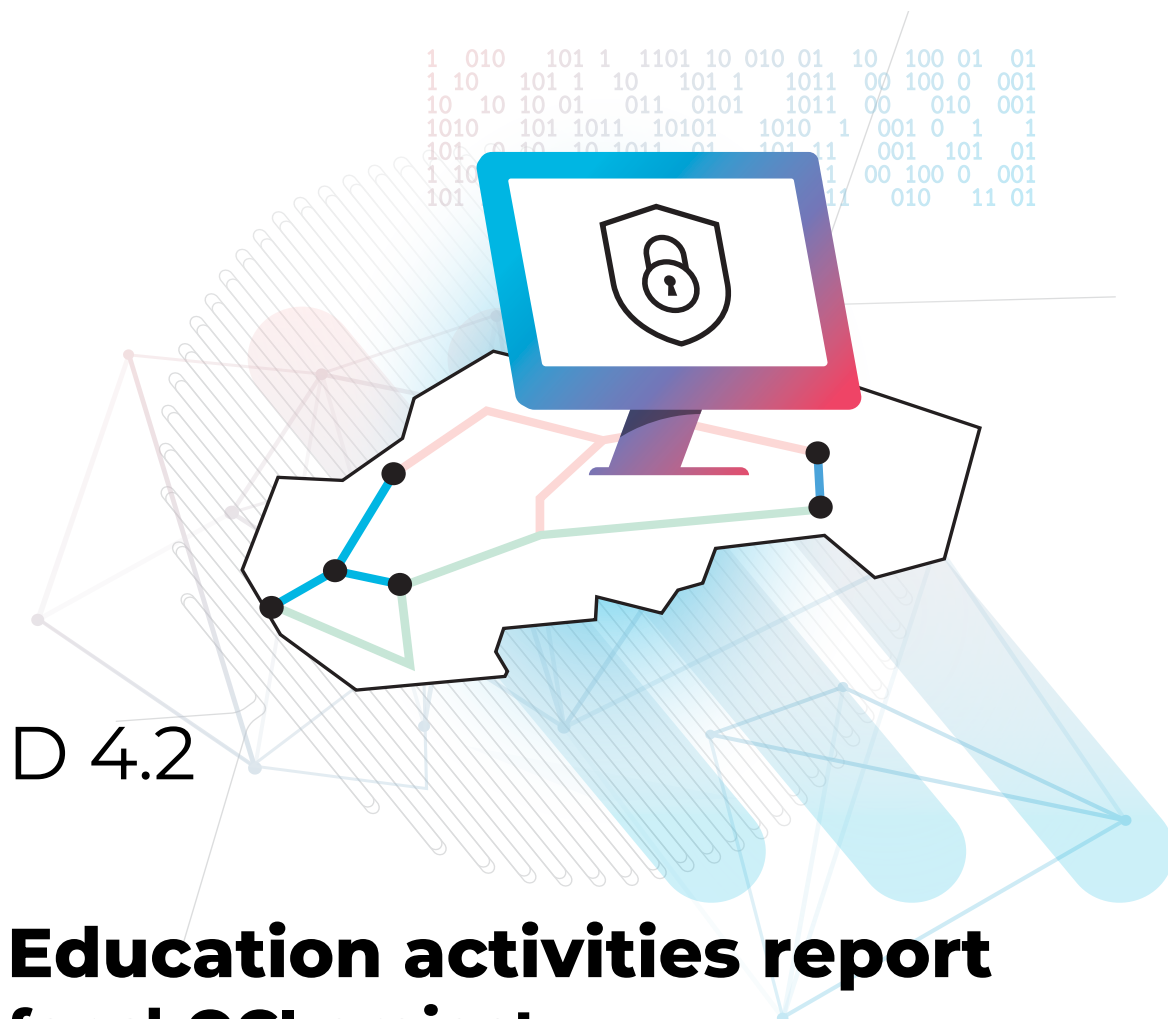




Slovak Quantum
Communication
Infrastructure



D 4.2

Education activities report for skQCI project



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BACKGROUND: ABOUT SKQCI PROJECT

This project aims to develop a quantum communication infrastructure in Slovakia.

THREE MAIN ACTIVITIES:

1. The goal is to use the same hardware and technology for implementing various entanglement-based QKD protocols to populate, in this first phase, six nodes across Slovakia (later on another six nodes), thus **creating the backbone of a national quantum network**. The chosen approach will not only meet the criteria of this call for connecting several European cities with QKD links. Still, it will also lay the foundation for the next steps in achieving a quantum internet that goes beyond simple cryptographic tasks, allowing Slovakia to consider other quantum communication protocols in the future.
2. The objective of building this infrastructure within the duration of this project will also be accompanied by the development of **our own superconducting nanowire single-photon detectors and cryogenic systems**, which will help accommodate the needs of a growing quantum network beyond the timeline of this funded research.
3. The current project enables Slovakia to actively participate in the EuroQCI European mission by developing quantum communication technologies and helping **establish a training research center** that will benefit the whole Central-European territory, creating a sustainable knowledge-based ecosystem for future quantum engineers.

1. Introduction

During the project (1 January 2023 – 30 June 2026), the consortium continued implementing the educational objectives of Work Package 4 (eduQUTE – International Training and Education Centre for Quantum Technologies) in accordance with the Description of Action and the Dissemination, Communication and Exploitation Plan.

Educational activities were designed to support the development of a sustainable quantum technology ecosystem in Slovakia by:

- strengthening interdisciplinary university education;
- developing practical skills in quantum communication and quantum computing;
- supporting early-stage researchers;
- establishing long-term cooperation between academia and industry;
- creating sustainable educational resources and training programmes.

Rather than focusing on individual educational events, the consortium established long-term educational structures that will continue beyond the duration of the skQCI project.

2. Coordination of University Quantum Education Programmes

TASK T4.1

OBJECTIVE

The objective of Task T4.1 was to coordinate educational activities among Slovak universities and research institutions and to establish the foundations for interdisciplinary university education in quantum technologies.

Activities implemented

During the project implementation period, the consortium coordinated educational activities between:

- Institute of Physics SAS,
- Comenius University Bratislava,
- Slovak University of Technology,
- Pavol Jozef Šafárik University,
- QUTE.sk – Slovak national Center for Quantum Technologies,
- FH Technikum Wien.

Regular coordination meetings enabled participating institutions to exchange educational experience, identify complementary expertise and jointly prepare new educational programmes in quantum technologies.

The consortium continued developing educational content covering quantum communication, quantum computing, quantum optics, quantum photonics and quantum information processing. Rather than creating an entirely new study programme, the project supported the integration of specialised quantum technology subjects into existing Bachelor's and Master's curricula at partner universities.

Based on this expertise the consortium has participated at open call for **novel quantum technology study programs** and Comenius University in Bratislava has completed the proposal for master program dedicated for quantum technologies.

The other achievement was starting of a discussion of the certified interdisciplinary course of UPJŠ Košice and QUTE.sk. The course combines theoretical foundations with practical laboratory demonstrations and provides students with an interdisciplinary introduction to modern quantum technologies.

The consortium also established international educational cooperation with FH Technikum Wien, laying the foundations for long-term joint educational activities, including mainly summer schools.

MAIN ACHIEVEMENTS

During the project implementation period the consortium successfully:

- strengthened cooperation between Slovak universities;
- start of a preparation a certified interdisciplinary university course;
- expanded specialised quantum subjects within existing study programmes;
- established international cooperation with FH Technikum Wien;
- created a national platform for future quantum technology education.

Contribution to project objectives

These activities significantly contributed to the long-term objective of establishing a coordinated national education ecosystem capable of supplying highly qualified experts for the future Slovak Quantum Communication Infrastructure and the wider EuroQCI initiative.

3. Training of Young Researchers

TASKS T4.5, T4.6 MILESTONES M11, M12

OBJECTIVE

The objective of Tasks T4.5 and T4.6 was to strengthen human capacity in quantum technologies by establishing support mechanisms for doctoral students and postdoctoral researchers. These activities contribute directly to the long-term sustainability of the Slovak Quantum Communication Infrastructure by preparing the next generation of researchers and engineers with expertise in quantum communication, quantum photonics, quantum computing and related technologies.

Activities implemented

Throughout the project implementation period, the consortium developed two complementary support schemes: **phdQUTE**, focusing on doctoral education, and **fellowQUTE**, supporting postdoctoral researchers.



Figure 1 – 16. 4. 2024, “Prvý kvantový FEIK,” a lecture series organised by Accenture, and held at Campus Lab of the Faculty of Electrical Engineering and Informatics (FEI) of the Slovak University of Technology (STU).

Figure 2 – 9 Dec. 2025, Final lecture in the course Computer Fundamentals at FEI STU, Bratislava, Slovakia. Mário Ziman.

phdQUTE

Project partners tried to establish the phdQUTE support scheme to increase the number of doctoral students working in quantum technologies across partner institutions. Due to national legislation governing doctoral studies, it was not possible to launch a single centralised international call. Instead, each beneficiary incorporated phdQUTE positions into its institutional recruitment procedures while maintaining common objectives and coordinated promotion across the consortium.

During the project implementation period, partner institutions advertised doctoral positions in research areas directly supporting the skQCI project, including quantum communication, quantum optics, quantum photonics and quantum information processing. Eleven doctoral positions were opened across the consortium, with seven students actively continuing their doctoral studies during the project implementation period. Doctoral researchers became integrated members of the research teams and contributed directly to the implementation of the scientific objectives of the project.

CourseQUTE Lecture Series and Colloquia

QUTE.sk has continued to serve as a hub for advanced learning, offering free lectures by leading international experts. These lectures, primarily targeting PhD students and professionals, covered topics such as:

- April 16-18, 2024 – **John Rarity**: *Quantum Photonic Device Engineering*
- May 13-17, 2024 – **Dieter Meschede**: *The Quantum World – From Experimental Insight to Technology*
- June 10-14, 2024 – **Mark Hillery**: *Introduction to Quantum Algorithms*
- April 1 - 10, 2026 – **Barry C. Sanders**: *Quantum Computing – Principles, Possibilities and Practicalities*

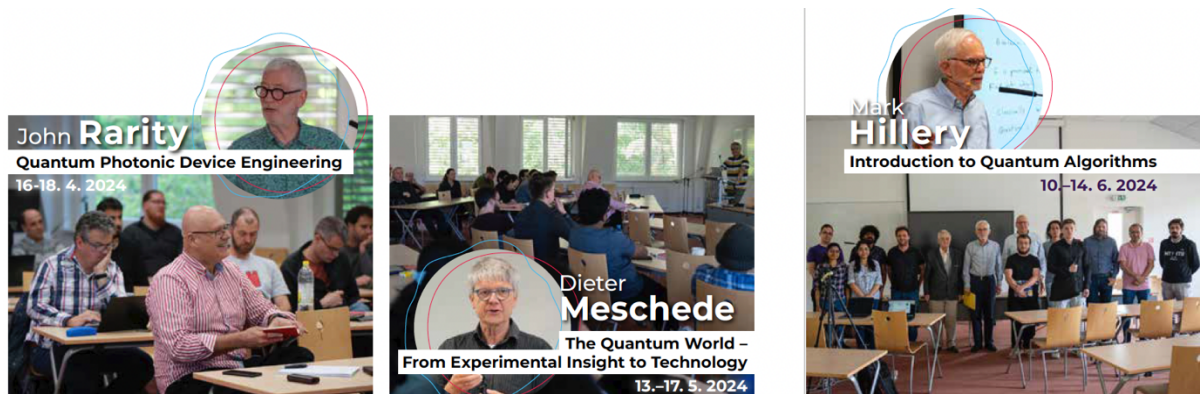


Figure 3 – coursQUTE series in 2024

Each session attracted 30–50 participants mostly PhD. students, reflecting the growing interest in quantum technology education. More about:

courseQUTE: <https://qute.sk/eduqute/coursequte/>

colloQUTE: <http://qute.sk/eduqute/colloqute/>

fellowQUTE scheme

In parallel, the consortium prepared the fellowQUTE programme to attract talented postdoctoral researchers in quantum technologies. Preparation of the programme included the development of eligibility criteria, evaluation procedures, communication strategy and dissemination activities. The programme was designed as an open international fellowship supporting excellent researchers interested in pursuing their research careers at one of the QUTE.sk partner institutions.

The first fellowQUTE call was published in 2024 through the QUTE.sk website and the EURAXESS portal. Although the fellowship programme was developed within the framework of WP4, its financial sustainability was ensured through resources provided by the QUTE.sk association rather than the skQCI project budget. This approach enables continuation of the programme beyond the duration of the project and supports the long-term development of the Slovak quantum research ecosystem.

fellowQUTE 2024 • Výsledky • Results

Poradie Order	Účastník Applicant	Téma Topic	Ústav Institution	Nástup Start day
1.	Marián Janík	High kinetic inductance superconductors for quantum circuits applications	EIÚ SAV IEE SAS	15. 11. 2024
2.	Ryszard P. Kostecki	Relative entropic and thermodynamic (post)quantum structures	FÚ SAV IP SAS	1. 1. 2025
3.	Fereshte Shahbeigi	Quantum Channels: Resources and Applications	FÚ SAV IP SAS	—

More about fellowQUTE scheme: <http://qute.sk/opportunities/fellowqute/>

mobiQUTE scheme

The consortium actively supported the mobility of young researchers through mobiQUTE scheme support collaborative research activities organised within the project and by partner institutions. These activities facilitated knowledge exchange, strengthened international collaboration and provided early-stage researchers with opportunities to interact with leading experts in quantum technologies.

Young researchers were actively involved in the implementation of the skQCI project throughout the whole project duration. Doctoral students, postdoctoral researchers and early-career scientists participated in research activities, development of quantum communication technologies, educational events, dissemination activities and practical demonstrations. Their direct involvement ensured that education and research progressed hand in hand, allowing

participants to gain experience with real research infrastructures and contribute to the scientific and technical objectives of the project.

More about mobiQUTE scheme: <http://qute.sk/opportunities/mobility-call/>

MAIN ACHIEVEMENTS

During the project implementation period, the consortium:

- established the **phdQUTE** doctoral support scheme across partner institutions;
- several **courseQUTE** series with actual topics from quantum technologies
- recruited a new generation of doctoral researchers working in quantum technologies;
- prepared and launched the **fellowQUTE** international postdoctoral programme;
- created transparent recruitment and evaluation procedures for future fellowship calls;
- strengthened career development opportunities for early-stage researchers.

Contribution to project objectives

The implementation of phdQUTE and fellowQUTE significantly strengthened the human capacity required for future quantum communication infrastructures. By supporting both doctoral and postdoctoral researchers, the consortium contributed to building a sustainable research environment capable of maintaining and further developing quantum technologies after completion of the project.

4. Practical Education and Hands-on Training

TASK T4.3 DELIVERABLE D4.1

OBJECTIVE

The objective of this activity (Task T4.3) was to complement formal university education with practical training, enabling participants to acquire hands-on experience with quantum technologies and to develop competencies directly applicable to quantum communication research and future quantum

infrastructures, while promoting collaboration between students, researchers and industrial partners from across Europe.

Activities implemented

Throughout the project implementation period, practical education formed an integral part of nearly all educational activities organised within WP4. Rather than being delivered as standalone laboratory courses, hands-on sessions were incorporated into university lectures, international lecture series, Quantum Experience events, workshops, OpenSlava, European Researchers' Night, and the annual Quantum Technologies Summer School.

Participants had the opportunity to work directly with educational and research platforms covering both quantum communication and quantum computing. Laboratory demonstrations introduced fundamental quantum phenomena, including quantum entanglement, Bell inequality experiments and Quantum Key Distribution (QKD), while practical exercises familiarised participants with quantum circuits, quantum algorithms and programming using modern quantum computing platforms.

Particular emphasis was placed on connecting theoretical concepts with experimental implementation. Participants were encouraged to perform experiments, analyse measurement results and discuss practical challenges associated with the implementation of quantum technologies. This educational approach significantly improved understanding of quantum principles while strengthening practical competencies required for future research and industrial applications.

Quantum Technologies Summer School

The Quantum Technologies Summer School represented one of the flagship educational activities integrating theoretical lectures with intensive practical training. The summer schools organised during the project implementation period further strengthened international collaboration and provided participants with access to advanced laboratory demonstrations and industry-led workshops. A detailed description of the organisation, programme and educational outcomes is provided in **Deliverable D4.1 – Quantum Summer School Report**.



Figure 4 – QUTE Summer School 2024 Bratislava



Figure 5 – QUTE Summer School 2025 Vienna

Practical education was further strengthened through the active involvement of doctoral students and early-stage researchers, who not only participated in the activities but also contributed to the preparation of laboratory demonstrations, workshops and educational events. This approach promoted peer learning while allowing young researchers to develop teaching, communication and technical skills alongside their research activities.

MAIN ACHIEVEMENTS

During the project implementation period, the consortium:

- established an annual international Quantum Technologies Summer School;
- strengthened cooperation with FH Technikum Wien and other European partners;
- trained students and young researchers through intensive theoretical and practical programmes;
- provided participants with hands-on experience in quantum communication and quantum computing;

- developed the low-cost optiQUTE educational kit for high school students as part of the Science Courier initiative within the European Researchers' Night 2025 programme;
- actively involved doctoral students and early-stage researchers in delivering educational activities;
- promoted international networking among participants and lecturers.

Contribution to project objectives

The integration of practical education across all educational activities ensured that participants developed not only theoretical understanding but also practical competencies directly relevant to the implementation of quantum communication infrastructures. The summer school has become one of the flagship educational activities of the project. It significantly contributed to developing advanced skills in quantum technologies, strengthening international cooperation and creating a sustainable educational platform supporting the long-term objectives of skQCI and the EuroQCI initiative. This approach supports the long-term objectives of skQCI by preparing a highly qualified workforce capable of contributing to future quantum technologies in academia, industry and the public sector.

5. Educational Resources and Training Packages

TASK T4.2

MILESTONE M13, M14

OBJECTIVE

The objective of Task T4.2 was to facilitate knowledge transfer between academia, industry and the public sector by developing educational resources, specialised training materials and consultation services tailored to different stakeholder groups. The task aimed to increase awareness of quantum technologies beyond the academic community while supporting the future adoption of quantum communication technologies by industry, public institutions and other potential end users.

Activities implemented

Throughout the project implementation period, the consortium developed a portfolio of educational resources and specialised training activities addressing

the needs of multiple target groups. Building on the scientific expertise of the project partners, educational content was prepared for university students, researchers, industrial partners, public authorities and organisations interested in the future deployment of quantum technologies.

The educational resources supported a broad range of consultation and training activities delivered throughout the project implementation period. These included expert consultations with industrial partners, public institutions and policymakers, where project members presented the opportunities, challenges and potential applications of quantum technologies in secure communications and digital infrastructure. These interactions also provided valuable feedback regarding stakeholder expectations and future application scenarios, helping to align educational activities with emerging societal and industrial needs.

A key objective was to establish a common language between researchers and non-academic stakeholders. To achieve this, the consortium prepared specialised **Training packages** explaining the principles, current state and future applications of quantum communication, quantum computing and quantum-safe cybersecurity. The materials were designed to provide an accessible introduction to quantum technologies while addressing the specific interests of different sectors, including banking, software development, cybersecurity, public administration and industry. More information could be found on dedicated website: <https://qute.sk/trainings/>



Figure 6 – Training for Public and Private sectors

To ensure long-term accessibility, educational materials and information about available training opportunities were made available through dedicated online platforms maintained by QUTE.sk. The consortium continuously updated these resources with information on educational programmes, specialised lectures, training opportunities and consultation services, providing a sustainable entry point for organisations and individuals interested in quantum technologies.

MAIN ACHIEVEMENTS

During the project implementation period, the consortium:

- developed specialised educational materials for different stakeholder groups;

- prepared training packages addressing industry, cybersecurity and public-sector applications of quantum technologies;
- provided consultation and advisory services for industrial partners and public institutions;
- established online resources presenting educational opportunities and available training services;
- strengthened knowledge transfer between academia, industry and the public sector.

Contribution to project objectives

The activities implemented under Task T4.2 strengthened the transfer of knowledge generated within the skQCI project beyond the academic environment. By providing educational resources, specialised training and expert consultations, the consortium contributed to increasing quantum technology awareness among future users and stakeholders while supporting the long-term exploitation of project results. These activities complement the formal educational programmes implemented under WP4 and contribute to building a sustainable ecosystem supporting the future deployment of quantum communication technologies in Slovakia.

6. Impact and Sustainability

Impact of the Educational Activities

The educational activities implemented throughout the project implementation period have significantly strengthened the national ecosystem for quantum technologies in Slovakia. By combining formal university education, practical laboratory training, international cooperation, and specialised training for external stakeholders, the consortium established a comprehensive educational framework supporting the long-term objectives of the Slovak Quantum Communication Infrastructure (skQCI).

The coordinated approach adopted within Work Package 4 enabled the consortium to address the needs of diverse target groups, ranging from undergraduate and graduate students to doctoral candidates, researchers, industry representatives and public-sector stakeholders. Educational activities were designed to complement ongoing research activities, ensuring that participants gained both theoretical knowledge and practical experience directly

relevant to the development and deployment of quantum communication technologies.

An important outcome of the project has been the strengthening of collaboration between Slovak universities, research institutions and international partners. These collaborations have contributed to the harmonisation of educational activities, the exchange of expertise and the establishment of long-term partnerships that will continue to support quantum education beyond the duration of the project.

The active involvement of doctoral students, postdoctoral researchers and early-career scientists in both research and educational activities has further strengthened the national human capacity in quantum technologies. By integrating young researchers into the implementation of the project, the consortium created opportunities for professional development while ensuring the transfer of knowledge between experienced researchers and the next generation of quantum scientists and engineers.

Sustainability

A key objective of Work Package 4 was to establish educational activities that would remain sustainable beyond the lifetime of the skQCI project. Rather than focusing solely on individual events, the consortium invested in the development of long-term educational structures, reusable training materials and institutional collaborations that can continue to evolve after project completion.

The educational programmes, certified university courses, lecture series, practical training activities and international collaborations established during the project implementation period provide a solid foundation for the continued development of quantum education in Slovakia. Likewise, the educational resources and training packages developed within the project will continue to support universities, researchers, industry and public institutions in building knowledge and awareness of quantum technologies.

The consortium also established mechanisms for the continued support of young researchers through doctoral and postdoctoral programmes, strengthening the long-term availability of highly qualified specialists capable of contributing to future quantum communication infrastructures and related quantum technology initiatives.

Collectively, the activities implemented under Work Package 4 have contributed to the establishment of a sustainable national education ecosystem that supports the strategic objectives of the skQCI project, the EuroQCI initiative and the broader development of quantum technologies in Europe.

OVERVIEW OF RELISED EDUCATIONAL ACTIVITIES:

Target Audience	Date	Name of the activity	Content
Primary and Secondary School Students	2023 – 2026	European Researchers' Night	Interactive workshops and hands-on demonstrations presenting quantum experiments to school groups and the general public.
High-School Students	2025 – 2026	Virtual Classroom KVANTA	Hybrid educational platform introducing the fundamentals of quantum physics through interactive lectures, educational videos and learning materials. The platform supports young students to explore quantum science and technology.
Bachelor's and Master's Students	2023– 2026	University Courses and Specialised Lectures	Integration of quantum technologies into existing university curricula through specialised courses, invited lectures and interdisciplinary educational activities organised by partner institutions.
	2024	Quantum Experience	Career-oriented educational event combining lectures, laboratory demonstrations and discussions with researchers to introduce participants to research opportunities and careers in quantum technologies.
University Students and Young Researchers	2023– 2026	Quantum Technologies Summer School	International intensive training programme combining advanced lectures, practical laboratory sessions and industry-led workshops. Further details are provided in Deliverable D4.1.
PhD Students	2023– 2026	phdQUTE Programm	Doctoral support programme integrating young researchers into the scientific activities of the skQCI project while strengthening national expertise in quantum technologies.

Postdoctoral Researchers	2024–2026	fellowQUTE Programme	International fellowship programme supporting postdoctoral researchers through competitive recruitment and integration into research teams at QUTE.sk partner institutions.
Researchers	2023–2026	mobiQUTE	Mobility programme by QUTE.sk supporting research visits and other collaborative activities. The programme promotes knowledge exchange, strengthens international cooperation and provides young researchers with opportunities to develop their scientific expertise and professional networks within the European quantum technology community.
	2023–2026	International Collaboration	Participation in international conferences, workshops, lecture series, collaborative research activities and scientific exchanges, promoting knowledge transfer and strengthening European cooperation.
Industry Professionals and Public Authorities	2023–2026	Training Packages	Specialised educational resources and training activities covering quantum communication, quantum-safe cybersecurity and future applications of quantum technologies, supporting knowledge transfer beyond academia
	2023–2026	Consultation Services	Expert consultation and advisory services supporting industry, public authorities and academic institutions in the adoption and application of quantum technologies and quantum-safe communication.

Overall, the educational objectives of Work Package 4 were successfully implemented during the project implementation period. The consortium established a coordinated and sustainable framework for quantum education, strengthened national and international collaboration, supported the development of young researchers, and created educational resources that will continue to contribute to the growth of the Slovak quantum technology ecosystem beyond the duration of the project.