QUANTUM TECHNOLOGY NEEDS SKILLED HANDS

A quantum computer may be one of the most advanced technologies ever conceived. Yet before it can calculate, communicate or sense, it must first be built. As quantum technology moves from research laboratories to pilot production lines, demand is growing for people who can assemble cryogenic systems, integrate optical hardware, maintain vacuum equipment and build precision components.

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From quantum science to precision engineering

Quantum technology is often associated with theoretical physics, complex calculations and groundbreaking scientific discoveries. However, turning quantum principles into working equipment requires much more than scientific knowledge. It requires skilled technicians who understand materials, manufacturing processes, electronics and precision assembly. Precisely the domain of the research instrument maker.

Since 2021, the Leidse instrumentmakers School (LiS) has been developing quantum-related education specifically for vocational students. In collaboration with national quantum initiative QDNL, LiS coordinates national efforts to introduce quantum technology into vocational education and connect students with this rapidly developing industry.



Workshop 'Niks is cool' (Nothing is cool): students experiment with liquid nitrogen and vacuum equipment to investigate various phenomena.

The objective is not to turn instrument makers into quantum physicists, but to prepare them for the engineering challenges behind quantum hardware.

Key quantum players

LiS

The Leidse instrumentmakers School (LiS) is the oldest Dutch vocational educational institutions and has, over the years, retained its status as an independent vocational school, dedicated to the training of (research) instrument makers. The school, located in Leiden (NL), provides project-based education in close collaboration with academia and industry.

QDNL

QDNL is the national initiative championing the growth and continued development of a world-class quantum technology ecosystem in the Netherlands. The Netherlands is already home to groundbreaking quantum research, talent and entrepreneurial momentum. QDNL helps translate those strengths into working technologies, commercial companies and practical applications that create economic value and societal impact.

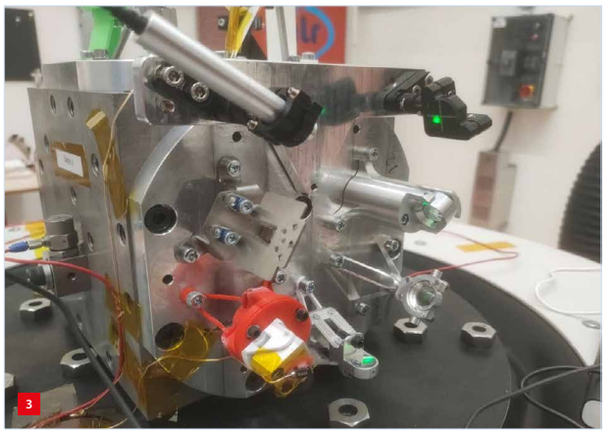
TLCs

To accelerate the adoption of quantum technologies in the economy, Talent & Learning Centres (TLCs) are dedicated to building a highly skilled workforce equipped with the expertise needed to turn scientific breakthroughs into real-world applications and commercial products. Strategically embedded within the QDNL ecosystem, TLCs play a vital role in fostering sustainable growth now and in the future. Locations are in Delft/Leiden, Amsterdam, Twente and Eindhoven.

WWW.LIS.NL
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Cleanroom workshop: gowning, contamination control and precision assembly.



Elective Optical Engineering: optomechanical assembly and alignment.

Research instrument makers: a natural fit

The connection between quantum research and instrument making has deep historical roots in Leiden. In 1901, physicist Heike Kamerlingh Onnes established a school for instrument makers alongside his laboratory. His cryogenic research required highly skilled technicians capable of developing equipment that did not yet exist. His instrument makers helped build the apparatus of the laboratory where helium was first liquefied in 1908 and superconductivity was discovered in 1911.

More than a century later, LiS still operates at the interface between scientific research and instrument making. The four-year, secondary vocational education programme Research Instrumentmaker combines mechanical design, precision manufacturing, materials, electronics and programming. Students learn not only how to manufacture components, but also how to translate technical requirements into functional instruments. This combination of designing and making is particularly valuable in quantum technology, where equipment frequently involves prototypes, exceptional tolerances and challenging operating conditions.

Bringing quantum into the workshop

Rather than concentrating on advanced quantum theory, LiS focuses its quantum education on a different question: which engineering skills does the quantum industry require? The answer is found not in quantum algorithms, but in the enabling technologies behind quantum hardware: cryogenics, vacuum technology, vibration isolation, cleanroom procedures, optics, photonics, electronics and precision mechanics.

These topics are brought to life through hands-on experiments, developed in close cooperation with universities, research institutes and industrial partners, including Leiden University, The Hague University of Applied Sciences ('De Haagse Hogeschool', HH), Nikhef, SRON, Leiden Cryogenics, Onnes Technologies, Demaco, Hittech and several vacuum technology specialists connected to the Dutch Vacuum Society (NEVAC). These collaborations bring industrial equipment, real components and real engineering challenges into the classroom.

Cryogenics and vacuum technology

With the workshop 'Niks is cool' (Nothing is cool), students experiment with liquid nitrogen and vacuum equipment to investigate phenomena such as thermal contraction, leak detection and vacuum behaviour (Figure 1). Questions include how much a stainless-steel component shrinks during cool-down, why a thermal link is often made from OFHC (oxygen-free high thermal conductivity) copper while a support structure is not, and how outgassing affects achievable vacuum levels. Demonstrations such as an expanding marshmallow, a silent bell under vacuum and a collapsing vessel make the underlying physics visible.

Vibration isolation

The workshop 'Toveren met massa's, veren en zwaartekracht' (Magic with masses, springs and gravity) introduces students to resonance, damping and transmissibility above the natural frequency. They learn how vibration isolation systems suppress disturbances from pumps, pulse-tube coolers and building vibrations before these can affect sensitive measurements.

Cleanroom technology

LiS developed cleanroom education in cooperation with SRON Space Research Organization Netherlands, initially for space instrumentation. Students learn contamination control, cleanroom classification, ESD (electrostatic discharge) discipline and precision assembly (Figure 2). Particular attention is paid to particle generation, handling procedures and traceability, all critical factors when assembling photonic chips, quantum devices and other high-tech components.

The programme has since been adopted by other vocational institutions. In March 2026, a shared educational cleanroom opened at HH's Bètafactory on the TU Delft campus. This facility enables students from vocational education, applied



Gunter Helms (LiS, TLC Delft/Leiden) with the Bloch sphere: a transparent sphere with an arrow, driven by three omniwheels, that shows the state of a single qubit. (Photography: De Kabelfabriek)

science universities and research universities to gain practical experience in a professional cleanroom environment.

Optics and photonics

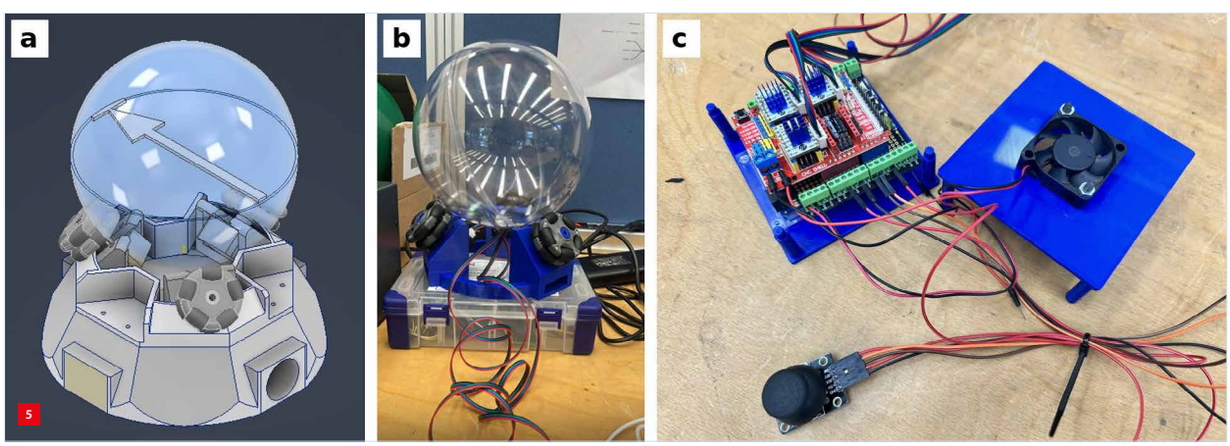
Optical systems are increasingly important in quantum communication, sensing and computing. Through the Optical Engineering elective, students gain experience with optical components, mechanical mounting, alignment and optomechanical design (Figure 3). They learn how alignment tolerances, thermal stability and mounting stresses influence optical performance, and how these factors affect systems used in quantum communication, sensing and photonics. An introductory quantum course provides additional background on concepts such as superposition, entanglement, qubits and quantum gates.

Making quantum tangible

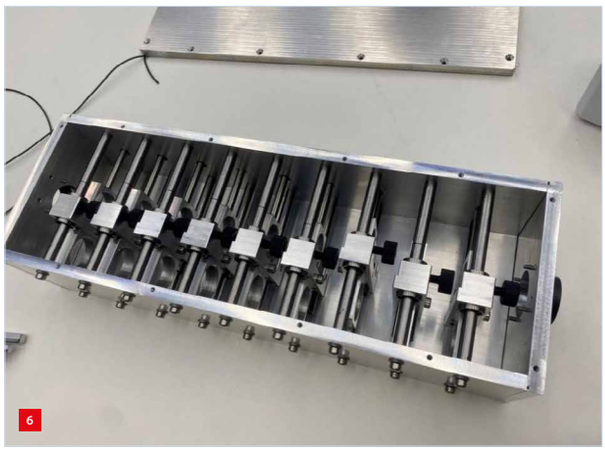
One of the most successful approaches within the LiS programme is the development of physical demonstrations that make quantum concepts understandable. These projects bring together students from vocational education, universities of applied sciences and research universities. While physics students contribute scientific knowledge, research instrument makers translate concepts into practical designs and working equipment.

An example is the mechanical Bloch sphere, a device that visualises the state of a quantum bit (Figures 4 and 5). LiS students designed and manufactured a transparent sphere supported by three motor-driven omniwheels. The project required CAD design, mechanical manufacturing, motion control, electronics integration and software interfacing, turning an abstract quantum concept into a multi-disciplinary engineering challenge. By controlling the motors, the sphere can rotate in different directions to demonstrate quantum operations. In cooperation with HH students, the system was further developed into an interactive demonstration connected to a web application.

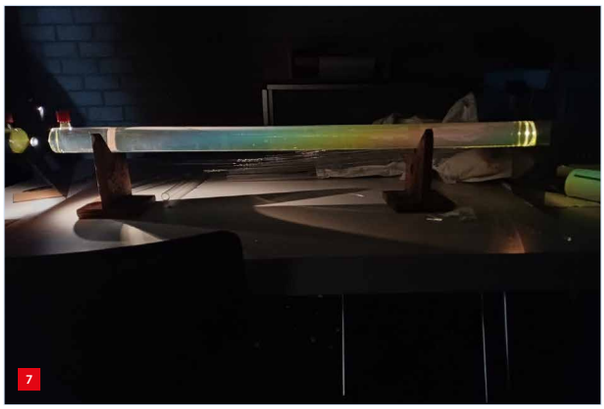
Other educational projects include a reconstruction of the Stern-Gerlach experiment (demonstrating quantised spin), an optical polarisation puzzle (Figure 6), a demonstration of optical activity using sugar solutions (Figure 7), and a Planeterrella, which simulates auroral effects. Each project challenges students to combine mechanical engineering, electronics, programming and scientific understanding. But more importantly, students experience the complete engineering process: from initial requirements and design decisions to manufacturing, assembly, testing and improvement.



The Bloch sphere.
(a) CAD design.
(b) First prototype with three omniwheels.
(c) Stepper-motor electronics with joystick.



The photon filter puzzle for the education lab.



The barber pole: a tube of sugar solution lit with white light.

Industry as a classroom

Quantum companies are not only future employers; they are active partners in the educational programme. Companies such as QuantWare, Leiden Cryogenics, Qblox, Orange Quantum Systems, Single Quantum, QphoX and Delft Circuits offer internships, graduation projects, company visits and collaborative assignments.

Students may work on cryogenic assemblies, precision components, cabling, vacuum equipment, test systems or cleanroom processes. These experiences expose students to the realities of a developing industry, where specifications change rapidly and innovative solutions are often required. They also allow companies to engage early with talent that is in demand across the entire high-tech sector.

Building a national educational network

Quantum education cannot depend on a single institution. Within QDNL, LiS works with other vocational schools, including ROC Twente, Vista College, Noorderpoort, Summa and ROC Mondriaan, to share educational materials and practical workshops. The program also connects to the regional Talent & Learning Centres, which bring together educational institutions, research organisations and businesses. These centres facilitate internships, teacher training, company visits and interdisciplinary projects.

Teachers themselves are an important part of this approach. By spending time at quantum companies and research institutes, they can keep their knowledge current and translate industrial developments into relevant educational activities. A flexible educational structure makes the program accessible to different audiences. Quantum-related subjects are offered through regular courses, electives and shorter workshops that other institutions can incorporate into their own programmes.

Preparing for a growing industry

The Dutch quantum sector is moving towards industrialisation, with increasing attention to manufacturing, reproducibility, quality control and reliability. European pilot production lines for superconducting, photonic and semiconductor quantum technologies illustrate this transition.

At the same time, the Netherlands faces a broader shortage of skilled high-tech professionals. National initiatives such as the Beethoven programme (focused on the semiconductor industry) aim to strengthen technical education and expand the workforce needed by high-tech industries. That is why, in July 2026, LiS launched a national programme with partner institutions to strengthen precision craftsmanship and expand educational capacity.

For research instrument makers, this creates opportunities extending well beyond quantum technology. The skills required to assemble a cryogenic quantum system are closely related to those needed in scientific instrumentation, aerospace and advanced medical equipment. This overlap makes investment in practical quantum education particularly valuable.

Making quantum education sustainable

An important next step is ensuring that quantum-related education becomes a permanent part of vocational training. Embedding the relevant technologies in existing instrument-making programmes will make the education sustainable and accessible to future generations. Further cooperation with industry, international internships and recognised qualifications in areas such as cleanroom technology could strengthen this development.

The ambition is not simply to train technicians for one emerging industry, but to educate adaptable research instrument makers who can contribute across the high-tech sector. After all, quantum hardware is built from the same foundations as many other precision-engineering systems: cryogenics, vacuum technology, optics, electronics and precision mechanics.