



## Quad collaboration for STEM workforce growth

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### Key points

- A sufficient science, technology, engineering, and mathematics (STEM) workforce is a prerequisite for achieving the Quad's technology-related policy objectives.
- Despite the vital need for STEM workers, we see shortages across many industries.
- There are levers available to foster STEM workforce growth across the Quad — international research collaboration, existing Quad agreements, and bilateral cooperation between member states offer existing means to increase STEM workforces within the Quad.
- While the Quad should make use of these levers, most of the work to train sufficient STEM talent must be done through domestic policy.

### Policy recommendations

- Expand the existing Quad International Standards Cooperation Network to include assisting in the development and dissemination of workforce frameworks for critical emerging technologies.
- Government stakeholders, universities, research institutions, and private sector partners should increase research collaboration by creating: grants for joint research projects; scholarships and fellowships for visiting researchers and academic exchanges; and workshops and conferences.
- Maintain support for bilateral agreements between Quad member states with STEM workforce impacts and explore successful areas for multilateral expansion.
- Develop or update domestic STEM education and workforce strategies to meet labour demands of the 21st century.

### STEM talent is key, but shortages are common (and harmful)

The priorities of the Quad, mentioned in both the Quad Leaders' Summit and reflected in the topics of the QTN dialogue include telecommunications, biotechnology, artificial intelligence (AI), cybersecurity, semiconductors, quantum computing, and energy. Facing the challenges and realising the promises associated with each of these technologies requires a population educated in STEM. Without a sufficient STEM workforce drawn from each countries' population, each Quad member state will struggle to implement any tech-related strategy, regardless of how well it is formulated.

The need for skilled workforces will only increase as Quad nations' economies become increasingly digitised with widespread AI, continued reliance on semiconductors, proliferating adoption of 5G networks, the need for development and the adoption of green energy, and the possible arrival of quantum computing applications. In such an economy, the line between STEM and non-STEM workers begins to blur, and education and workforce development systems must adapt to such a paradigm.

As the four leading democracies in the Indo-Pacific, the United States, Australia, India, and Japan see the Quad as a partnership that can curb China's disruptive regional behaviour. China's digital authoritarianism, seen in its export of repressive surveillance technologies and economic coercion, poses challenges to regional democratic interests. Furthermore, COVID-related supply chain shocks and the existence of key technology chokepoints underscore the importance of a Quad with capable and complementary STEM workforces to promote supply chain resilience.

## Shortages exist across countries and industries

Even though the number of STEM graduates is increasing worldwide, there are STEM talent shortages in many key industries. In August of 2022, the US passed the *CHIPS and Science Act*, hoping to re-shore domestic chip manufacturing. It will likely create tens of thousands of jobs, with demand for engineers and software developers up 19 per cent over the next decade.<sup>1</sup> But chipmaking companies are warning that a lack of qualified employees will stymie their attempts to ramp up domestic production.<sup>2</sup>

This is but one example, but there are similar stories from Australia, Japan, and India. Over the next two years, Australia needs 100,000 digitally skilled workers and 40,000 more engineers.<sup>3</sup> The Japanese Ministry of Economy, Trade and Industry has projected a shortfall of 450,000 information technology professionals by 2030.<sup>4</sup>

Shortages can be particularly pronounced in cutting-edge technologies where the competition for talent is global and fierce. For example, the need for quantum computing experts is far outpacing the number of qualified graduates.<sup>5</sup>

## Each Quad country must address gender equity in their STEM workforce

- While India does well in graduating women in STEM fields, only about 14 per cent of STEM jobs are held by women.<sup>6</sup>
- Japanese girls' mathematics and science test scores rank in the top three of all countries, but only 16 per cent of university students in engineering, manufacturing and construction are women.<sup>7</sup>
- Women make up less than a third of the Australian STEM workforce and face a gender pay gap of 22 per cent.<sup>8</sup>
- In the US, women account for 60 per cent of college graduates, but only make up 40 per cent of STEM graduates, and one quarter of graduates in AI fields.<sup>9</sup>

## Leveraging the alliance: how we can help each other

Globalisation and the growing interdependence of economies create an environment in which some STEM challenges cannot be solved on a country-to-country basis. Some tools for collaborative problem-solving include:

- IP and innovation policies
- collaborative R&D
- direct foreign investment
- immigration policy
- talent programs and exchanges.

## Existing Quad partnerships that empower the STEM workforce should be maintained and strengthened

In the last few years, the Quad has created a number of partnerships and agreements to advance mutually beneficial goals. The Quad Fellowship was announced in 2021 and will sponsor 25 STEM master's and doctoral students from each of the Quad member countries to study in the US. This program is sponsored by a group of philanthropic and private sector partners and its first cohort of students is beginning studies in 2023.

A second partnership, the Quad Critical and Emerging Technology Working Group, aims to promote global technology markets and standards based on openness, diversity, trust, and resilience.<sup>10</sup> Alignment between Quad member countries with these goals, and support for industry-led, multi-stakeholder approaches will help stimulate technological collaboration, investment, and innovation, and help to foster demand for STEM workers.

## Difficulty in matching skills to jobs can be a major cause of shortages, but an existing Quad network can help

Another partnership that can address future needs in a unique way is the Quad International Standards Cooperation Network. Its stated purpose is to increase situational awareness, coordination, and influence in international standards development.<sup>11</sup> This is an important goal, but the group could also be expanded to include the development of workforce frameworks for critical emerging technologies.

As new technology fields emerge, they can suffer from a mismatch of graduate skills and employer needs. Degree programs, especially at the university level, are often slow to adapt to changing labour market needs. Alternative training methods such as online certification programs or apprenticeships can help to bridge the gap, but they must understand what skills and competencies to teach. Unfortunately, when adapting to and adopting new technologies, companies can struggle to adequately define those skills for evolving work roles.

In the early 2000s, the emerging field of cybersecurity faced these exact problems. In response, the US government created the Workforce Framework for Cybersecurity (NICE Framework) to assist employers and educational institutions. It created a common lexicon that defines cybersecurity work roles and the skills and competencies needed to perform those roles. Since its creation, the NICE Framework has enabled a thriving ecosystem of cybersecurity degree programs and certifications that are globally recognised.

As new technologies mature, the Quad can use the Quad International Standards Cooperation Network to help create similar workforce frameworks. While the Quad neither have the capacity nor the ability to create such frameworks itself, each member state can promote the creation of frameworks domestically. Any effort undertaken should be shared through the cooperation network to align efforts across the Quad and facilitate cooperation and communication. This would require collaboration between universities, non-profit organisations, private industry, and international standards organisations to create effective and adaptable frameworks that promote multinational workforces.

## Research collaboration between the four Quad nations can fuel innovation and fill talent gaps

The Quad countries are home to many of the world's leading universities and research institutions, and often lead the global chart in research publications output in emerging technologies such as AI. International research collaboration is imperative for scientific progress, and often produces research that is more impactful, innovative and widely cited.

International research collaboration also allows scientists and researchers to gain and transfer skills that in turn strengthen domestic STEM workforces. Additionally, there is evidence that working in diverse teams increases our capacity for innovation and creative thinking, and the development of trustworthy AI systems requires diverse teams that coalesce around a shared set of ethical principles.<sup>12</sup>

Over the past decade, all four of the Quad countries have become more open to international research collaboration in AI. That said, the rates of international co-authorship differ significantly across the partnership, with Australia and the US having a much higher percentage of internationally co-authored publications than Japan and India. Moreover, while the US is the number one AI research partner of Japan, Australia, and India, collaborations between the latter three nations are far less frequent. It is also worth mentioning that all four countries (but especially the US) have close research ties with China in AI. While these scientific linkages are important and largely mutually beneficial, there are nonetheless legitimate concerns about research security, technology transfer and other vulnerabilities that are causing the Quad countries to reassess joint research with China.

There is much to gain from strengthening research collaboration across the Quad, and especially between Australia, India and Japan. Government stakeholders, universities, research institutions, and private sector partners can support existing research partnerships and facilitate new joint research projects in emerging technology areas in a variety of ways, including:

- grants for joint research projects
- scholarships and fellowships for visiting researchers and academic exchanges
- workshops and conferences.

Another pathway to strengthen research collaboration and cultivate the STEM workforce ecosystems across the Quad countries is to leverage the tech talent of diaspora communities. For the US, for example, the ability to attract and retain STEM talent from around the world, including India, has long been a competitive advantage. Indeed, immigrants from India comprised 11 per cent of the founders of the top 50 AI start-ups in the US and 6 per cent of the country's leading AI researchers.<sup>13</sup> Promoting research collaboration between Indian scientists and India's tech talent diaspora in the US, for instance, can benefit both countries by elevating the impact and visibility of India's AI-related publications, bringing diverse perspectives to the AI research and development process, and helping to fill STEM talent gaps.<sup>14</sup>

## Bilateral agreements encourage cooperation and collaboration, and an avenue for multilateral expansion

Since the revitalisation of the Quad in 2017, the four countries have also announced bilateral collaborations that impact the STEM workforce. The US-Japan University Partnership for Workforce Advancement and Research & Development in Semiconductors (UPWARDS) for the Future is a memorandum of understanding between industry partners and 11 universities from both countries, and its signing was presided over by US Secretary of State, Antony J. Blinken, and Japanese Minister of Education, Culture, Sports, Science and Technology, Keiko Nagaoka. This agreement is a promising example of government support for multi-stakeholder collaboration to increase STEM workforce pipelines between Quad allies in a critical technology.

Other bilateral agreements, such as the Australia-India Comprehensive Strategic Partnership from 2020 and Australia-United States Climate, Critical Minerals and Clean Energy Transformation Compact, signal continued support for collaboration. A review of the successful features of bilateral agreements could offer an avenue for expansion of similar agreements between all four Quad countries.

## Reviewing and revising domestic education strategies can refocus attention and ensure they promote STEM education best practices

The importance of STEM education in the context of global competitiveness calls for modern and effective national STEM education strategies. When reviewing and updating their strategies, countries should focus on three broad areas of focus: invest in their STEM education system, promote growth within the private sector, and foster an inclusive and exciting STEM culture.<sup>15</sup>

Investing in a strong education system means more than throwing additional funds at schools. It means creating viable, affordable pathways into STEM careers outside of four-year degrees and fostering opportunities for upskilling and reskilling. This includes building and strengthening non-degree credential programs, vocational training, and apprenticeship systems. Furthermore, in support of non-degree (and degree) training pathways, educational programming should align skills learned within local employer needs.

Promoting industry growth means targeted investment in critical technology industries and ensuring they have IP protection, while encouraging collaboration training providers.

As mentioned previously, each Quad member country would benefit greatly from increasing the representation of underserved populations in their STEM workforce. To do this, governments can fund initiatives targeting underserved groups from an early age in their primary school systems. Initiatives can create hands-on learning experiences, provide mentorship opportunities, fund extracurricular STEM-related activities, and support non-profit organisations that work in this space.

## Notes

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<sup>3</sup> Australian Academy of Technological Sciences and Engineering, “Our STEM skilled future: an education roadmap for an innovative workforce”, 2022, accessed 15 November 2023, <https://www.atse.org.au/research-and-policy/publications/publication/our-stem-skilled-future-an-education-roadmap-for-an-innovative-workforce/>

<sup>4</sup> M. Foster, “Japan Needs a Lot More Tech Workers. Can It Find a Place for Women?”, *New York Times*, 2021, accessed 15 November 2023, <https://www.nytimes.com/2021/09/01/business/japan-tech-workers-women.html>

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<sup>6</sup> N. Sabanayagam, “Women in the Workplace: The Need to Build a Diverse Talent Pipeline from Roots”, accessed 15 November 2023, <https://ansr.com/women-in-the-workplace-the-need-to-build-a-diverse-talent-pipeline-from-roots>

<sup>7</sup> M. Katsumura, “How Japan is encouraging more women into STEM”, *World Economic Forum*, 2023, accessed 15 November 2023, <https://www.weforum.org/agenda/2023/07/japan-encouraging-women-into-stem/>

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- <sup>10</sup> Department of the Prime Minister and Cabinet, “Quad Working Groups”, 2023, *Australian Government*, accessed 15 November 2023, <https://www.pmc.gov.au/quad-2023/quad-working-groups>
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## About this paper

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## About the Quad Tech Network

The Quad Tech Network (QTN) is an initiative of the NSC, delivered with support from the Australian Government. It aims to establish and deepen academic and official networks linking the Quad nations – Australia, India, Japan, and the United States – in relation to the most pressing technology issues affecting the future security and prosperity of the Indo-Pacific.

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