Quantum Information Science and Technology (QIST) is an area of strategic focus due to applications in the areas of Quantum Computing, Sensing, and Communications. The demand for QIST workforce in the Mountain West is expected to experience a compound annual growth rate of 18%[[1]](#footnote-1). It is also projected that ~76% of QIST jobs will only require a Bachelor’s degree or below. A 2021 study of QIST courses offered at US institutions found that 88% were offered at PhD granting institutions and that only 21% of the Hispanic Serving Institutes (HSIs) surveyed offered QIST courses[[2]](#footnote-2). This indicates that students at Predominantly Undergraduate Institutions (PUIs) and HSIs have less opportunity to engage in this field. A concerned effort is needed to train technician and entry-level engineers for the emerging Quantum workforce needs.

Infrastructure to provide hands-on experience with QIST hardware is also a gap in creating the necessary workforce. Hands-on training is one of the most important skillsets for a quantum-ready workforce[[3]](#footnote-3) and one of the most difficult to obtain due to the sparsity, expense, and complexity of quantum research labs.  Oftentimes, the only way to obtain hands-on opportunities is through funded internships in industry, national labs, and research universities, which require buy-in from researchers and professionals at those institutions who are willing to let students learn on their equipment and set aside the time to mentor and train these students. Generally, demand for internships outweighs the supply, and prior hands-on experience is preferred, significantly limiting opportunities for many communities that are already underrepresented in Science, Technology, Engineering, and Mathematics (STEM).

Building upon the success that Central New Mexico Community College (CNM) and CNM Ingenuity[[4]](#footnote-4) (CNMI) have had in immersive workforce development, a Quantum Technician bootcamp and Quantum Learning Lab are being established to train technicians for the QIST workforce needs. This training will be based on CNMI’s Deep Dive Bootcamps which are 10 to 12 week full-time (40 hours per week) immersive education. The Quantum Technician bootcamp will be developed drawing up the successes of the Internet of Things and Rapid Prototyping bootcamp which often takes students with no prior STEM experience and teaches them embedded programming, basic electronics and circuit design, 3D modeling, and additive manufacturing. This program utilizes experiential learning and just-in-time math to prepare and place students into high tech jobs.

PROJECT DESIGN

Central New Mexico Community College (CNM) and CNM Ingenuity (CNMI) have several goals centered around this hands-on quantum learning laboratory. CNM aims to deepen students' comprehension of quantum mechanics and its applications through hands-on experimentation and enhance the understanding of quantum principles to a diverse group of learners. CNM aims to cultivate a culture of interdisciplinary collaboration by integrating quantum science with other STEM disciplines. Additionally, the quantum lab will nurture learners’ research abilities by providing access to state-of-the-art equipment and mentorship opportunities.

The activities that will support these goals:

1. Develop a 10-week immersive Quantum Technician curriculum which can attract a diverse student base by having no STEM prerequisites. The program will prepare individuals for Quantum Technician jobs by developing proficiency in five topic areas:
   1. Photonics – photon sources, optical components, optical alignment, fiber coupling, and spectroscopy.
   2. High Vacuum Systems – vacuum system principles, vacuum system assembly, maintenance of pumps and pressure transducers, helium leak detection, vacuum system troubleshooting.
   3. Quantum Techniques and Phenomenon – interferometry, double-slit experiments, quantum cryptography, and entanglement. As well as laser cooling, optical tweezers, magneto-optical traps, and quadrupole traps.
   4. College Algebra – mathematical techniques needed to maintain and troubleshoot optical and vacuum systems.
   5. Mechanical Design – 3D CAD techniques to create mechanical components for troubleshooting and improvement to QIST hardware.

The above curriculum will be designed to not only meet the needs of the QIST workforce but will also address current technician needs to the semiconductor, solar cell manufacturing, and opto-electronics industries.

1. Build a Quantum Learning Lab (QuLL) at CNM to provide an accessible hands-on training component to the above curriculum. Additionally, the QuLL will offer students from 4-year research institutions to be provided with hands-on QIST experience. When fully built out, the QuLL is envisioned to include 10 different experiments with relevance to QIST spanning multiple qubit technologies, including neutral atom qubits, trapped ion qubits, photonic qubits, defect qubits, and spin qubits.
   1. *Neutral Atom and Trapped Ion Qubits*: experiments covering absorption spectroscopy, laser cooling, optical tweezers, magneto-optical traps, and quadrupole traps. These experiments will introduce students to crucial hardware tools utilized in quantum computing with atomic qubits (lasers, electronics, optics, vacuum systems), as well as concepts such as isolation of qubits, atomic structure, measurement, etc.
   2. *Photonic Qubits*: Interferometry, double-slit experiment, quantum cryptography analogy, and entanglement experiments will introduce students to hardware tools for quantum computing with photons (lasers, optics, detectors, electronics) and concepts including wave vs particle nature of light, polarization, superposition, interference, measurement, and entanglement.
   3. *Defect Qubits*:a quNV system to introduce basic principles of defect qubits – in this case using nitrogen vacancies in diamond. This experiment introduces students to NV- defect quantum states for quantum computing and non-invasive quantum sensing, including energy levels, laser addressing, and measurement.
   4. *Spin Qubits*:Spin qubits will be introduced through an experiment with quantum dots that allows students to study the absorption and emission properties of quantum dots, introducing them to yet another two level system and reiterating concepts such as absorption and emission spectra.
2. Prepare new and diverse communities of participants for education and careers in QIST. CNM and CNMI will partner with research scientists at Sandia National Labs and faculty at New Mexico’s Research Universities to provide a hands-on environment to expose underrepresented students to QIST concept and experiments in order to better prepare them for internships, careers, and additional educational opportunities in QIST. This will include making the Quantum Learning Lab available for Quantum Summer Camps and other workshops.
3. Incorporate wrap-around services to increase probability of successful outcomes. Utilizing experiences from other CNMI programs and CNM students services infrastructure … (do we have some boiler plate verbiage on wrap around services and can we include graduation rates from the Deep Dive bootcamps?)

TIMELINE

The project timeline will include the below milestones:

|  |  |
| --- | --- |
| Time Period | Milestones |
| Jul – Sep 2024 | * Order QIST Equipment * Order Vacuum System Training Equipment * Outfitting of Quantum Learning Lab – tables, cabinets, fixtures * Arrival of Photonic Equipment * Develop Lean Manufacturing Curriculum |
| Oct – Dec 2024 | * Develop Photonics Curriculum * Develop Just-In-Time College Algebra Curriculum for Photonic/Vacuum * Arrival of first Vacuum Training System |
| Jan – May 2025 | * Arrival of QIST Equipment * Develop Quantum Phenomenon Curriculum * Finalize full Just-In-Time College Algebra Curriculum * Recruit students for first Quantum Technician Bootcamp * Ensure all student success services are in place |
| Jun – Aug 2025 | * Conduct first Quantum Technician Bootcamp * Partner with Sandia National Labs on Quantum Summer Camp for K-12 |
| Sep – Dec 2025 | * After Action Review of first Quantum Technician Bootcamp * Revise and systematize Quantum Technician Bootcamp curriculum and learning materials. |
| Jan – Jun 2026 | * Conduct second Quantum Technician Bootcamp * Develop QIST workshops |
| On-going | * Conduct two Quantum Technician Bootcamps annually * Partner with Sandia National Labs on ongoing Quantum Summer Camps * Provide year-round QIST workshops for students throughout New Mexico. |

MEASUREABLE OUTCOMES:

|  |  |  |
| --- | --- | --- |
| Key Outcomes | Data | Goals |
| Recruit diverse participants into QIST | Participant demographics: gender, race/ethnicity, first generation college students, age, veteran status, socio-economic status. | * > 40% female * > 50% people of color * > 20% veterans |
| Bootcamp participation | Number of students in each Quantum Technician Bootcamp | * 6 in first bootcamp * 9 in second bootcamp * 12 in subsequent bootcamps |
| Graduation Rate | Percentage of Students completing Quantum Technician Bootcamp | * >90% |
| Employability | Perfectiona of Quantum Technician Bootcamp Students employed\* in Quantum or High Tech Manufacturing, or pursuing additional QIST/STEM education. | * >60% within 3 months of graduating * >80% within 6 months of graduating |

PROJECT PERSONNEL

The Project Team will consist of: (Melissa to add percentage of time per the budget)

* Program Director: Dr. Brian Rashap who will be responsible for specifying Quantum Learning Lab equipment specifications, developing the initial Quantum Technician Bootcamp curriculum, and will be the lead instructor for the first bootcamp. Additionally, Dr. Rashap will lead the after action review of the first bootcamp and drive an necessary curriculum improvements.
* Program Manager: Ms. Monica Olmsted who will be responsible for recruiting students for the first bootcamp, ensuring all support services are in place, and ensuring that all the necessary data is collected to measure program outcomes vs goals. Additionally, Ms. Olmsted will support the purchase of QuLL equipment and other infrastructure and logistical needs.
* Bootcamp Trainer: Mr. Edward (EJ) Ishman who will assist with the development of Quantum Technician Bootcamp curriculum and training material, will drive the installation of equipment into the QuLL, and will assist in instruction for the first bootcamp.

NOTE: Additional faculty may be hired for subsequent Quantum Technician Bootcamps. If so, Dr. Rashap and Mr. Ishman will be responsible for ensuring they are fully trained.

MANAGEMENT PLAN

At its core, the Quantum Technician Bootcamp and the Quantum Learning Lab facility works to utilize students, faculty, and the interactions between them to make efficacy and persistence part of the culture at CNM in an effort to help more Hispanic, women, and low-income students succeed in and graduate from STEM programs. Additionally, the program needs to meet the needs of high technology employers in New Mexico including quantum information systems companies, semiconductor and solar cell manufacturers, and opto-electronics/aerospace companies. In order to best serve both of these constituencies, the management team will consist of a Program Director, Program Manager, and Bootcamp Trainer. They will work in conjunction with CNMI’s Deep Dive program team including the Deep Diver Program Director, the Bootcamp Success Coach, and the Employer Outreach Manager. This team will ensure that students not only receive a high-quality immersive training experience, but also are supported with services (including tutoring) that will increase graduation rates as well as prepare students for interviews with employers. Additionally, one of CNM’s Internal Researchers will spend a portion of their time helping both the Program Director and Program Manager collect data on participants and outcomes.

1. Lightcast, Quantum Computing Report, Expert Interviews [↑](#footnote-ref-1)
2. B. Cervantes, G. Passante, B. Wilcox, and S. Pollack, “An Overview of Quantum Information Science Courses at US Institutions”, 2021 PERC Proceedings (2021) [↑](#footnote-ref-2)
3. H.R.6227 - 115th Congress (2017-2018): National Quantum Initiative Act. (2018, December 21). <https://www.congress.gov/bill/115th-congress/house-bill/6227>. [↑](#footnote-ref-3)
4. CNM Ingenuity is a non-profit entity established under the New Mexico Research Park Act whose mission includes innovation in workforce training pathways. [↑](#footnote-ref-4)