manner? Where should the questions thus studied come from, and how should it work in practice?

TEACHING / RESEARCH / COLLABORATION

08 / YOUR HOSTS

The organising committee.

Department of Mathematical Sciences, NTNU

Yael Fleischmann, IMF-NTNU, Norway

Alexander Schmeding, IMF-NTNU, Norway

Max Hoffmann, Paderborn University, Germany

Kurusch Ebrahimi-Fard, IMF-NTNU, Norway

EXPLORE FURTHER

Workshop webpage / DidactiQC project / Official schedule

DidactiQC

Teaching and Learning of Quantum Computing
5–9 October 2026 • NTNU, Trondheim

EDUCATION × RESEARCH × INDUSTRY