QUANTUM FOR EDUCATORS AND YOUNG STUDENTS

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IQC teacher resources
bit.ly/IQC-Teacher-Resources

IYQ 2025

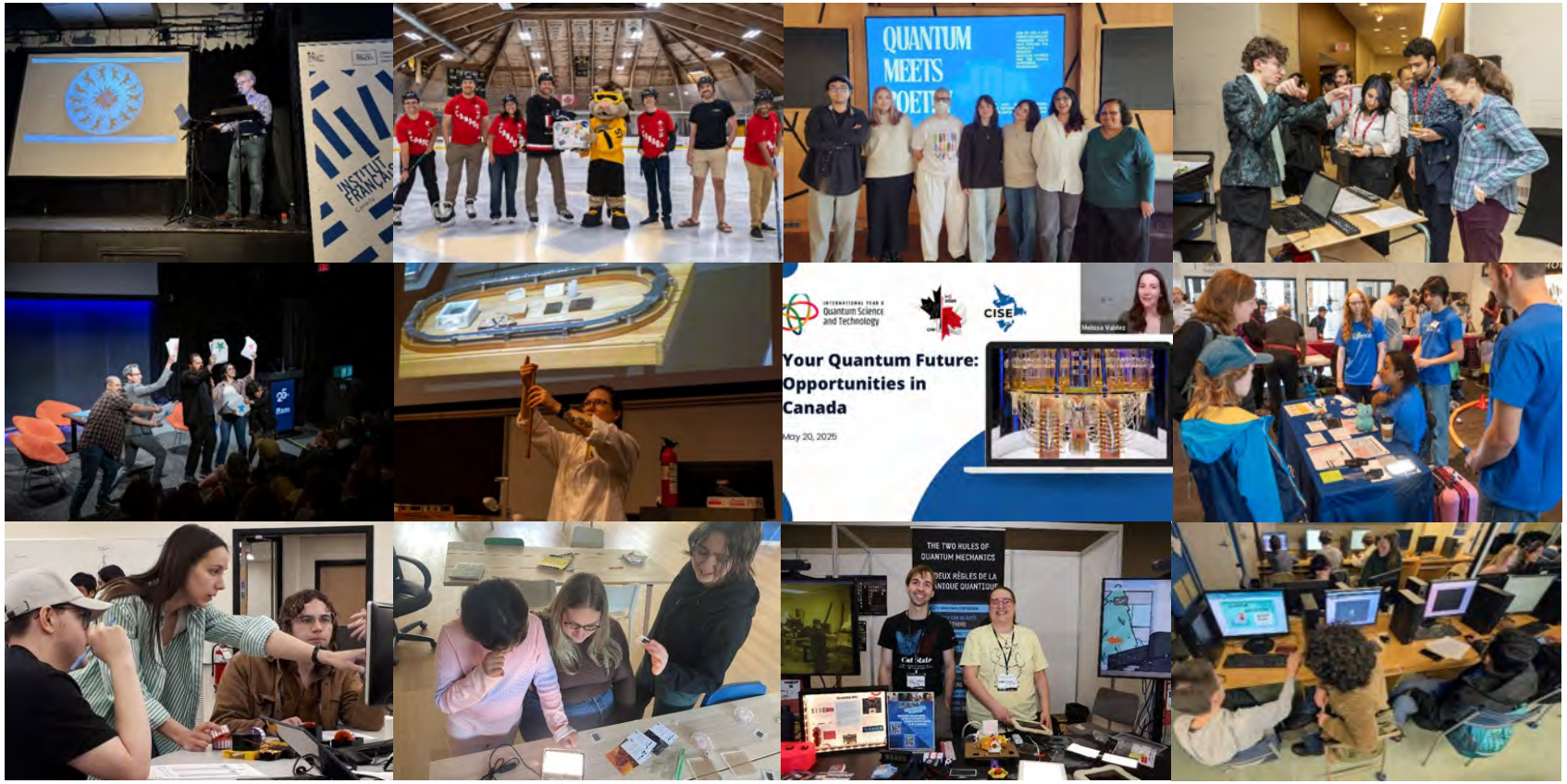
INTERNATIONAL YEAR OF Quantum Science and Technology

unesco

IYQ 2025

CAP

"The **International Year of Quantum Science & Technology** (IYQ), celebrated in 2025 to mark the 100th anniversary of quantum mechanics, helped raise public awareness of the importance and impact of quantum science and its applications on all aspects of life. Anyone, anywhere, was invited to participate in IYQ by helping others to learn more about quantum on this centennial occasion or simply taking the time to learn more about it themselves." (quantum2025.org)



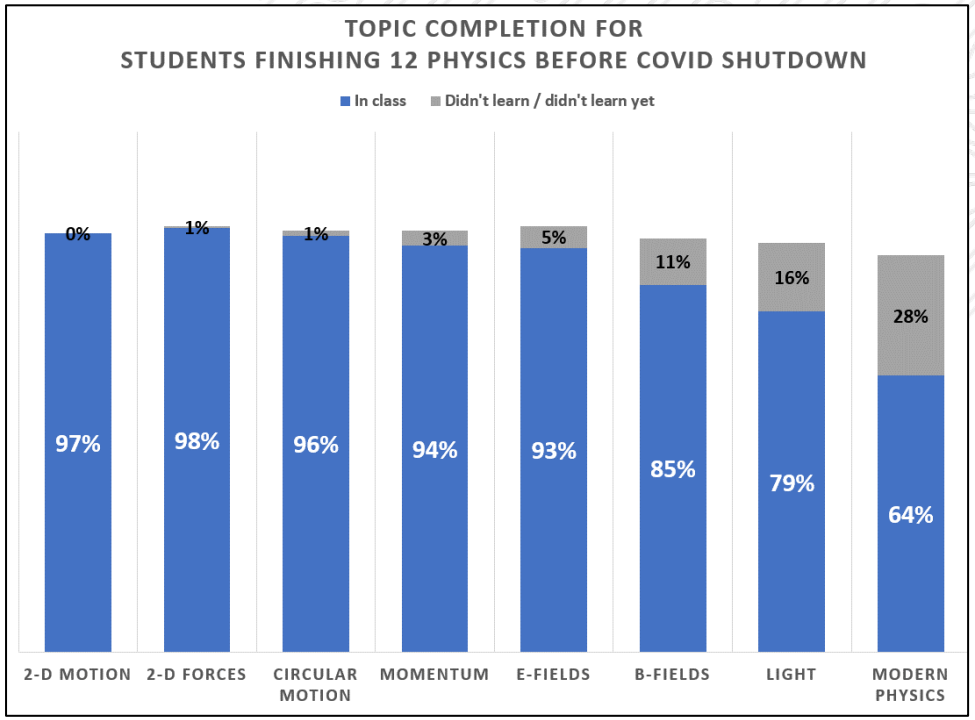
See the IYQ Canada yearbook,
"Quantum Science Across Canada in 2025."
Physics in Canada vol. 81 no. 2, pic-pac.cap.ca

Quantum for everyone

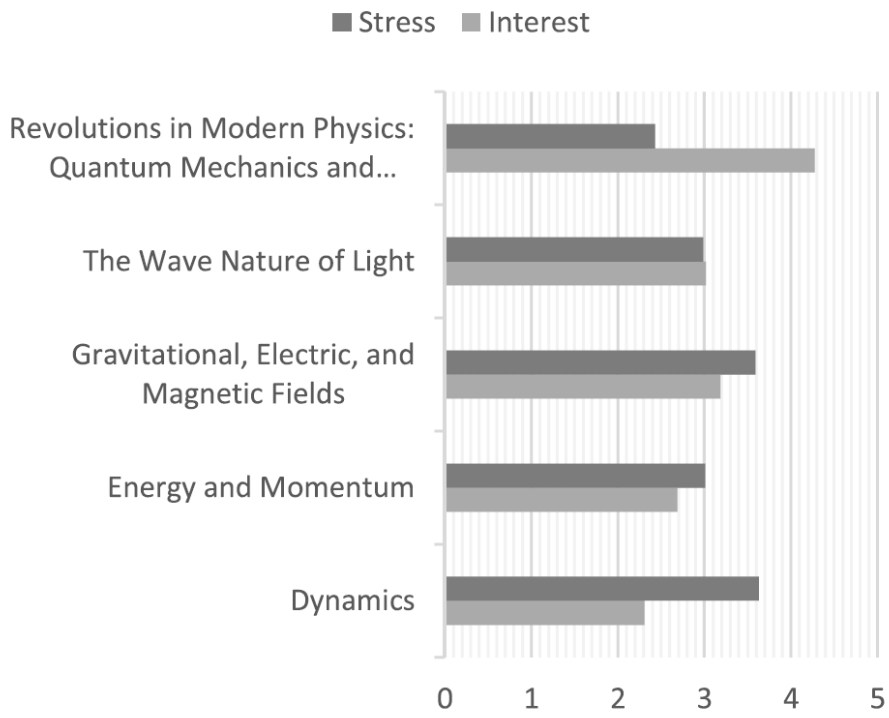
- Programs for educators
- Programs for high-school students
- Programs for undergraduate students
- Accessible materials for everyone

Quantum in the Curriculum

Case Study: Ontario SPH4U



Modern physics is often left out in Grade 12 physics classes
Source: Chris Meyer, Ontario Association of Physics Teachers
Pool: 432 incoming UofToronto Engineering Students
Link: http://newsletter.oapt.ca/files/effects-of-covid-shutdown.html



Modern physics is high-interest and low-stress for students
Pool: 101 students in SPH4U
Source: T. Richardson, *Phys. Educ.* 59, 035018 (2024)

Problems with quantum in HS

- **Time**: Course schedules are already packed
- **Comfort**: Teachers are uncomfortable with the material

If teachers find quantum confusing, they will likely (intentionally or not) pass on that assumption to their students.

Resources for secondary educators

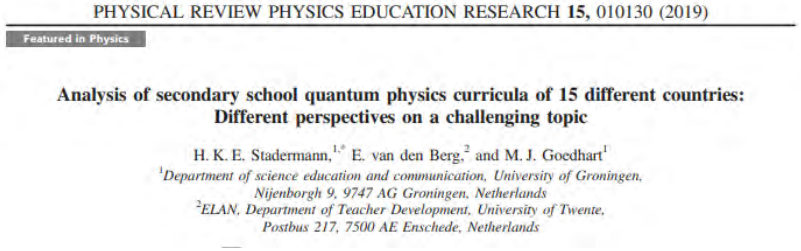
Lesson plans and resources

Workshops

National Q-12 Education Partnership

QIS KEY CONCEPTS for HIGH SCHOOL PHYSICS

Hubs and frameworks (USA)



Growing body of PER, especially in Europe

Quantum FOR ALL

Teacher-led networks (USA)

QEd Quantum for Educators

3-day workshop for high-school physics educators.

30-40 teachers annually, 250+ in-person program alumni.

Held annually since 2015.

Materials developed in collaboration with educators.

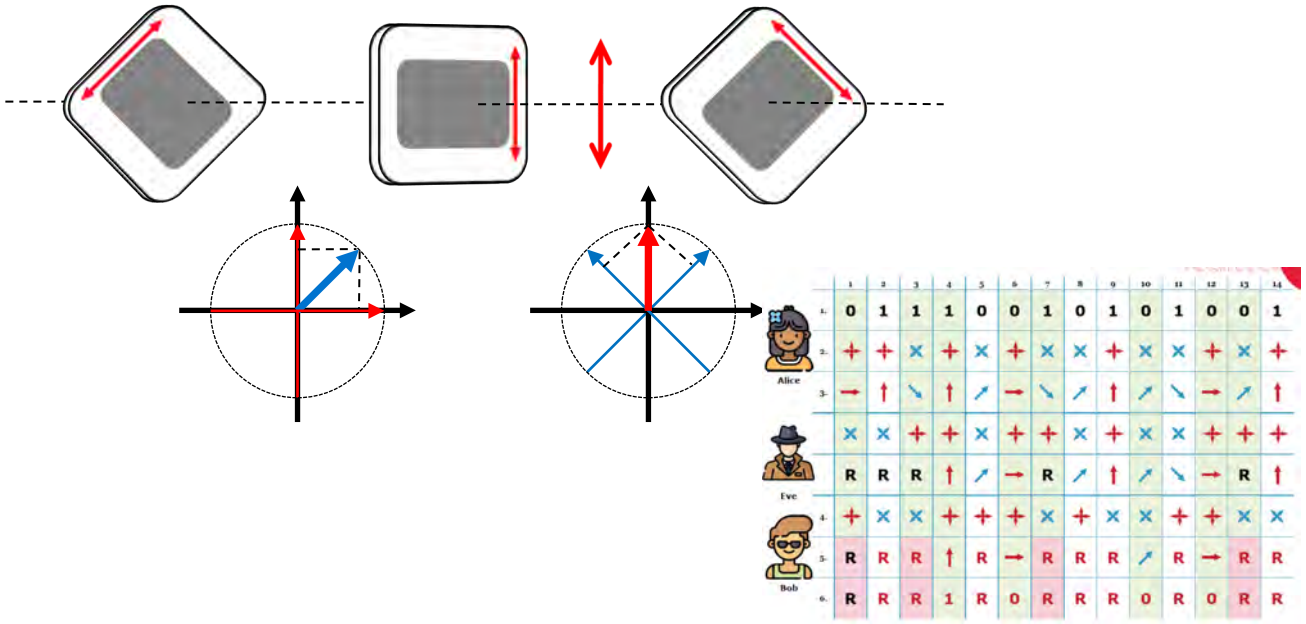
All costs covered by IQC for teachers within Canada, including substitute coverage.

Next sessions 2026 November 20-22, open to educators internationally.

* Known as Schrödinger's Class until 2023

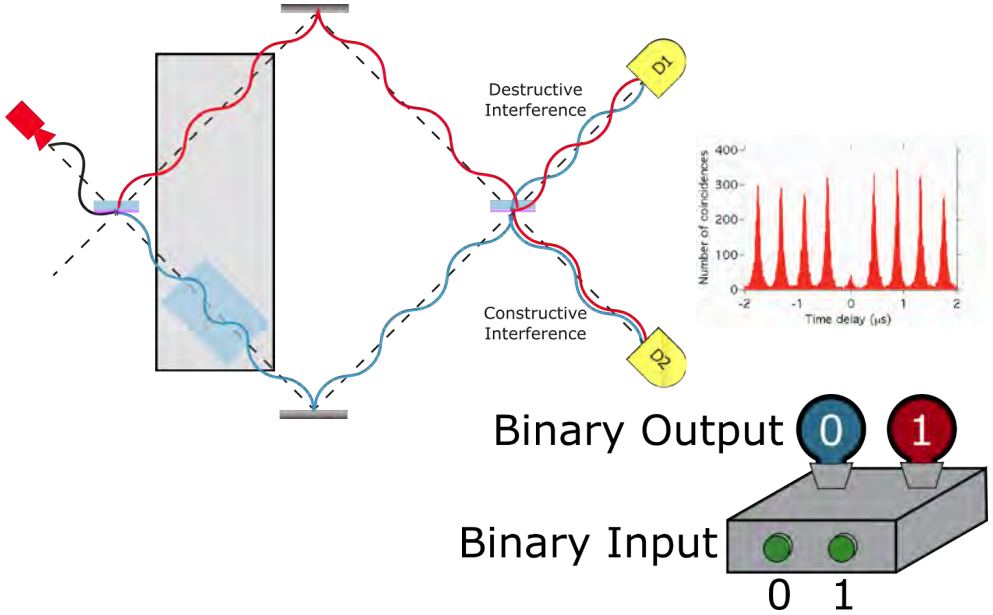
QEd Content

Key Lesson
Ensure that materials developed connect to both quantum technology and existing topics in the curriculum.



Familiar Concept: Light polarization
New idea: Measurement bases
Application: Quantum Cryptography

Familiar Concept: Wave-particle duality
New idea: Mach-Zehnder Interferometers
Application: Quantum Computing



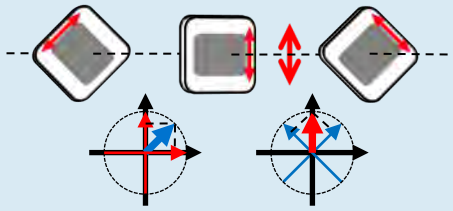
QEd Conceptual Flow

Vector Components

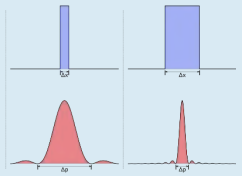
Basic Probability

Wave Interference

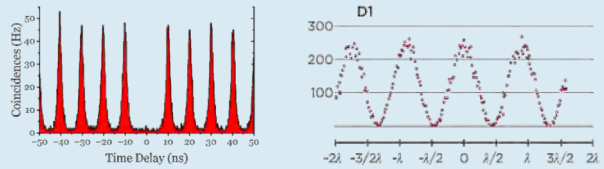
Superposition + Measurement



Uncertainty Principle

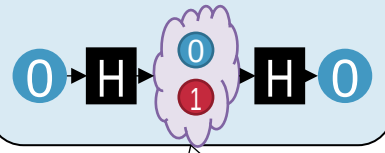


Wave-Particle Duality with Interferometers



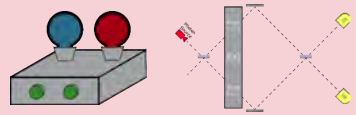
Quantum Key Distribution

Quantum Logic

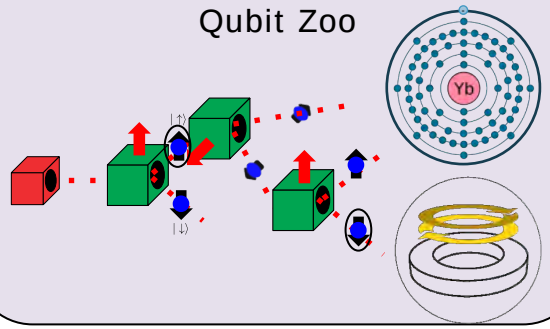


Quantum "Firework" Paradox

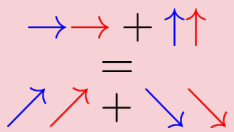
Deutsch-Josza



Qubit Zoo



Quantum Entanglement



Quantum Search Algorithm

Plus

- Curriculum roundtables
- Research keynote
- Lab tours
- Hands-on activities

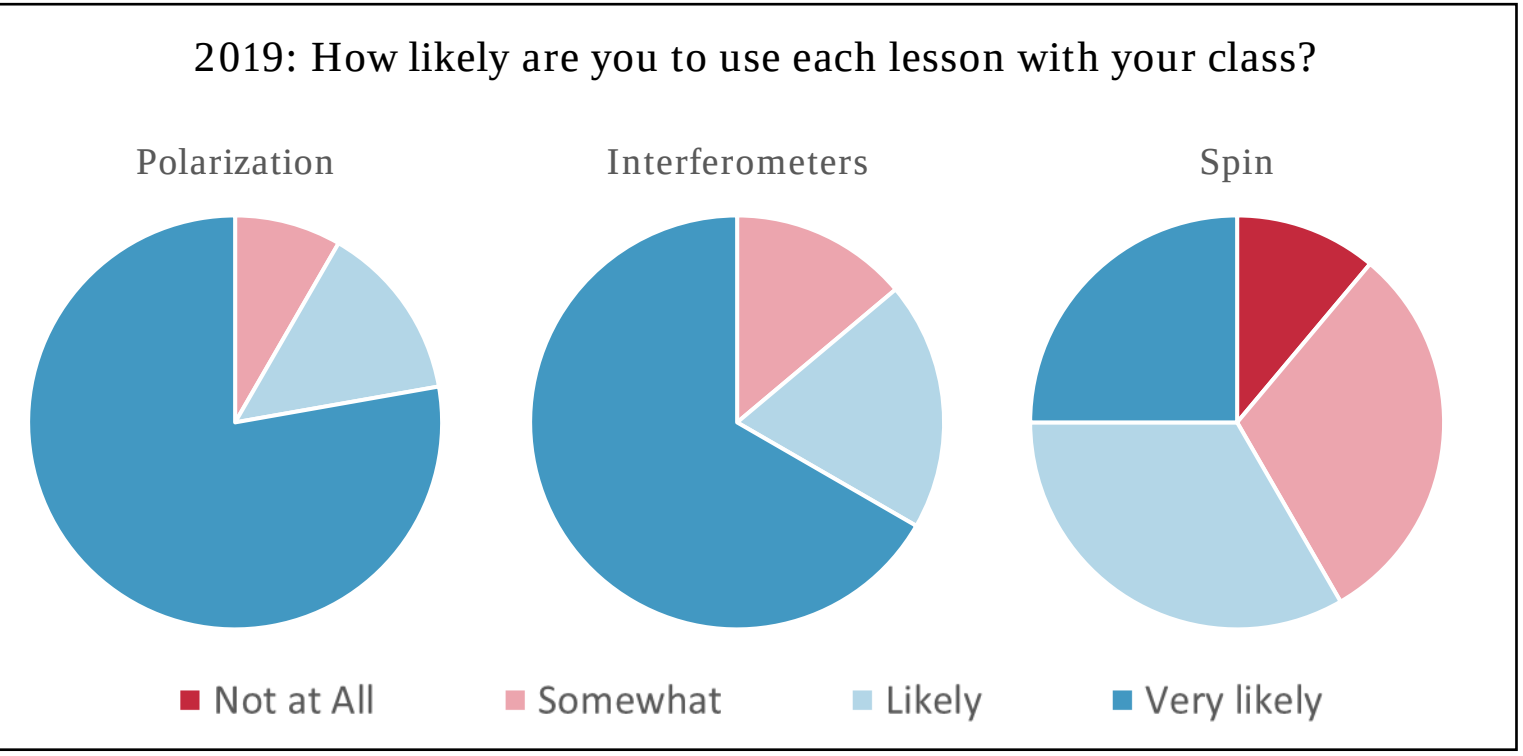
Feedback Collection

We collect feedback on the workshop through:

- A post-workshop survey
- Identical pre- and post-tests, sent before, right after, and one year after
- Recorded one-on-one interviews with participants
- Roundtable discussions with recorded answers
- Alumni surveys sent periodically (most recently in 2022)

QEd Content

Key Lesson
Ensure that materials developed connect to both quantum technology and existing topics in the curriculum.



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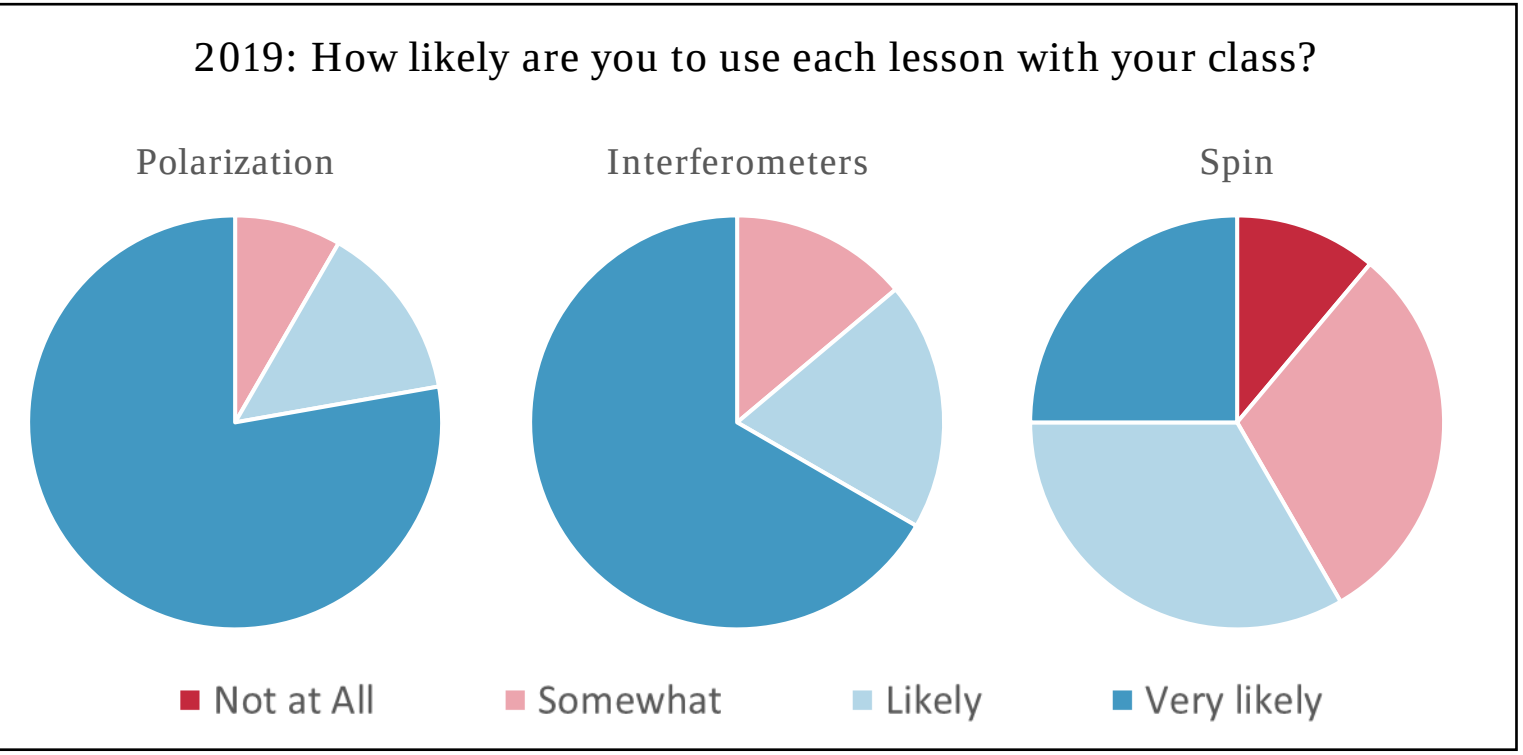
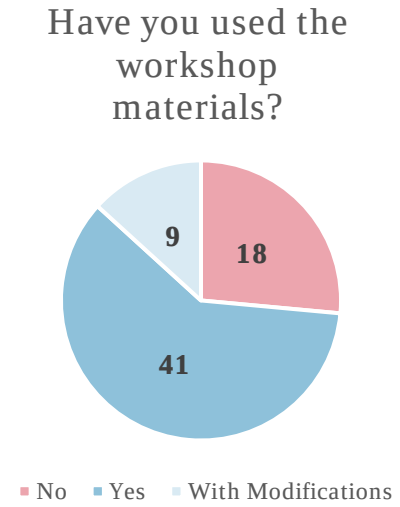
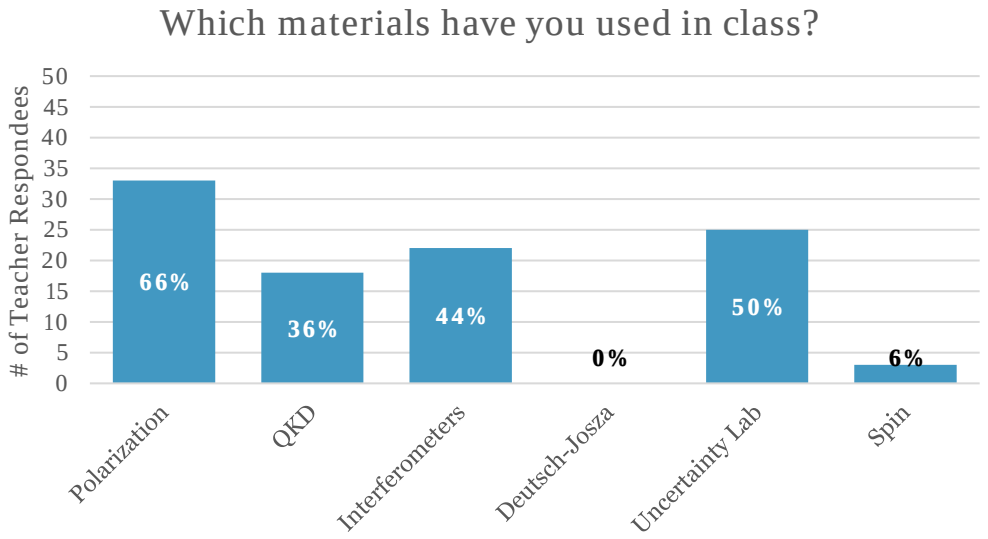


2022 survey of 68 program alum
(24% response rate)





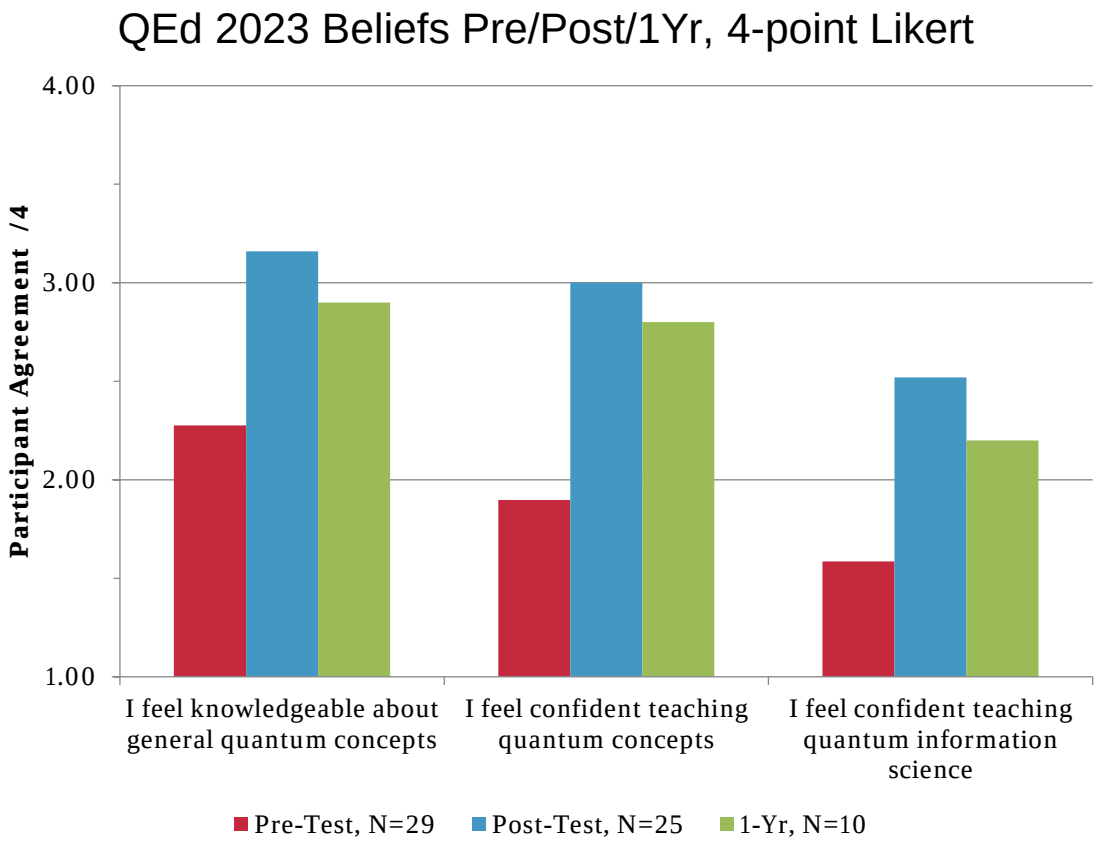
Confidence Levels Pre/Post

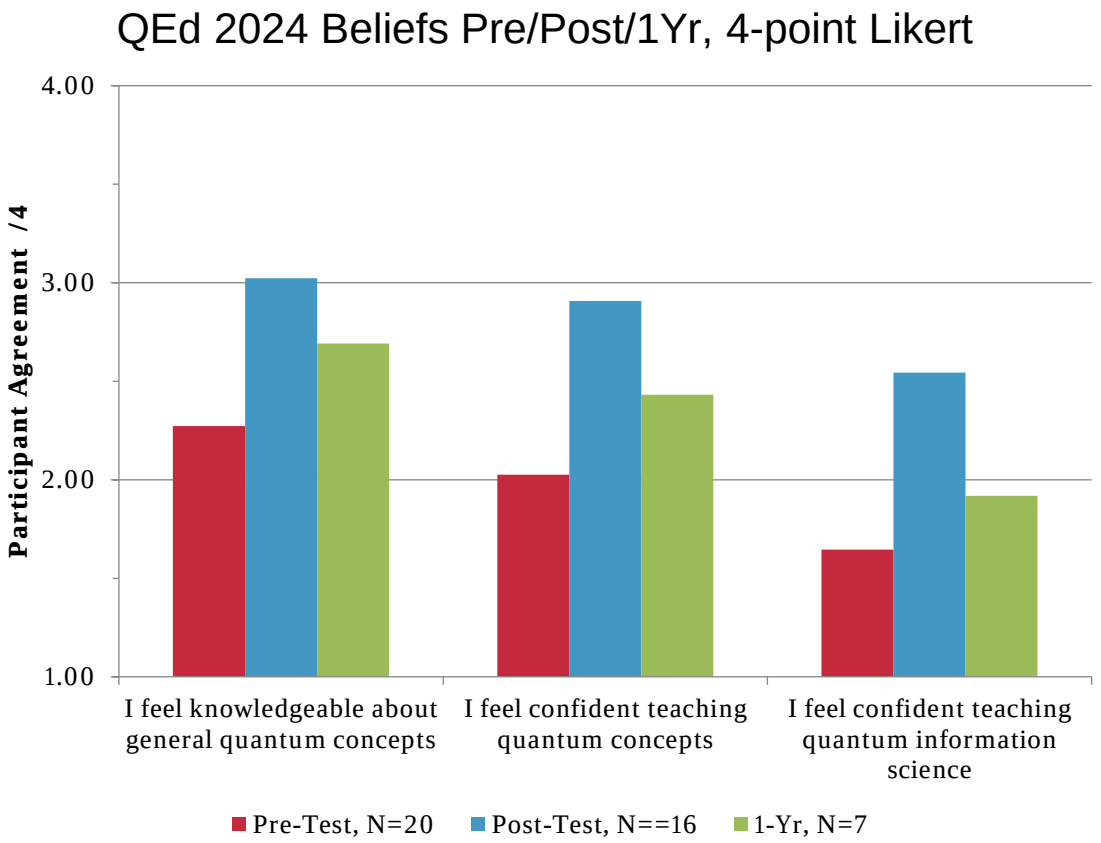
Self-rated from 1 (strongly disagree) to 4 (strongly agree)

Participants were sent surveys before, after, and one year after the workshop.

Their feels of knowledgeability and confidence rise significantly but fall modestly after time.

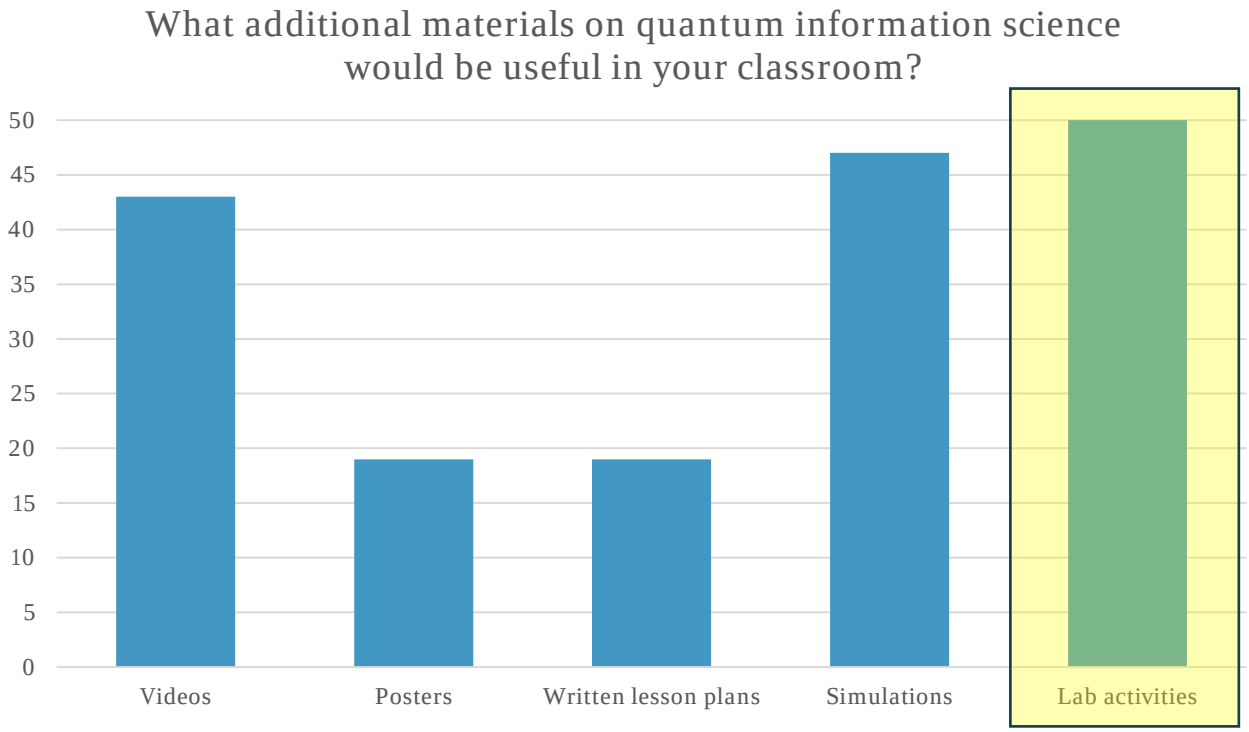
Continued engagement is essential, not just one-off interventions.



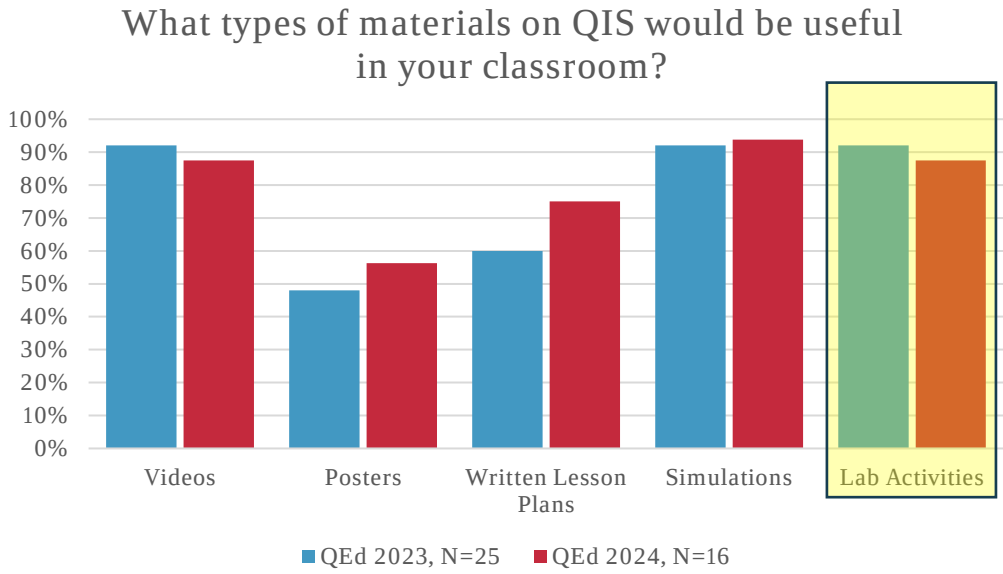


What materials are needed?

2022 Survey of 68 alum



Post-workshop surveys, 2023/2024



Hands-On Activities

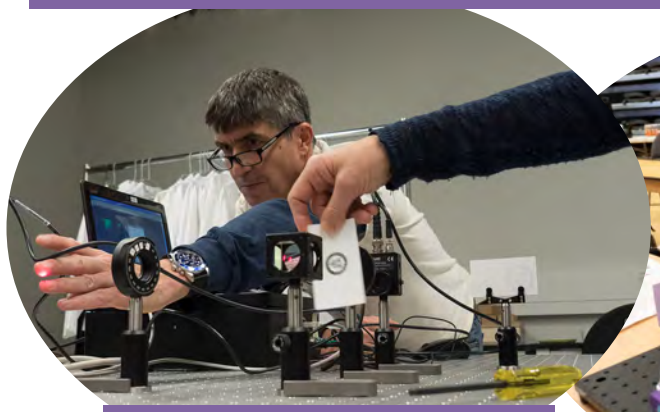
Designed to be implemented in the classroom

Affordable and Q-Info-centric, but somewhat contrived

Uncertainty and squeezing with dice

Quantum Key Distribution, coin-flipping activity

Q-Info-centric and close to real, but expensive



Quantum Key Distribution, build-it-yourself

Interferometers and the quantum eraser

Quantum Dots

Measuring Planck's Constant

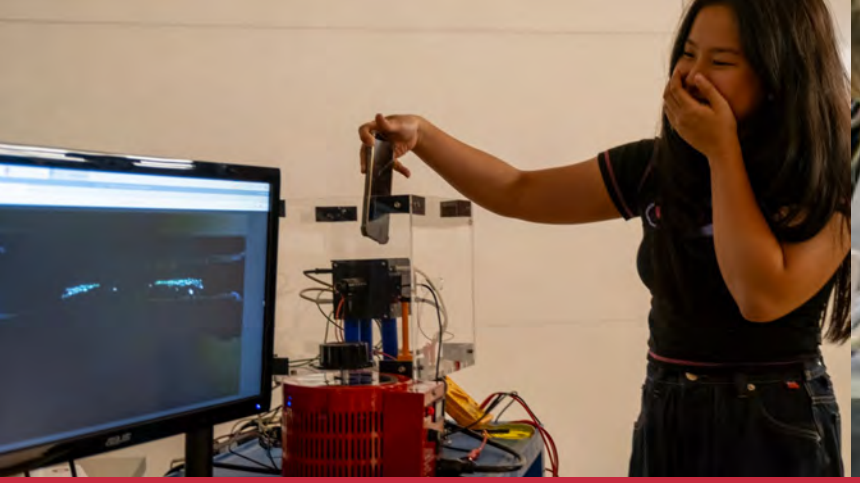
Affordable for classrooms, but not Q-Info-centric

The Uncertainty Principle and Diffraction, measured with laser pointers

3D movies

Polarization art

What about bringing the students to us?



QSYS Quantum School for Young Students

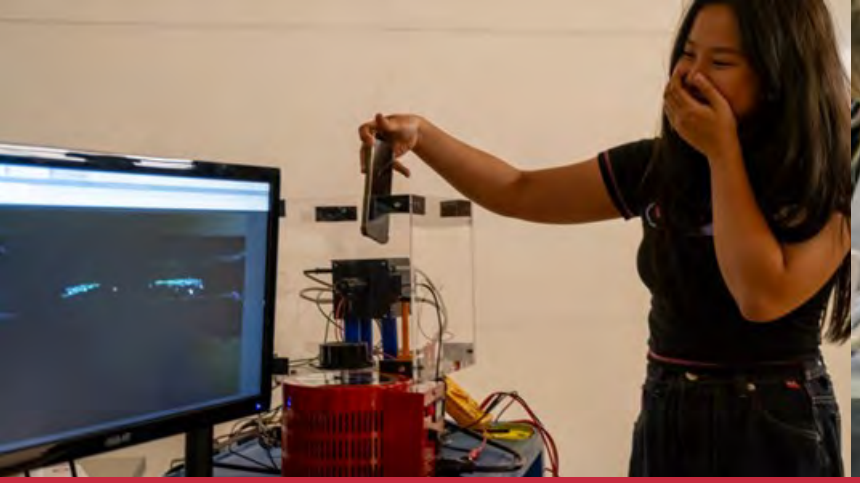
- Formerly known as the Quantum Cryptography School for Young Students.
- Held annually at the University of Waterloo since 2008
  - In-person (2008-2019, 2022-2023): Up to 45 students per year
  - Online (2020, 2021, 2024-present): Up to 200 students per year
- Open to high-school students ages 15-18 from around the world
- Lectures led principally by staff and graduate students.
- Cost-intensive
  - Reduced to virtual-only in 2024
  - Single in-person day for local students introduced in 2025

QSYS 2026

9 two-hour virtual sessions
open to students across Canada

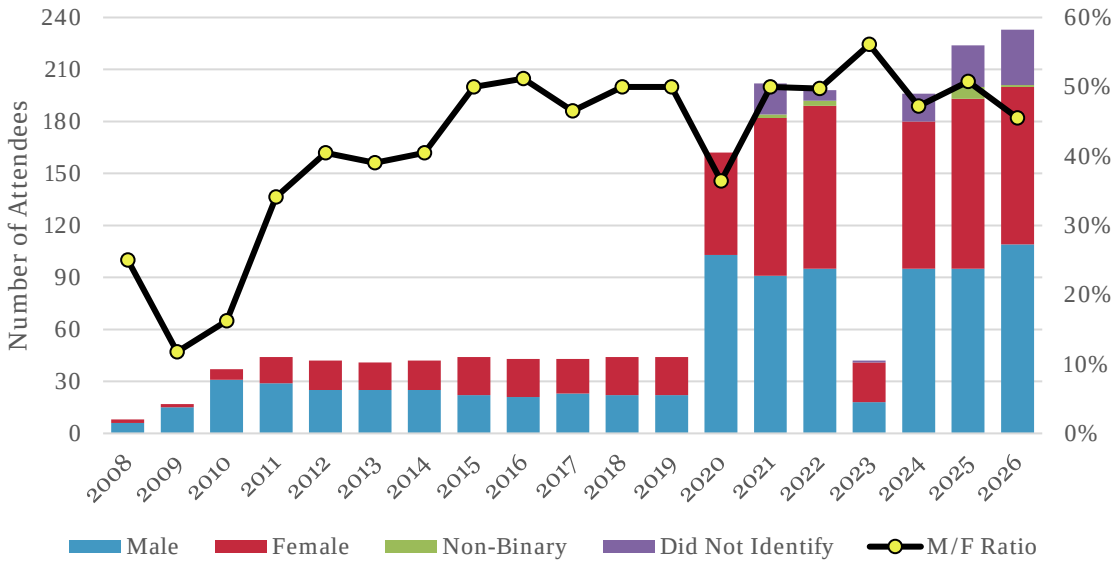
1 full-day in-person workshop
for students in the Waterloo region

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

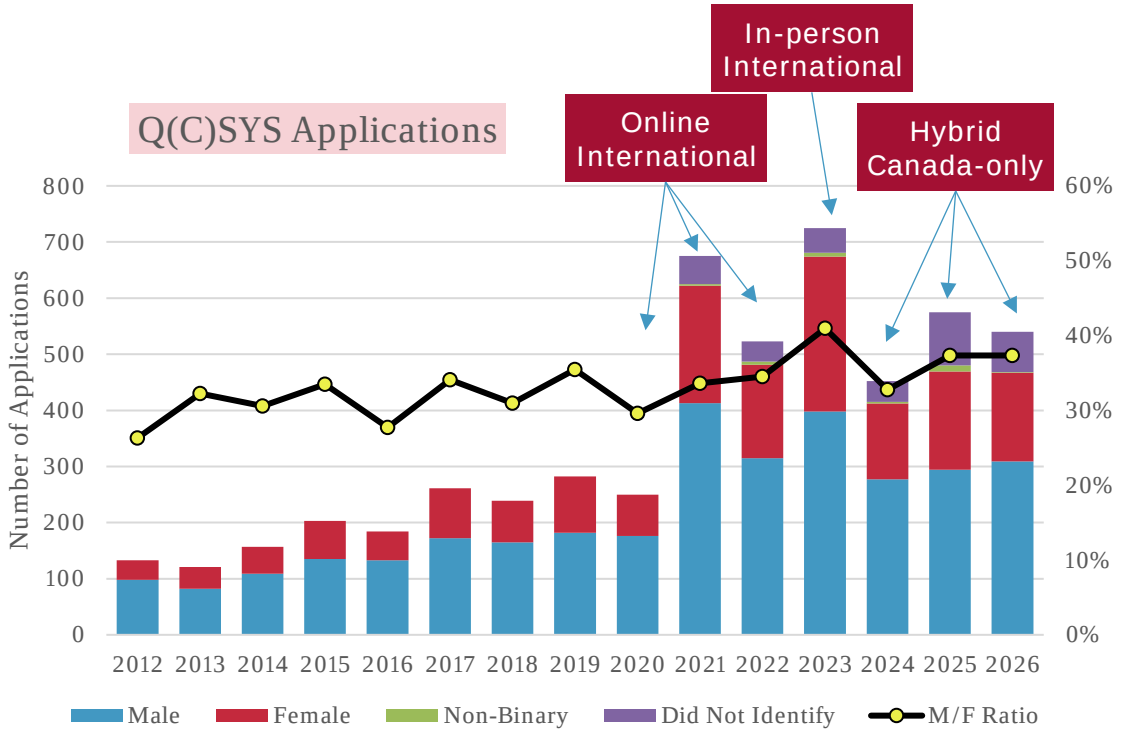


QSYS

Q(C)SYS Participants



Q(C)SYS Applications



Slight improvement in gender ratio of applications over time, huge explosion in interest in general (not just due to virtual accessibility)

QSYS Content

Primer Text

Linear Algebra & Complex Numbers

Bra-Ket Notation

History of Quantum Mechanics

QSYS Content

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Superposition & Measurement

Polarization, Path and Spin

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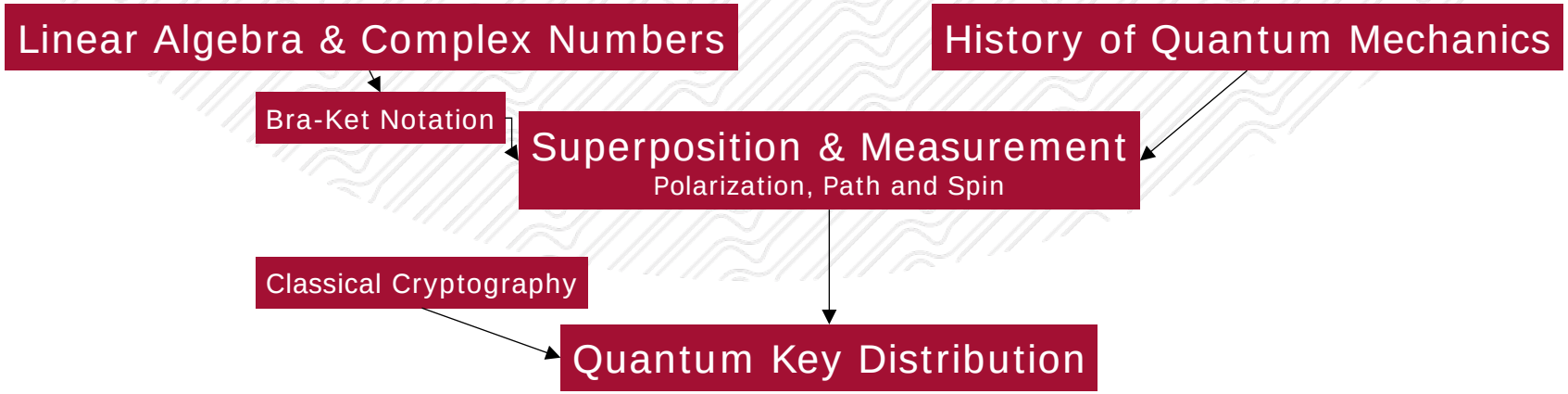

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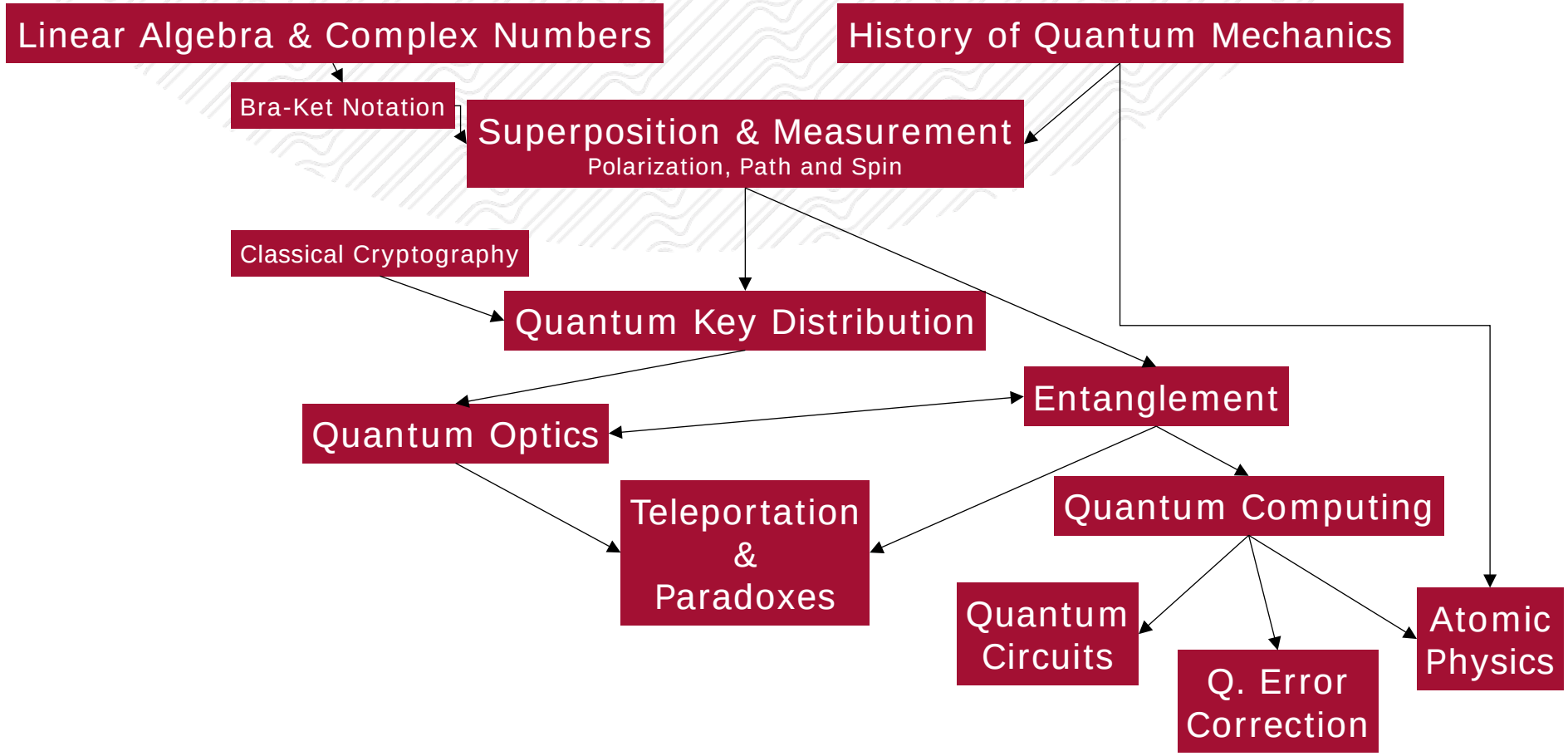


QSYS Content

Primer
Text

Linear Algebra & Complex Numbers

History of Quantum Mechanics

Bra-Ket Notation

Superposition & Measurement
Polarization, Path and Spin

Classical Cryptography

Quantum Key Distribution

Entanglement

Quantum Optics

Teleportation
&
Paradoxes

Quantum Computing

Quantum
Circuits

Q. Error
Correction

Atomic
Physics

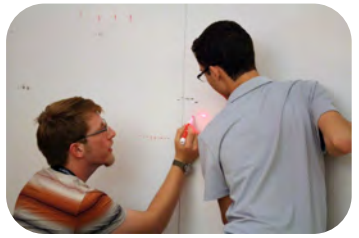
Mentoring roundtables
Problem sets
Social activities
Discord server
Labs

QSYS Labs

QM Fundamentals

Foundations of quantum mechanics commonly taught in school

Atomic spectra
Planck's constant with LEDs
Sound resonance and clocks
Diffraction and measurement
The uncertainty principle



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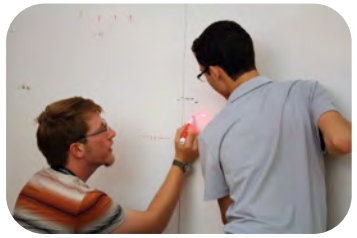

QI Components

Non-QI experiments that can be taught with QI language


Superconducting levitation
Interferometers
Circuit design
Building polarization gates


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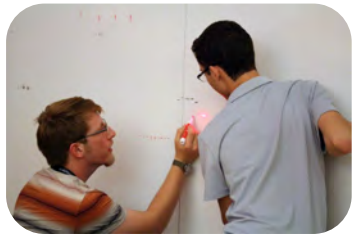

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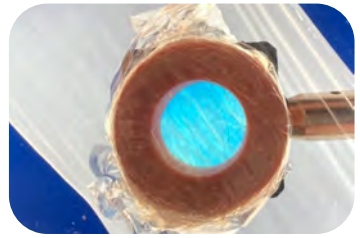
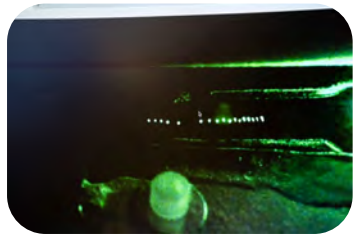


Quantum Information
Direct implementations of quantum-information topics


Quantum key distribution
Nuclear magnetic resonance
Trapping charged particles
Bell's inequalities

QSYS Lab Feedback 2023

4- Strongly Agree
3 – Agree
2 – Neutral
1 – Disagree
0 – Strongly Disagree

I found the experiment **interesting** and **engaging**	The experiment **connected to** and **helped clarify** lecture content	The experiment was **unlike other** activities I have seen before

Bold – Average rating greater than 3.3
Grey – Average rating lower than 3.0

QSYS Lab Feedback 2023

4- Strongly Agree
3 – Agree
2 – Neutral
1 – Disagree
0 – Strongly Disagree

I found the experiment **interesting** and **engaging**		The experiment **connected to** and **helped clarify** lecture content		The experiment was **unlike other** activities I have seen before	
Ion Traps	3.69	**QKD**	3.55	**Ion Traps**	3.72
Superconductivity	3.50	**Bell's Inequality**	3.50	**Birefringent Q. Gates**	3.66
QKD	3.31	**Birefringent Q. Gates**	3.48	**Bell's Inequality**	3.61
		Ion Traps	3.31	**QKD**	3.52
				Interferometers	3.46
				NMR	3.41
				Superconductivity	3.39

QSYS Lab Feedback 2023

4- Strongly Agree
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QKD	3.31	**Birefringent Q. Gates**	3.48	**Bell's Inequality**	3.61
Birefringent Q. Gates	3.21	**Ion Traps**	3.31	**QKD**	3.52
Bell's Inequality	3.14	Superconductivity	3.29	**Interferometers**	3.46
LED Planck's Constant	3.14	Atomic Spectra	3.20	**NMR**	3.41
Interferometers	3.11	Interferometers	3.14	**Superconductivity**	3.39
Atomic Spectra	3.10	LED Planck's Constant	3.10	LED Planck's Constant	3.14
Width of Hair	2.90	NMR	3.03	Resonance Clocks	3.07
NMR	2.90	Width of Hair	2.93	Atomic Spectra	2.93
Resonance Clocks	2.79	Resonance Clocks	2.86	Width of Hair	2.47

Key Takeaway

QI-specific labs rank highly in student engagement and help clarify learning, but are uncommon

But is it effective?

The Quantum Challenge

Quantum Scavenger Hunt

Team Name		Points
Members (max 3)		

Challenge	Answer	Points	Time Complete	Confirmed By:
Quantum Circuits		5		
Projection Perplexion		3		
Connect the Dots		5		
Interferometers -R-Us		3		
Infinite Wells		2		
Mystery Monitor		1		
Guess the Phase		4		
To Trap an Ion		3		
Guess the Width		3		
An Element of Mystery		2		
NMR Redux		4		
Missing Pieces		3		

Final day 2.5-hour “escape room” challenge, tying together elements of week.

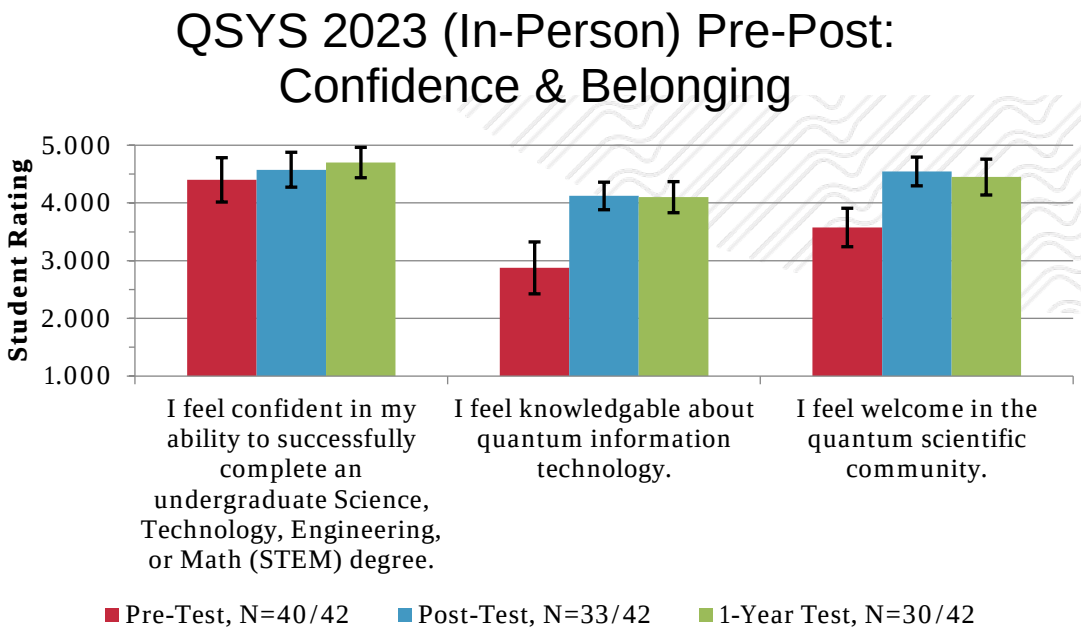
Groups compete to:

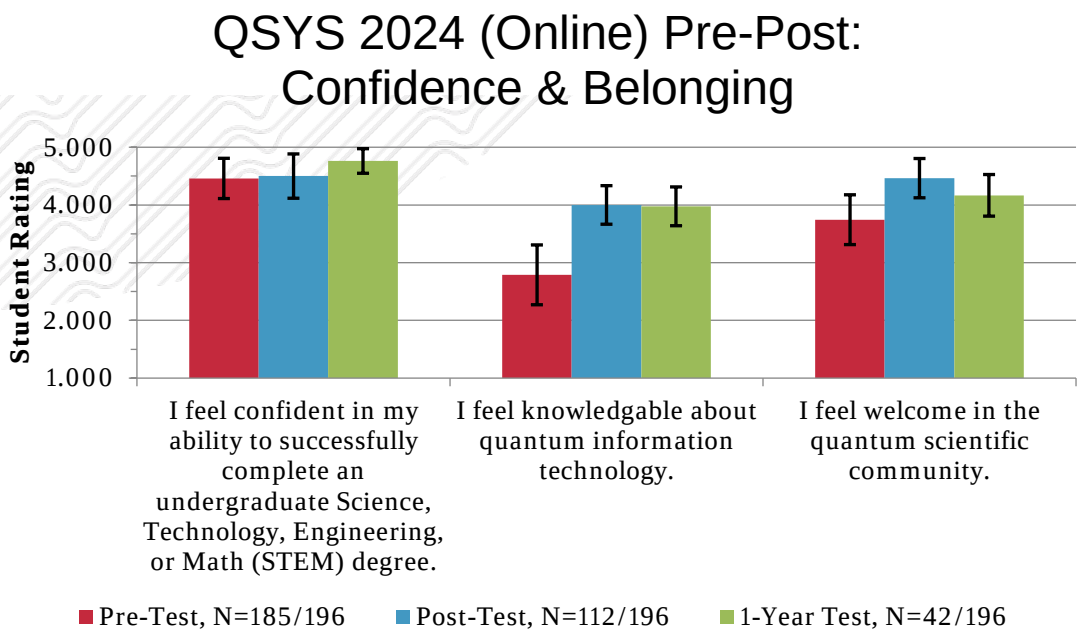
- Trap a specific number of charged particles
- Find the pi-pulse in an NMR experiment
- Identify unknown elements
- Deduce the phase of a polarization rotator
- Solve various pen-and-paper puzzles

All groups succeeded within the time limit

Pre/Post for QSYS 2023 and 2024

Participants were provided the same survey before and after the workshop, as well as a full one year later





Knowledge test (multiple choice + true/false)

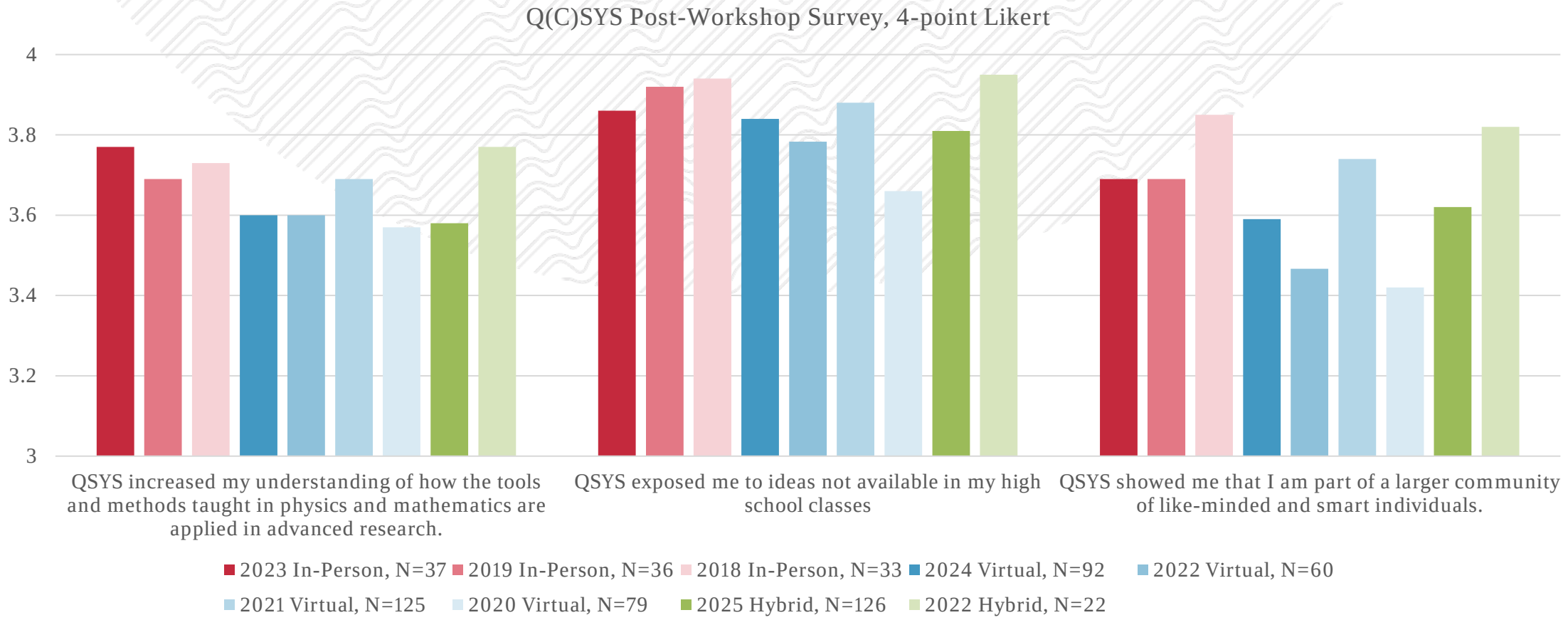
	Pre	Post	1-Year
Average (/5)	64.1%	83.3%	74.2%
Change		+19.20%	-9.10%

Knowledge test (multiple choice + true/false)

	Pre	Post	
Average (/5)	49.4%	81.4%	67.4%
Change		+32.0%	-18.7%

QSYS Student Feedback

In-Person
Virtual
Hybrid



Whether in-person or virtual, QSYS students self-report that the content is novel and applicable, and that it builds a sense of community for them.

Next steps?

- Undergraduate QI programs are relatively new
- Can we provide a similar experience at the undergraduate level?

Details: arXiv:2604.25124

USEQIP

Undergraduate School on Experimental Quantum Information Processing

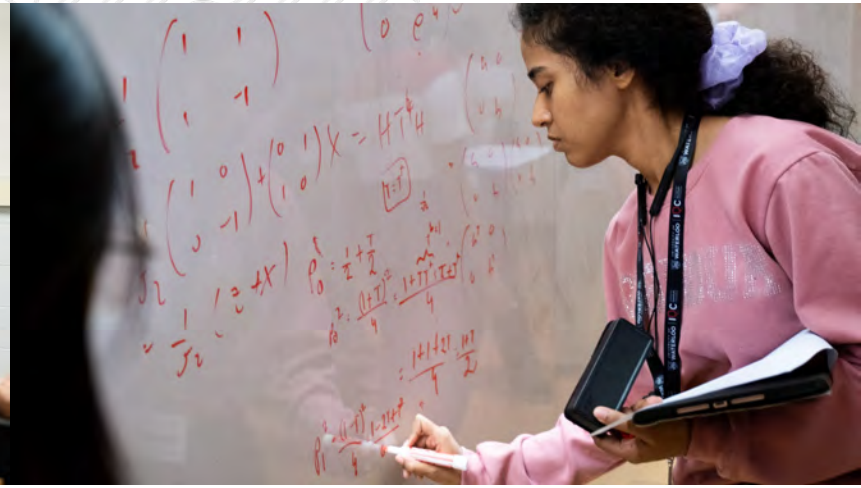


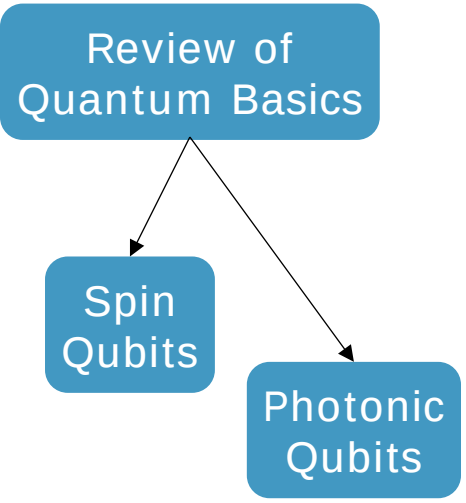
- Two-week intensive summer school for third-year undergraduates
- Held annually since 2009 with up to 30 students per year
- 443 program alumni, 52 returned for graduate studies at IQC
- Undergraduate research awards for students to stay for the summer
  - Student stipends are covered 50/50 by institutional and faculty funds

uwaterloo.ca/iqc/useqip

USEQIP

Undergraduate School on Experimental Quantum Information Processing





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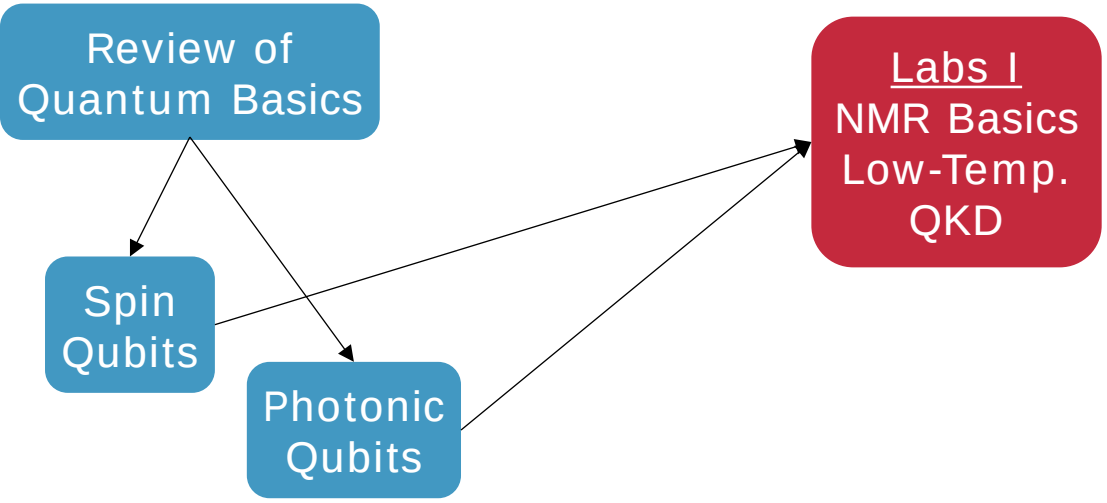

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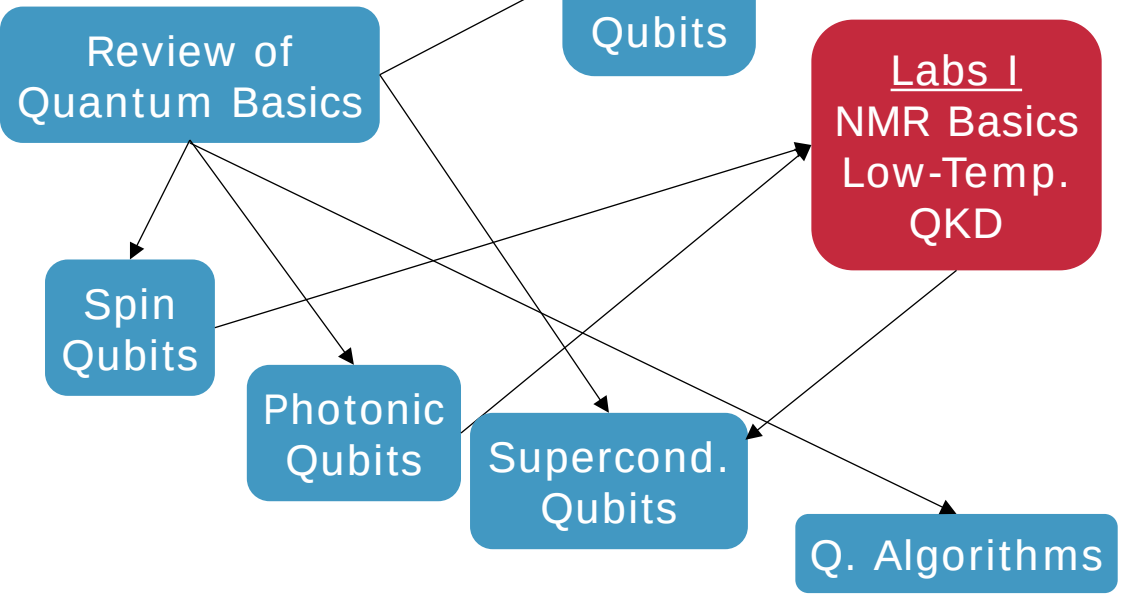

USEQIP

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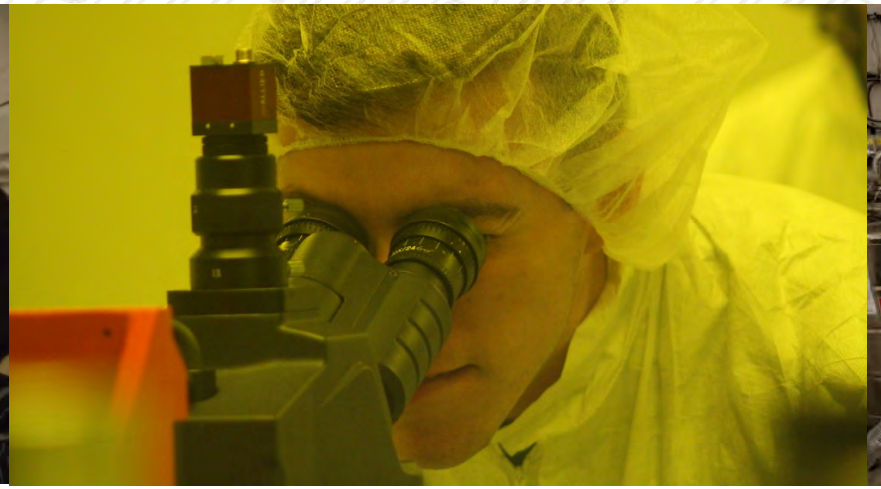
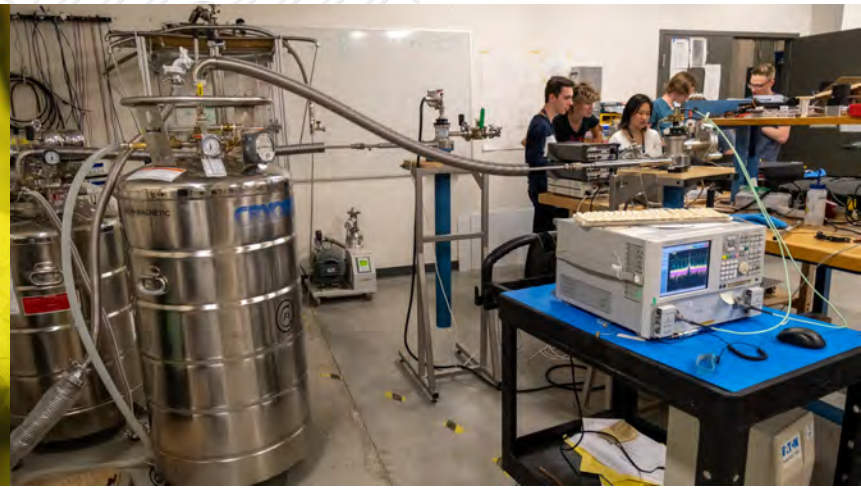




Review of Quantum Basics

Atomic + Ionic Qubits

Spin Qubits

Photonic Qubits

Supercond. Qubits

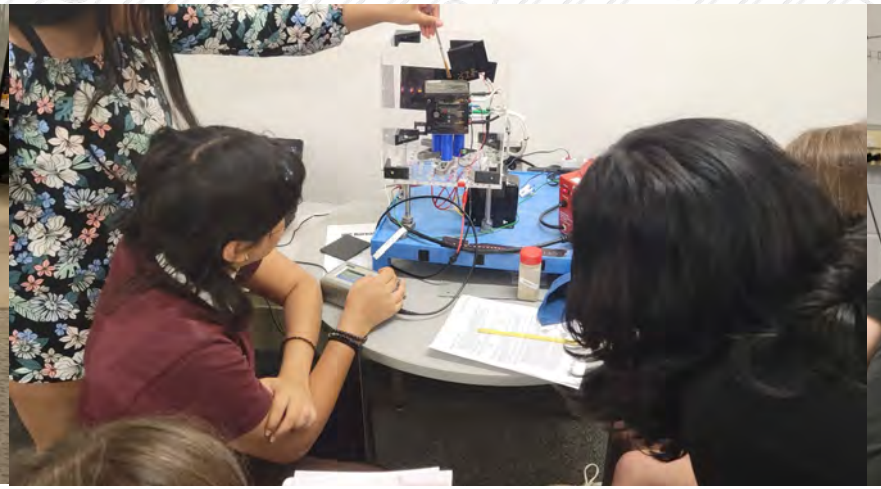
Q. Algorithms

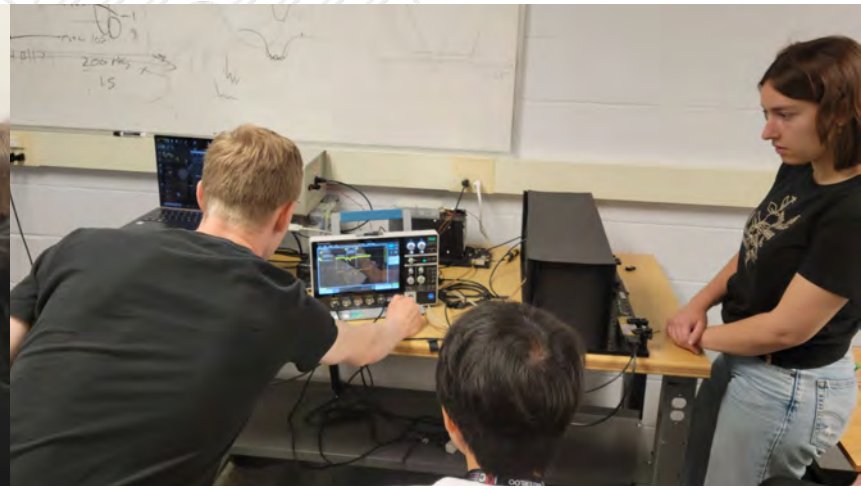
Labs I
NMR Basics
Low-Temp.
QKD

Labs II
Bell's Inequality
Nanofabrication
Superconductivity

USEQIP

Undergraduate School on Experimental Quantum Information Processing





Review of Quantum Basics

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Labs I
NMR Basics
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QKD

Labs II
Bell's Inequality
Nanofabrication
Superconductivity

Labs III
NMR Specifics
Ion Traps
NV Centres

Applications Showcase

USEQIP

Undergraduate School on Experimental Quantum Information Processing

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Labs I
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NV Centres

Applications Showcase

DIY NMR Project

USEQIP

Undergraduate School on Experimental Quantum Information Processing

Anonymous feedback from post-workshop surveys

Consistent highlights include breadth, hands-on experience, and community

It pushes you to a new level that you haven't experienced before in your undergraduate. You get thrown into the deep end and get exposed to so many interesting topics that are super complex, but the lecturers and lab techs do a fantastic job of keeping you afloat enough so that you're learning the entire time. It's a no pressure environment, i.e., no tests, so it's all about what you make of it, what you want to learn is what you will learn. It was amazing getting to know other people with similar interests to me, and make new friends who will help me with my research journey. (2023)

It was great to experience this program right before starting master's degree, as it provided a good overview of different quantum platforms and topic. This is a great way to evaluate which sounds most interesting/promising to you personally and what do you want to focus on during your further studies. (2022)

USEQIP was an absolutely amazing experience. Not only were the lectures and labs engaging, it was the best chance to spend time with 30 other top students from around the world. The curiosity that everyone showed - from us undergrads to the tenured professors – really excites me for seeing a quantum computing revolution in our near future. (2018)

USEQIP

Undergraduate School on Experimental Quantum Information Processing

Anonymous feedback from post-workshop surveys

Question, four-point Likert scale (1 - Strongly Disagree to 4 - Strongly Agree)	Average /4 (2017-2025)	N
The things I learned in USEQIP, I could not have learned anywhere else in my UG studies.	3.33	118
The program was engaging and exciting.	3.69	118
The program gave me the tools I need to begin investigating the quantum information field.	3.50	118
USEQIP showed me that I am part of a community of like-minded and smart individuals.	3.46	44

Labs		
Most Interesting	Most Relevant	Most Novel
QKD	**NMR**	**Dust Trap**
3.71/4	3.65/4	3.85/4
Low-temp, Dust trap	QKD, Dust trap	NMR, Nanofabrication

Details: arXiv:2604.25124

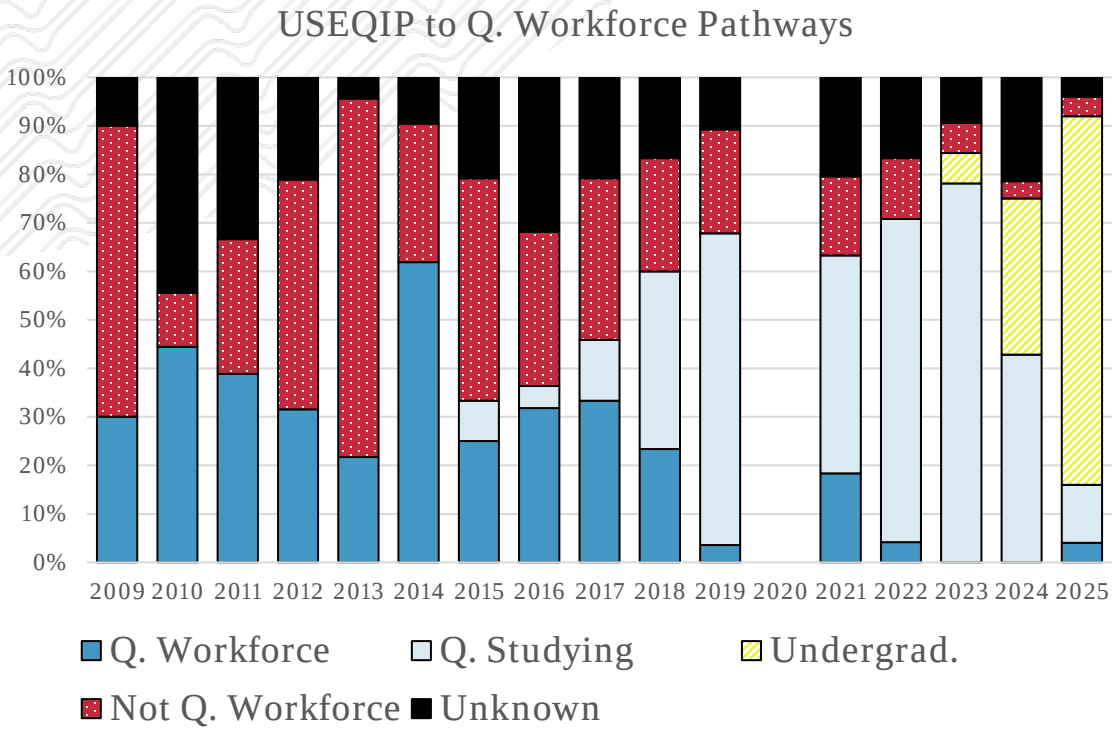
USEQIP Alumni Effects

Alumni survey 2025
36/198 responded

- 55% in QIST, 27% “quantum-adjacent”
- 25/36 (69%) identify USEQIP as influencing their academic/career path “a great deal”
  - Only 4/36 identify the impact as little or none, and all four were in the remote 2021 cohort

It is not an exaggeration to say that attending USEQIP was one of the key opportunities that enabled the career I have today in quantum computing. The experiences and expertise I gained at USEQIP led me back to the Institute for Quantum Computing for graduate school and ultimately to my position at IBM Quantum today. USEQIP provided me with opportunities to learn about quantum computing from experts who were otherwise not available to me, and in them, I found a passion for the field.
– Thomas Alexander, USEQIP 2013, now NVIDIA

Web survey
(publicly available information)



Details: arXiv:2604.25124

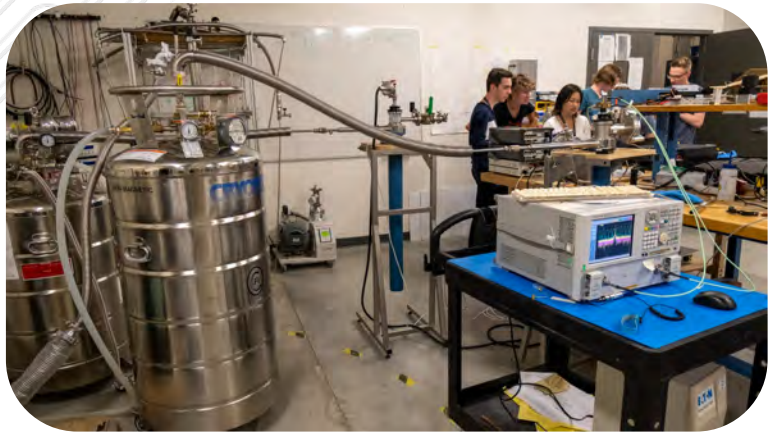
Quantum Explorations Space

Michael Grabowecky
Q. Tech. Lab Coordinator

Experiments built up for USEQIP over many years provided a baseline for lab-focused graduate courses.

QIC860 / PHY760
Lab on Control of Q. Technology

QIC861 / PHY761
Lab on Photonic Q. Technology



QIC862 / PHY762
Lab on Low-T. Q. Tech. & Nanofab.

Dedicated space for advanced educational labs have also allowed them to be used in HS and teacher programs, for student clubs, in undergraduate courses, and other workshops.

Cost vs. QI-ness

Axes very arbitrary

NMR Spin Control

Bell's Inequalities

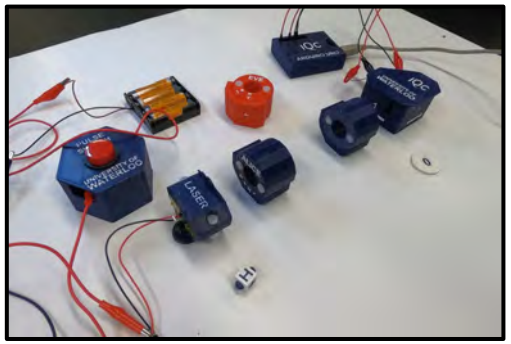
SC Circuits (SQUIDs)

Ion traps

QKD

Superconducting levitation

"Replicating QKD was my favourite – it allowed us to observe theory in practice in an engaging and fun activity."
- QSYS 2022 participant



3D-printed version
Cost ~ $150 CAD

Interferometers

Atomic spectra

Q. Dots

3D movies

Resonance

Uncertainty

LEDs

Diffraction

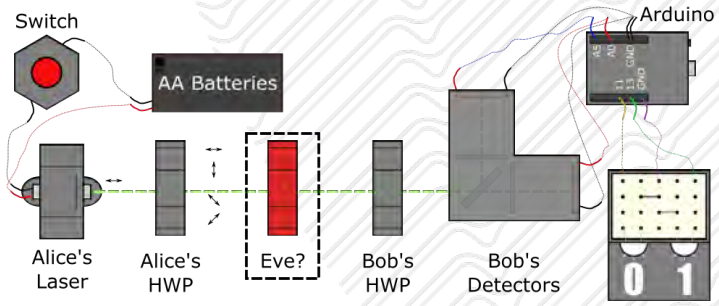
Polarization

Coding

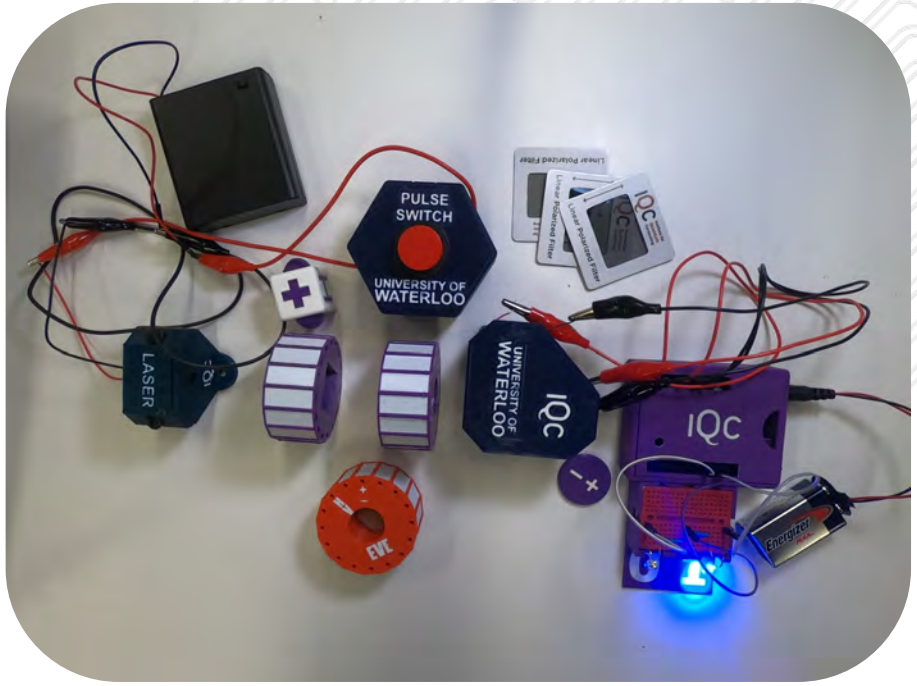
Pen + Paper

Cost

Relevance to Quantum Information



Low-Cost QKD Demo



Item	Role	~ Cost (CAD)
Beam Splitter	Measurement	$58
Arduino	Data Logging	$38
Laser	Photon Source	$52
3D filament	Structure	$10
Wave plates	Gates	$6
Solar panels	Detection	$14
Polarizers	Measurement	$3
Misc.		$25
	TOTAL	**$205**

DIY guide and 3D-print files
bit.ly/IQC-Teacher-Resources

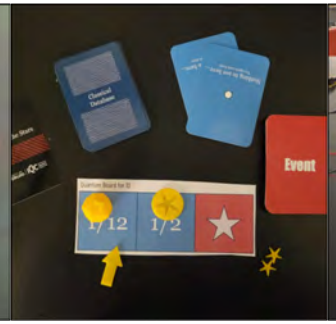
QuEST

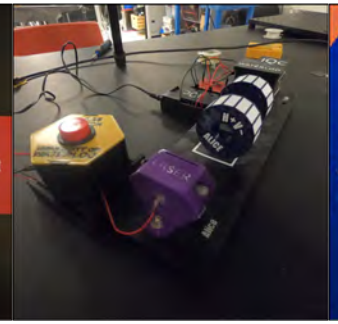
Quantum Explorations Student Toolbox

Goal: Provide accessible, affordable, and relevant hands-on materials to introduce K-12 students to quantum science and technology.

Method: Kit of experiments centrally assembled and shipped to teachers and outreach orgs.







Matthew Robbins
U. Toronto


Fiona Thompson
IQC & U. Waterloo


Andrew Chisholm
IQC & U. Waterloo


Taylor Pacholko
U. Waterloo


John Donohue
IQC & U. Waterloo

QuEST Catalog
& DIY Instructions
https://bit.ly/QuEST-Materials

Contributions from:

University of Waterloo | IQC Institute for Quantum Computing

UBC Geering Up Engineering Outreach

Perimeter Institute

Institut Quantique Université de Sherbrooke

Pure Unobtanium

let's talk science outreach | parlons sciences sensibilisation

Engineering Outreach

The City College of New York

The Games Institute

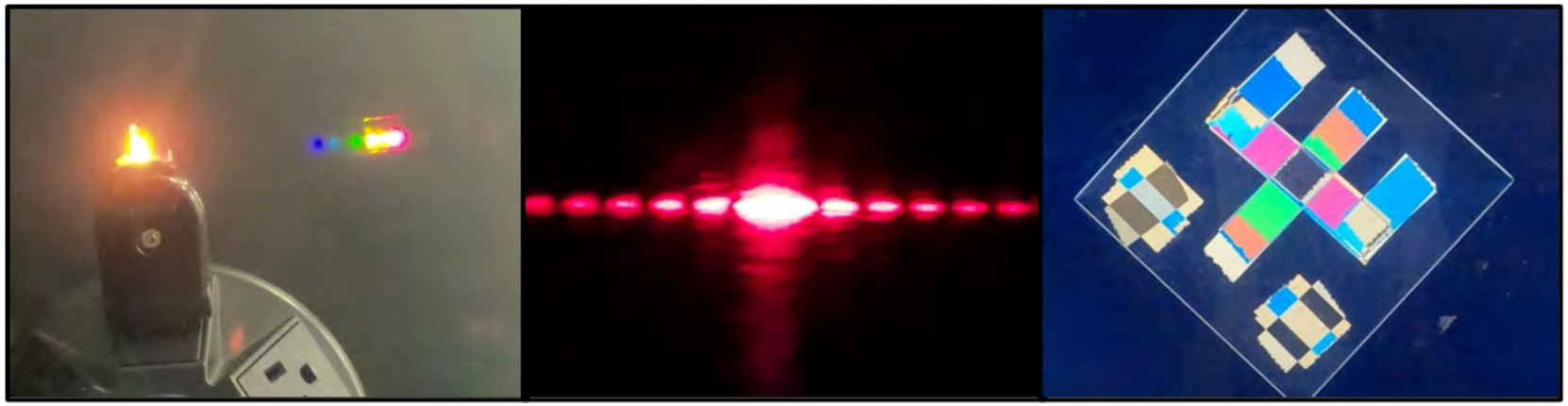
APS Advancing Physics

Example

Quantum Detectives

PhysiX Girls-in-STEM Workshop, 2025/11, Waterloo ON

- Mystery narrative to guide students through three hands-on activities related to quantum principles.
  - **Qubits**: Hidden binary messages in polarization,
  - **Interference**: Measuring diffraction patterns, and
  - **Quantization**: Atomic spectroscopy and identification.
- Shipped to 17 locations and used in 40 activities in 2025.
- Developed with outreach organizations for sustainable use beyond 2025.



Grade 7-10 recommended

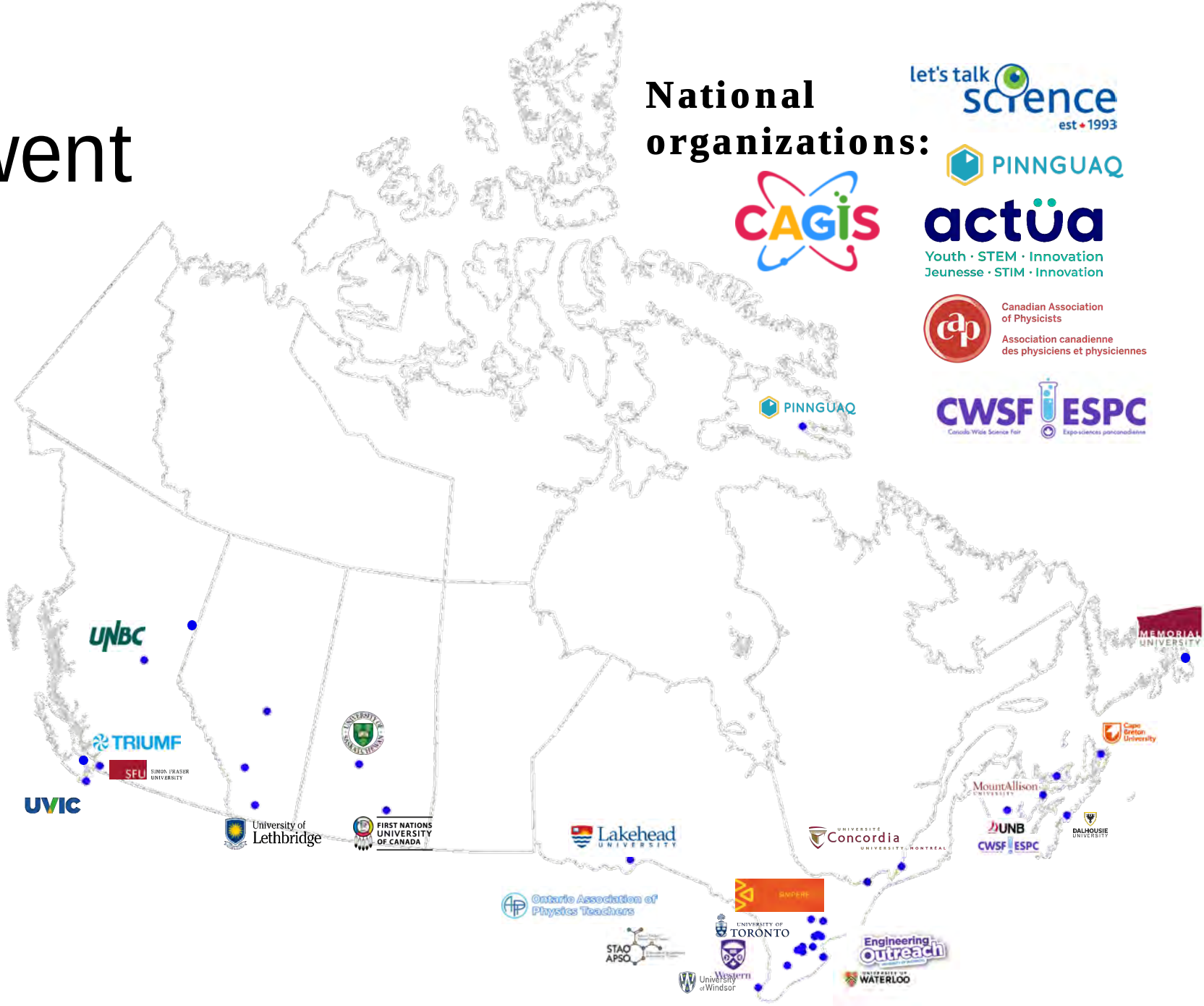
Curriculum connections:
- Science 9 (Nature of matter)
- Science 10 (Light and optics)

Quantum key concepts:
- Quantum bits
- Quantum sensing
- Light-matter interactions

Where QuEST went

QuEST materials were:

- Shipped to 39 locations in nine provinces/territories
- Used in at least 100 events
- Used to engage 9,500+, including 6,300 K-12 students and 270 K-12 teachers
- Added to catalogs of national partner organizations to ensure long-term use



QuEST event highlights

LUMEN Festival of Light
2025/09 in Waterloo ON

Canada-Wide Science Fair
2025/05 in Fredericton NB

Canadian Association for
Girls in Science (CAGIS)
2026/02 in Oakville ON

Royal BC Astronomy Day
2025/05 in Victoria BC

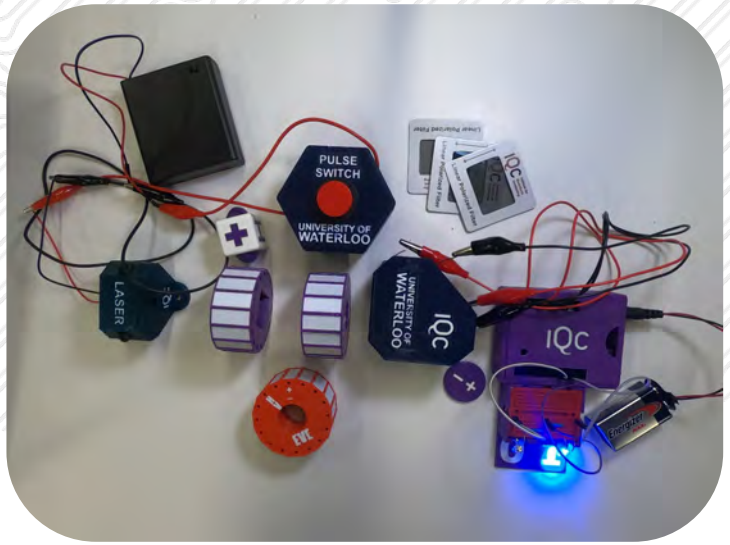
Elementary class visits in
2026/05 in Iqaluit NU

Science Teachers Association of
Ontario (STAO) Workshop
2025/11 in Toronto ON

Ask me about my suitcase

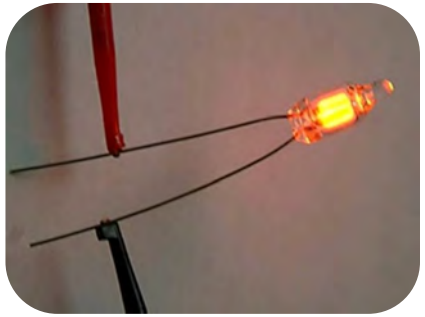
More in DPE/DQI R1-7

Quantum Search board game

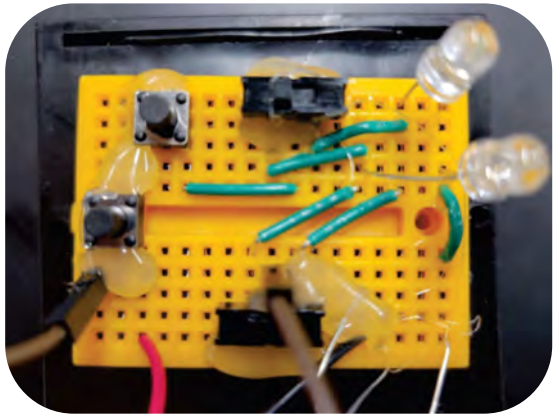


QKD demo

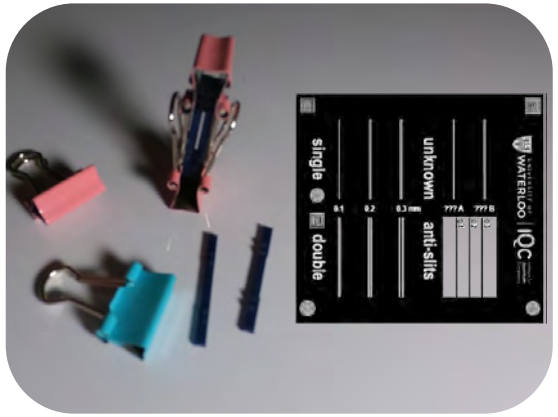
Uncertainty dice



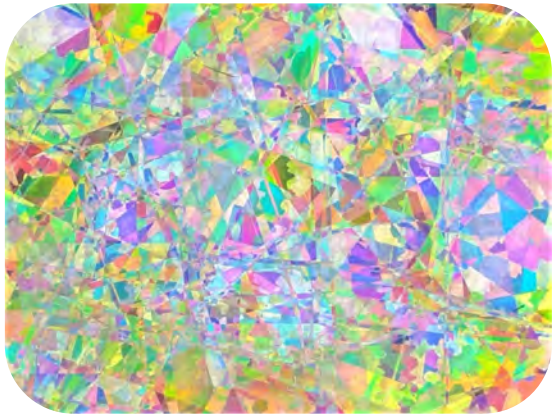
Neon emission bulb and spectra matching activity



Deutsch-Josza Box

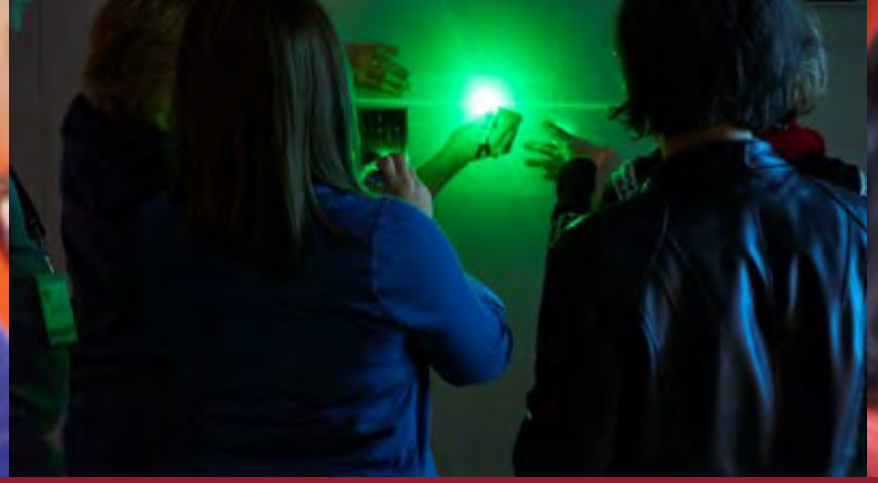


Uncertainty & Diffraction



Polarization art

& stickers


Bring quantum mechanics to your classroom

- Three-day in-person workshop for high-school educators
- Curriculum-appropriate materials developed by quantum experts in collaboration with physics teachers
- Affordable and class-appropriate hands-on activities
- Connect with an international network of motivated educators
- Held annually at the University of Waterloo since 2016 with over 500 program alumni
- All costs, including meals and accommodation, are covered for teachers at Canadian schools
- Physics-focus, but open to Chemistry, Mathematics, and CS

QEd Quantum for Educators

November 20-22, 2026
Applications due October 1, 2026

uwaterloo.ca/iqc/quantumeducators
iqc-outreach@uwaterloo.ca

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

Quantum Science Across Canada
Teacher Workshop

Saturday September 12, 2026
at the University of Toronto St. George Campus

Hosted by: UNIVERSITY OF TORONTO FACULTY OF ARTS & SCIENCE
Centre for Quantum Information & Quantum Control

Reserve your spot today:
https://ed.quantum.ieee.org/qseec26/
Open to all interested teachers.
No cost to attend.

Featuring hands-on, classroom-ready workshops from:

INSTITUT QUANTIQUE UdS — *"A maple-syrup powered quantum computer."*

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing — *"Exploring quantum algorithms with card games."*

PERIMETER INSTITUTE — *"Tabletop escape rooms: Can you build a QC?"*

UBC Geering Up Engineering Outreach — *"Teaching through games with the Quantum Arcade."*

In co-ordination with:

Special thanks
Martin Laforest
Fiona Thompson
Kim Kuntz
Tianna Smith

USEQIP
Michael Grabowecky
George Nichols
David Cory
MITACS

QSYS
Michele Mosca

QEd
James Ball

QuEST
Matthew Robbins (UofT)
Taylor Pacholko
APS Innovation Fund

Thank you!

www.uwaterloo.ca/iqc
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UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

Undergrads
Jamiel Nasser
Aaron Xayvongsa
Andrew Chisholm
Courtney Kates
Azzam bin Aamir
Cindy Karamy
Yashvi Damji
Alish Vadsariya
Hannah Gallop
Hazel Gifford
Quazell Cunningham
Khanjan Soni
Chloe Attard
Aerin Schmall
Shraddha Aangiras
Julien Cote

+ many IQC grad students

See also:
USEQIP: arXiv:2604.25124
Physics in Canada vol. 81 no. 2

QEd Workshop
November 2026
https://bit.ly/QEd-Workshop

IQC teacher resources
bit.ly/IQC-Teacher-Resources

USEQIP 2026

USEQIP Undergraduate School on Experimental Quantum Information Processing

	Monday May 25	Tuesday May 26	Wednesday May 27	Thursday May 28	Friday May 29
9:00	**Intro to USEQIP**	**Spin Qubits**	**Labs**	**Photonic Qubits**	**Superconducting**
9:30	**and Review of**	Michael Grabowecky	RAC 3003 + QNFCF	John Donohue	**QIP**
10:00	**Quantum Principles**	RAC 3003		QNC 0101	Meg Panetta
10:30	John Donohue		A) Superconductivity		QNC 0101
11:00	QNC 1201		B) Cleanroom		
11:30			C) NMR I	Lunch	
12:00	Lunch	Lunch	Lunch	St. Jerome's	Lunch
12:30	St. Jerome's	RAC 3003	RAC 2009	Labs	St. Jerome's
1:00	**Cleanroom Prep**	**Labs**		RAC 3003 + QNFCF	**Trapped-Ion QIP**
1:30	K. Halys - QNC 1201	RAC 3003 + QNFCF	**Problem Solving**		K. Rajibul Islam
2:00	**QNC Lab Tours**		Caroline Lima	A) Cleanroom (12:30)	QNC 0101
2:30		A) NMR I	RAC 2009	B) NMR I (1:00)	
3:00	Break	B) Superconductivity	**RAC Lab Tours**	C) Supercond. (1:00)	
3:30	**Low-Temp. Physics**	C) Cleanroom (1:30)			
4:00	George Nichols			**IQC Community**	
4:30	QNC 1201			**Gathering**	
5:00	**Mini-Golf @ 5:45pm**			RAC Patio	
5:30	Putt Social				
	Monday June 1	**Tuesday June 2**	**Wednesday June 3**	**Thursday June 4**	**Friday June 5**
9:00	**NV Spins**	**Q. Algorithms**	**Labs**	Short Labs Prep	**NMR Challenge**
9:30	Michael Grabowecky	John Watrous	RAC 3003	**Labs** RAC 3003	
10:00	RAC 3003	RAC 3003		A) Ion Trap	
10:30	**QKD**		A) NV Centres	B) NMR II	
11:00	Kimia Mohammadi		B) QKD	C) NV II	
11:30	RAC 3003		C) Entanglement	Lunch	
12:00	Lunch	Lunch	Lunch	RAC 3003	Lunch
12:30	RAC 3003	RAC 3003	RAC 2009	**Labs** RAC 3003	RAC 3003
1:00	**Labs**	**Labs**	**Q. Information**	A) NMR II	**NMR Challenge**
1:30	RAC 3003	RAC 3003	William Slofstra	B) NV II	
2:00			RAC 2009	C) Ion Trap	
2:30	A) QKD	A) Entanglement		Break	
3:00	B) Entanglement	B) NV Centres		**Labs** RAC 3003	**Results**
3:30	C) NV Centres	C) QKD		A) NV II	**Presentations**
4:00				B) Ion Trap	
4:30	**Perimeter Institute**	**Ball Hockey**	Ball Hockey	C) NMR II	
5:00	**Tour**	RAC Parking Lot	Rain Date		**Pub Night @ 6pm**
5:30					Huether Hotel

University of Waterloo | IQC Institute for Quantum Computing | TQT Transformative Quantum Technologies

QEd 2024 and 2025

Time	Monday July 29	Tuesday July 30	Wednesday July 31
	QNC 0101	QNC 0101	QNC 0101
8:30	Coffee/Tea	Coffee/Tea	Coffee/Tea
9:00	Introduction to Quantum for Educators	Wave-Particle Duality And Interferometers	Quantum Gates and Quantum Logic
9:30	Roundtable Discussion: Quantum in Class		
10:00	Break		
10:30	The Two Golden Rules of Quantum Mechanics	Break	Break
11:00		Quantum Paradoxes and Computing with Interferometers	**Guest Session** Quantum Coding and Quantum Enigmas (Tania Belabbas)
11:30			
12:00	Lunch @ St. Jerome's	Lunch @ St. Jerome's	
12:30			Lunch @ St. Jerome's
1:00	Quantum Cryptography	Interference and Uncertainty Labs	
1:30			Quantum Entanglement
2:00			
2:30		The Uncertainty Principle	
3:00	Group Photo		Quick Break Roundtable Discussion: Quantum in the Curriculum
3:30	Break	Break	
4:00	The Qubit Zoo	**Guest Session** Wavicles in the Classroom! (Jim Martin & Urja Nandivada)	End of Quantum for Educators
4:30			
5:00		End of Day Go to Perimeter Institute (Walk or ION) Tour of the Perimeter Institute	
5:30	End of Day		
6:00			
6:30	Group Dinner @ Huether Hotel	Free Choice of Dinner	
7:00			
7:30			

Time	Wednesday July 16	Thursday July 17	Friday July 18
	QNC 0101	QNC 0101	QNC 0101
9:00	Coffee/Tea	Coffee/Tea	Coffee/Tea
9:30	Introduction to QEd	Wave-Particle Duality and Interferometers	Quantum Gates, Quantum Logic, and Quantum Algorithms
10:00	Roundtable Discussion: Quantum in the Classroom		
10:30	Break		
11:00	Superposition, Measurement, and Polarization	Break **Guest Session** Wavicles in the Classroom! (Jim Martin & Urja Nandivada)	Break Roundtable Discussion Quantum in the Curriculum
11:30			
12:00	Lunch @ St. Jerome's	Lunch @ St. Jerome's	Lunch @ St. Jerome's
12:30			
1:00	Quantum Cryptography and Lab Activities	Quantum Paradoxes and Quantum Computing with Interferometers	Bus to Research Advancement Centre Quantum Entanglement
1:30			
2:00		The Qubit Zoo	
2:30			Quantum Magnetic Sensors
3:00		Break	RAC Lab Tours
3:30	Group Photo Break	Lab Activities Interference, Uncertainty, and Atomic Spectra	
4:00			Return bus to QNC
4:30	**Keynote** Laser Cooling and Quantum Chemistry (Alan Jamison)		
5:00	End of Day	End of Day	
5:30			
6:00		Group Dinner @ Grad House UW	
6:30	Group Dinner @ Huether Hotel (upstairs boardroom)		
7:00			
7:30			

Time	Wed Aug 9	Thu Aug 10	Fri Aug 11	Sat Aug 12
	QNC 0101	QNC 0101	QNC 0101	QNC 0101
8:00	Breakfast	Breakfast	Breakfast	Breakfast
	at REV	at REV	at REV	at REV
9:00	Welcome to QSYS!	Labs Prep	Quantum Key	Labs Prep
	Mathematics of	Lab Session #1	Distribution	Lab Session #2
10:00	Quantum Review	Uncertainty	(C. Lima)	QKD
	(L. Coffman)	Planck's Constant	Break	Interferometers
11:00		Atomic Spectra	Ultracold Atoms	Ion Traps
		Resonance Clocks	(A. Jamison)	
12:00	Group Photo	Lunch	Lunch	Lunch
	Lunch			
13:00		Bra-Ket		Early Quantum
	History of Quantum	Problem Solving	Quantum	Computing
14:00	(J. Donohue)	Interferometers	Entanglement	(J. Donohue)
		(J. Donohue)	(E. Patterson)	
15:00				
	Break	Break		Break (fruit)
16:00	Polarization and	Quantum Gates	Break	Superconductivity
	Quantum Mech.	(J. Donohue)	Free Time	(F. Thompson)
17:00	(A. Anand)	Problem		(J.P. Houle)
		Solving		
18:00	Bus	Dinner at REV	Dinner at REV	Dinner at REV
	Bowling			
19:00				

Time	Mon Aug 14	Tue Aug 15	Wed Aug 16	Thu Aug 17
	QNC 0101	QNC 0101	RAC 2009	QNC 0101
8:00	Breakfast	Breakfast	Breakfast	Breakfast
	at REV	at REV	at REV	at REV
9:00	Problem Solving	Quantum Spin	Lab Prep	Quantum
	and Review	(S. Harrigan)	(C. Rodriguez)	Teleportation
10:00			(J. Donohue)	(S. Srivastava)
	Break	Break	Break	Break
11:00	Astrophysics	UWaterloo	RAC Labs	Grover's Algorithm
	(R. Haggar)	Presentations		(S. Li)
12:00	Lunch	Lunch	Lunch	Lunch
13:00	Quantum Optics	Quantum Error	*Birefringence*	Quantum Ethics
	(J. Donohue)	Correction	*NMR*	(J. Arrow)
14:00		(S. Li)	*Entanglement*	
	Modern Quantum		*Problem Solving*	Final
15:00	Computing		Break	Challenge
	(J. Arrow)	Break	RAC Labs	
16:00	Break	Interpretations of	continued	
	Speed-Mentoring	Quantum		
17:00	Roundtable	(H. Gifford)	Ball Hockey	
18:00	Dinner at QNC	Dinner at REV	Dinner at RAC	Dinner at REV

Sample QSYS Schedule
Fully in-person 2023

Date/Time	Session
Wed Aug 7 1-3pm ET	**Mathematics Practice Session (Donohue/Kates)**
Mon Aug 12 1-3:30pm ET	**A Brief History of Quantum Mechanics (Donohue/Kates)** **QSYS Introductory Social Session (Courtney Kates)**
Tue Aug 13 1-3pm ET	**The Rules of Quantum Mechanics (Donohue/Kates)**
Wed Aug 14 1-3pm ET	**Polarization Qubits (Amit Anand)**
Thu Aug 15 1-3pm ET	**Quantum Key Distribution (Alec Gow)**
Fri Aug 16 1-3pm ET	**Interferometers and Quantum Gates (Donohue/Kates)**
Mon Aug 19 1-3pm ET	**Problem Solving Session (Donohue)**
Tue Aug 20 1-3pm ET	**Quantum Entanglement (Everett Patterson)**
Wed Aug 21 1-3pm ET	**Quantum Circuits and Quantum Computing (Aangiras)**
Thu Aug 22 1-3pm ET	**The Qubit Zoo (Katie McDonnell)**
Fri Aug 23 1-3pm ET	**Quantum Teleportation (Sanchit Srivastava)**

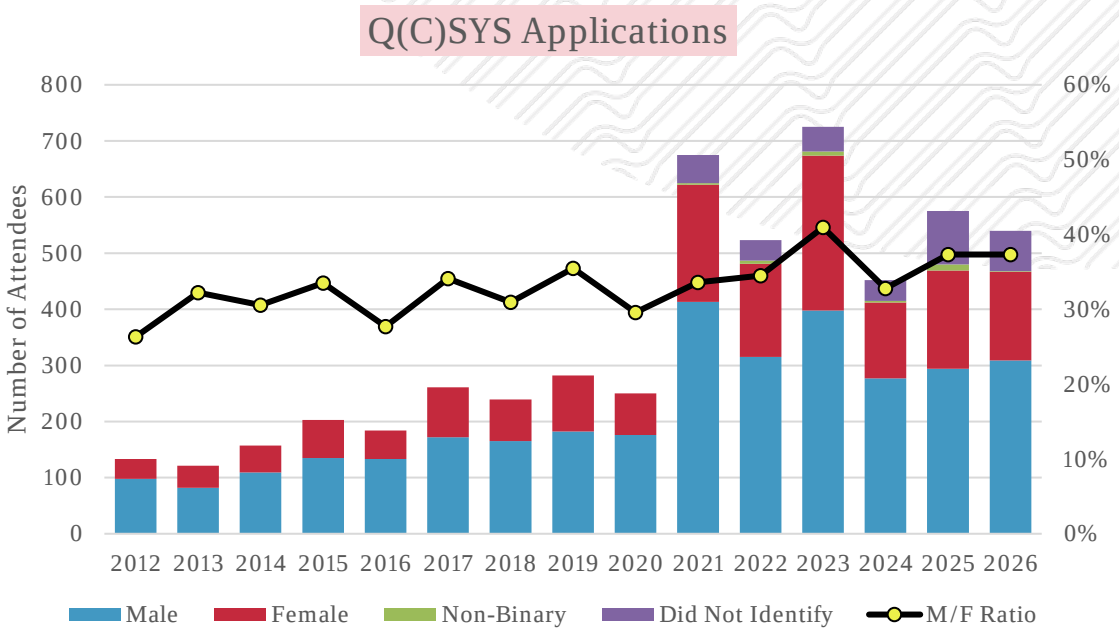
Sample QSYS Schedule
Fully online 2024

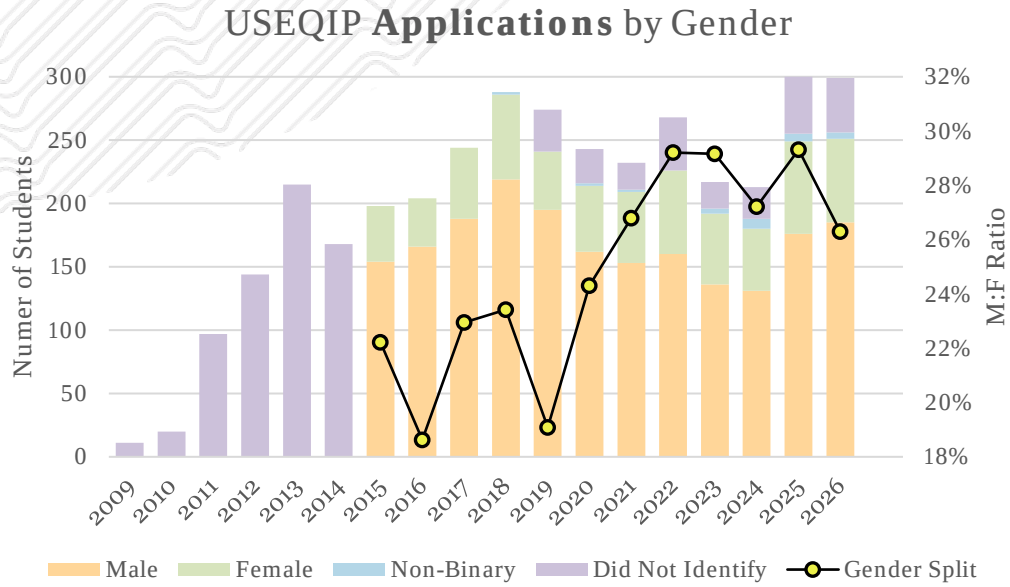
Date/Time	Session
Tue Aug 5 1-3pm ET	**Mathematics Practice Session**
Mon Aug 11 1-3pm ET	**The Rulebook of Quantum Mechanics**
Tue Aug 12 1-3pm ET	**Polarization Qubits & Quantum Communication**
Wed Aug 13 1-3pm ET	**Interference, Quantum Gates, and Quantum Circuits**
Thu Aug 14 1-3pm ET	**Quantum Entanglement and Teleportation**
Fri Aug 15 1-3pm ET	**Quantum Algorithms**

Time	Session	Location
9:00	Arrivals and Sign-in	RAC Front Entrance
9:30	Introduction to QSYS Lab Day	RAC 3003
10:00	Meet the Qubits: Light and Spin	RAC 3003
10:30	Lab: Quantum Key Distribution (Group A) Lab: Quantum Spin Control (Group B)	RAC 2009 RAC 3003
11:30	Lab Tour	RAC First Floor
12:00	Lunch break	RAC 3003 & Patio
1:00	Tutorial: Entanglement and Bell's Inequality	RAC 3003
2:00	Lab: Quantum Spin Control (Group A) Lab: Quantum Key Distribution (Group B)	RAC 3003 RAC 2009
3:00	Snack break	RAC 3003
3:15	Meet the Qubits: Atoms, Ions, and Superconductors	RAC 2009
4:00	Liquid Nitrogen Ice Cream Social	RAC 2009
4:30	End of QSYS Lab Day	

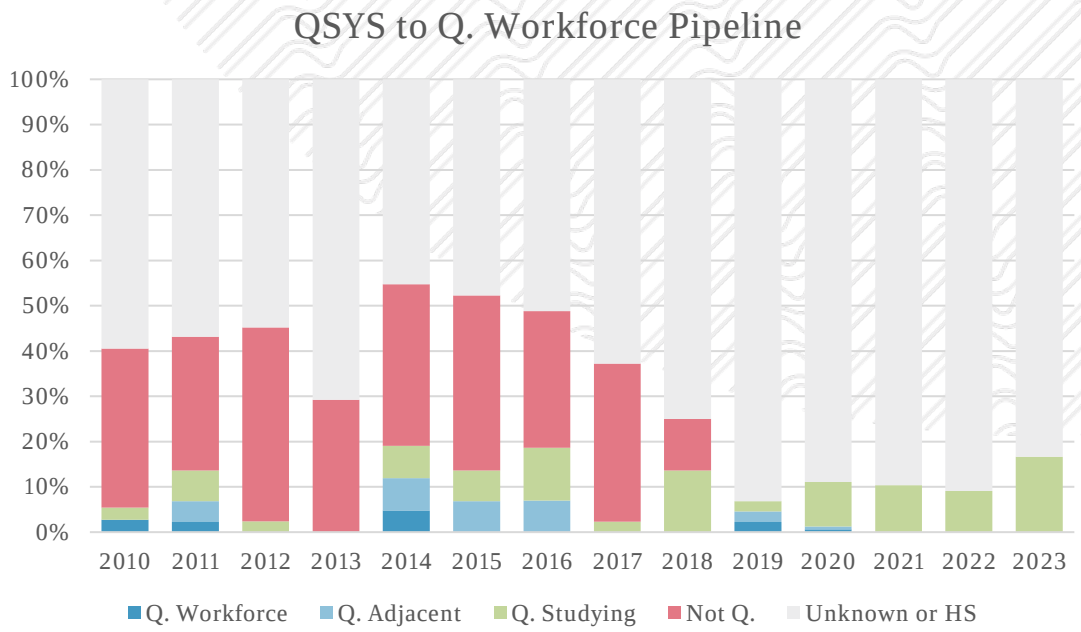
Sample QSYS
Schedule 2025
Five-day online
One-day in-person

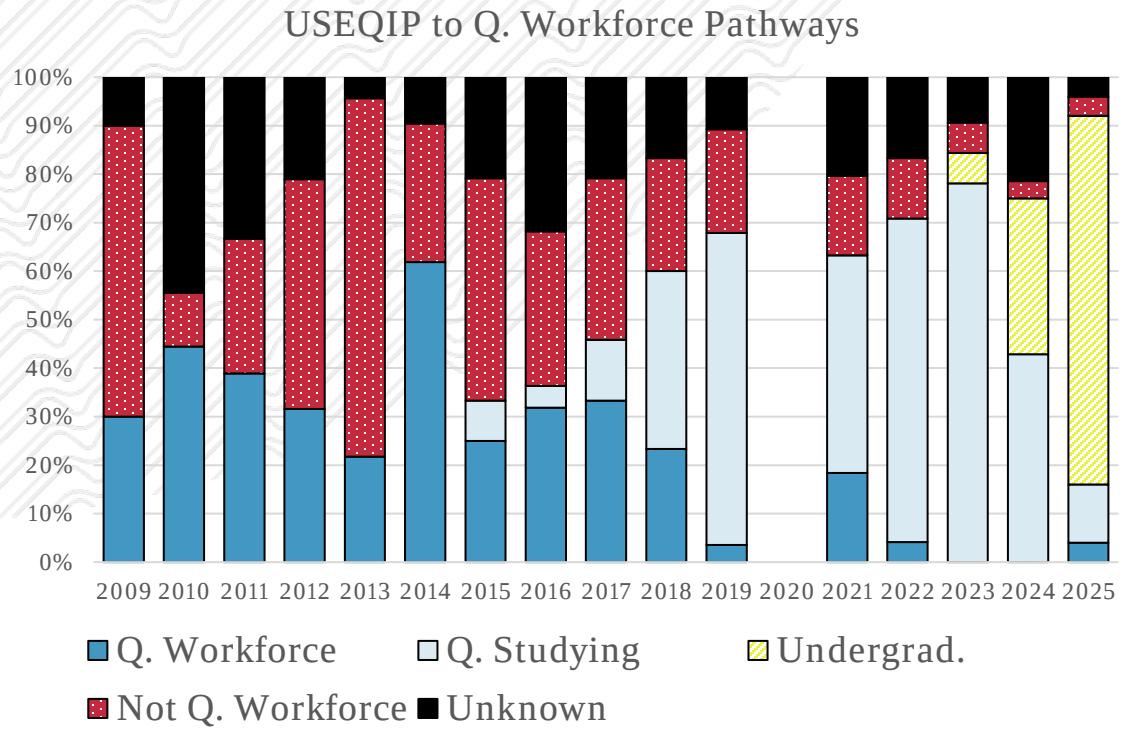
Application statistics





HS vs. Undergrad

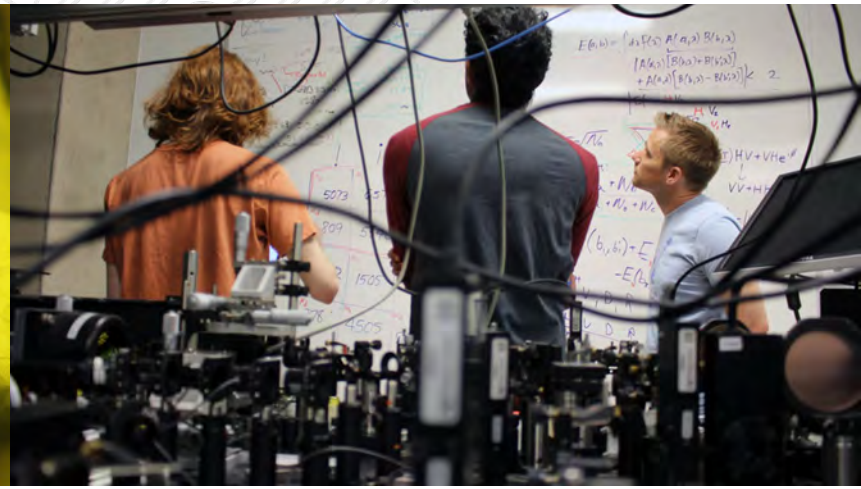


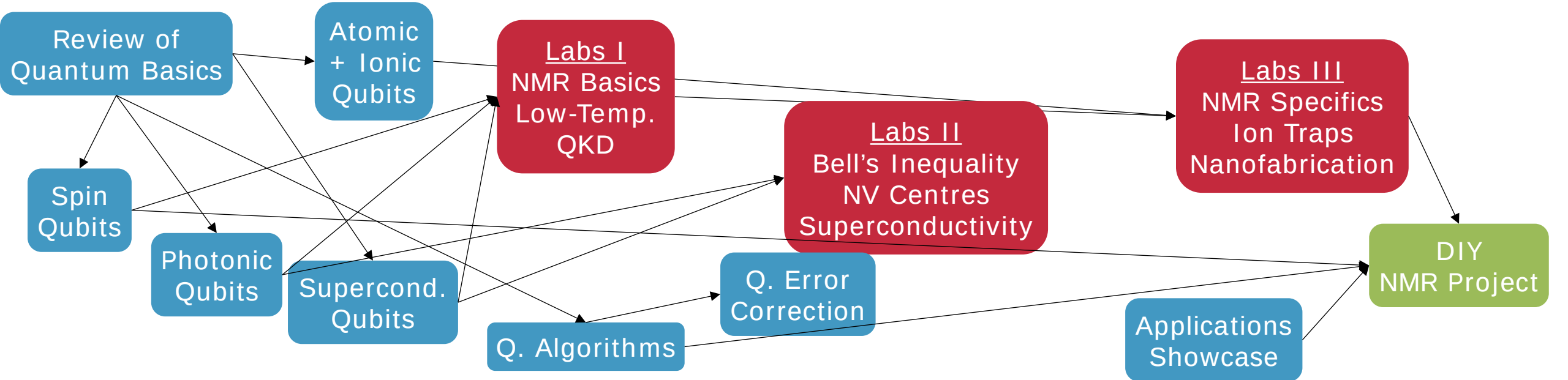


- Significant easier to track undergraduates than high-school students
- Majority of known are either in the quantum workforce or studying a relevant track

USEQIP

Undergraduate School on Experimental Quantum Information Processing







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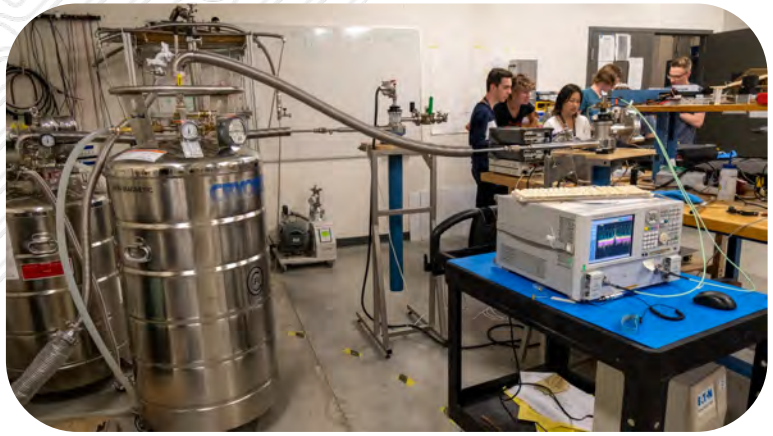
Lab Courses in Quantum Technologies

QIC860 / PHY760
Lab on Control of Q. Technology
Prof. David Cory

- Nuclear magnetic resonance with 2-qubit samples
- Pulse programming and gates
- Decoherence and decoupling
- Nitrogen-vacancy centres
- Randomized benchmarking

QIC861 / PHY761
Lab on Photonic Q. Technology
Prof. Kevin Resch

- Quantum state tomography
- Photon counting and statistics
- The Bell-CHSH inequality
- Hong-Ou-Mandel interference
- Phase super-resolution
- Quantum eraser



QIC862 / PHY762
Lab on Low-T. Q. Tech. & Nanofab.
Prof. Chris Wilson

- Superconducting transitions
- Low-temp. thermometry
- Josephson junctions
- Cryostats and dil. fridges
- Vector network analyzers
- Nanofabrication techniques