Addressing the talent gap in quantum computing

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Key points

- With rising government expenditure and private sector investments in quantum computing, the need for talent in academia, industry, and government has increased. Unlike other emerging technologies, quantum computing will need to be managed by scientists and physicists.
- The talent gap has reduced, but continues to be significant: in 2022, about two-thirds of quantum computing jobs could be taken up by recent graduates, compared to a third in 2021.
- Workforce development is impeded by overburdened academia, industry not keeping pace with R&D, and the fact that many quantum computing companies are led by non-experts.

Policy recommendations

- Quad members could formulate and devise a common curriculum for schools and university education in quantum computing. A consortium of quantum labs, research institutes, university departments, and institutes of higher education among the Quad members can be built to design this curriculum.
- Tailored proofs-of-concept (POCs) should be provided by academia and R&D labs to industry to strengthen their interlinkages. This will deepen the trust of industry in quantum science, while also helping to fine-tune their investment strategies.
- Key decision-making roles should be provided to quantum scientists to deliver timely outcomes, reduce siloed working, and give proper direction to technological development.
- Governments should spearhead the creation of a *network of networks*, which consists of academia, civil society, technologists, scientists, and relevant government agencies to ensure the many facets of quantum computing workforce are developed.

Introduction

The economic value addition of quantum computing is estimated to reach over US$1 trillion by 2040.[1] From solving complex computation problems to optimising solutions in no time, fault-tolerant quantum computers[2] will dramatically impact industries such as finance, health, education, aviation, automation *et al.* To spearhead this “second quantum revolution”,[3] a key factor is workforce development.

This paper discusses the quantum talent gap which Quad members face today and suggests a few recommendations.

A holistic view of the quantum computing ecosystem

- Scientists, researchers, academicians, PhD students, and postdocs.
- Trained personnel who can build, operate, and maintain these mega machines.[4] [5]

- Technologists, developers, software and hardware professionals, analysts, interns, and other skilled personnel.
- Quantum security experts.[6]
- Lawyers, Tech policy professionals, policymakers, and civil society.
- Government agencies and regulatory bodies.

Key drivers for growing talent demand

Countries around the world have rolled out national-level quantum strategies, missions, and flagship programs. The initiatives of Quad members have been summarised in Table 1.

Table 1. Quantum initiatives of Quad members.

Country	Quantum initiative	Budgetary allocation	Time period
United States	The National Quantum Initiative Act, 2018[7]	US$1.2 billion (in government funding). Private organisations and several US universities have also pledged a contribution of US$340 million to research centres that have been set up through the act.	Five years (2018 – present)
India	National Quantum Mission[8]	US$1.1 billion	2020 – present
Australia	National Quantum Strategy[9]	US$670 million ($A1 billion)	7 years (2023 – present)
Japan	MEXT – Quantum Leap Flagship Program[10]	US$280 million	10 years (2018 – present)

Also, the private sector investment in quantum computing has grown in the last few years, with a record investment of US$2.35 billion in quantum technology start-ups in 2022-23.[11] These initiatives and investments have opened positions in government, academia, and industry. Also, with investors slowly willing to invest in quantum computing, the number of start-ups has also increased. From a handful of start-ups in 2010, to over 350 globally in 2022, the quantum computing market will continue to rise.[12] Fig. 1. shows the number of start-ups in Quad member states.

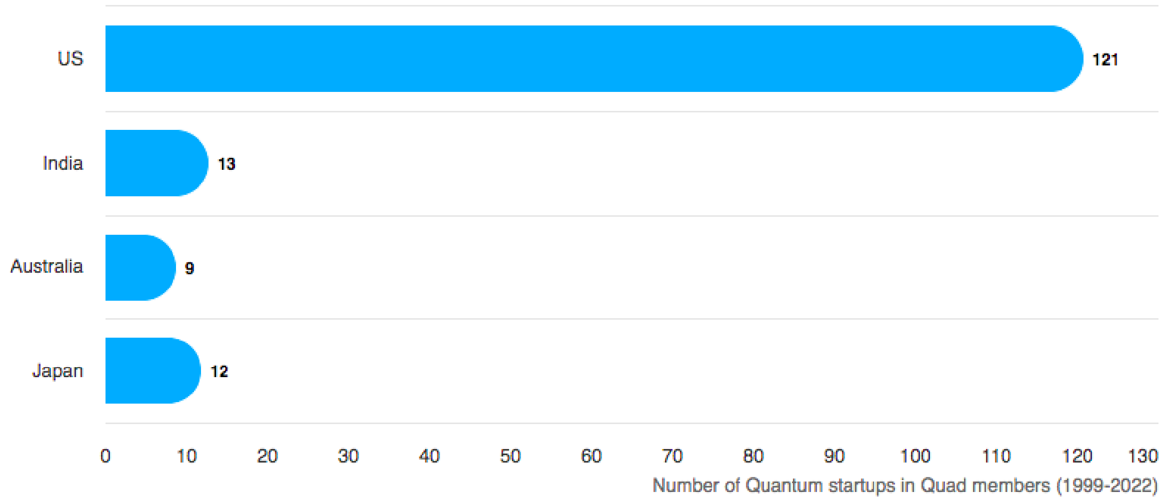

Fig. 1. Number of quantum start-ups across Quad members (1999-2022. Source: Springer, 'The landscape of the Quantum start-up ecosystem', October 2022.

As per McKinsey and Company, the quantum technology market size will be US$106 billion by 2040, of which quantum computing's share is expected to be up to US$93 billion.[13] As of 2030, the market size for the United States is estimated to be US$6.5 billion, Australia to be around US$2.2 billion, and Japan US$1.57 billion. Market data for the other Quad member, India, is not available.

All these factors have generated a steady demand for quantum computing talent. However, nation states, including Quad members, are gripped with certain personnel development challenges that they need to address.

Key challenges in quantum workforce development

While there has been a rise in the quantum computing workforce, the talent gap is still significant. As per research, most of the quantum computing talent of the day consists of physicists and engineers who are in any way related to quantum science.[14] For instance, these could be electrical engineers or IT professionals who double up as quantum workforce.

Among the Quad members:

- Research suggests that fewer than 50 per cent of quantum computing jobs in the US will be filled by 2025.[15]
- Over 60 per cent of Quantum jobs require at least a doctoral degree in quantum computing.[16] Australia has produced about 2,500 PhD scholars in the last 30 years, indicating a wide talent gap.[17]
- India's quantum ecosystem is in its infancy and has a handful of quantum researchers, professionals, and academicians.[18]

Author's research suggests that there are three key issues that pose a challenge to speedy quantum workforce development:

- **Academia is overstretched** — From publishing papers, to tutoring the next generation of quantum engineers, to filing patents, and innovating for national interests, academicians are overburdened. Compared to China, where each quantum lab has about 50 researchers, Quad members like India have a total of 50-60 quantum researchers across the country.[19] [20] This not only impacts the number of quantum personnel trained, but also diminishes the quality of the training offered.

- **Industry development is slow —** As gathered from primary research among Quad members, this is largely because quantum computers require heavy investments and their feasibility is uncertain. While investments have gone up, it will take years before fault-tolerant quantum computers are developed.
- **Quantum leadership is amiss —** In most countries, including Quad members, quantum computing efforts are led by those who are not necessarily experts in the field. To gain the first mover advantage, they tend to overcommit and under-deliver.[21] This puts commercialisation efforts in limbo, and creates a trust deficit amongst industry, thereby impeding the engagement of the private sector. All of this has a trickle-down effect on talent development.

Conclusion

With the disruptive potential of quantum computers, it is imperative that quantum computing talent be nurtured early on. From understanding the nature of the workforce, to the challenges that obstruct its development, policymakers must work together with the quantum ecosystem to address talent gaps. In fact, Quad members could pave the way for a global quantum computing community on workforce development.

Notes

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[4] Unlike classical computers, quantum systems need cryogenics to keep them cool and to reduce thermal noise. Hence, support staff like lab technicians and assistants are crucial.
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About this paper

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About the Quad Tech Network

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