The state of science in Queensland 2022

Data | Stories | Opportunities

#32373 | 0722

Queensland Government

Prepared by the Office of the Queensland Chief Scientist
+61 7 3215 3739
www.chiefscientist.qld.gov.au
info@chiefscientist.qld.gov.au
Engage with science
#qldscience
medium.com/queensland-science

Acknowledgements

We acknowledge and appreciate the leadership, guidance and support of Professor Hugh Possingham and Lauren Stephenson throughout the project. Thank you to the rest of the Office of the Queensland Chief Scientist team for assistance in proof reading and data checking. The authors would like to thank all reviewers for their time and valuable feedback.

Suggested citation

Office of the Queensland Chief Scientist (2022) The state of science in Queensland 2022, Queensland Government, Brisbane.

#32373 | 0722

Foreword from the **Queensland Chief Scientist**

All knowledge is useful. In this report, the word 'science' embraces all ways of knowing. Economics, Indigenous knowledge, technology, mathematics, the social sciences, engineering and the arts are all knowledge ventures and form part of the broader definition of 'science' embodied in this document.

As Queensland Chief Scientist much of what my office does includes:

- increasing participation of under-represented groups in science
- encouraging respectful debate and dialogue on disputed scientific issues
- bringing different forms of knowledge together to tackle wicked problems
- supporting the development of Queensland's science-based industries
- creating connections and synergies to help maximise the impact of the state's scientific capability.

The team assembles data and brings scientific thinking to inform Queensland Government policymaking and to encourage a participatory democracy.

If COVID-19 has given us anything positive, it is a new appreciation of the importance of science. From the rapid development and deployment of new vaccines to the mathematical modelling underpinning public policy responses. Indeed, Queensland's approach to managing this coronavirus has taken knowledge from every field of human thought. History will show again that science has saved millions of lives and ensured prosperity.

As I write this foreword, I am reminded of the multiple assessments and evaluations conducted, that show a substantial return on investment in science and technology. For example, research that underpins biosecurity routinely delivers a return on investment of greater than ten. That is, for every dollar spent on biosecurity research and action, we save at least $10 in remediation and containment actions.

Queensland's economy is healthy but narrow. Diversifying our economy into some of the areas identified in Queensland's COVID-19 Economic Recovery Plan, as well as the Data61 reports

(New Smarts and A New Chapter) presents opportunities, but also requires highly trained and skilled workers. Queensland has an overall skills shortage that is partly met through immigration. This reliance on importing talent has been exposed by the restrictions implemented to manage the impact of COVID-19. Increased investment in training and education for Queenslanders is essential.

Queensland's economic growth is too fast to rely solely on just training our own. We need to ensure attraction of the best and brightest scientists from all over the globe. Talent begets talent.

The latest data on the world's most cited scientists shows that Queensland is reaping the rewards of investing in talented scientists. For example, Professor David Craik, Fellow of the Royal Society, the Australian Academy of Science, and a former Australian Research Council (ARC) Laureate Fellow, has built a world-leading research program in discovery, structural characterisation, and applications of novel peptides at the University of Queensland's Institute for Molecular Bioscience.

Finally, and most importantly, talented researchers and innovators often experience career breaks, especially women. We need a system that supports career breaks rather than entrenching inequity and disadvantaging career progression. Bringing a greater diversity of thought to Queensland's problems and opportunities will generate better outcomes. Future funding schemes need to both acknowledge career breaks and level the playing field for under-represented groups by offering more flexible funding models.

Professor Hugh Possingham

Acknowledgement of country

The Office of the Queensland Chief Scientist acknowledges Aboriginal peoples and Torres Strait Islander peoples as the Traditional Owners and custodians of the land and our first scientists. We recognise their connection to land, sea and community, and pay our respects to Elders past, present and emerging.

Design developed by Boyd Blackman, a Butchulla and Birri Birri man, featuring the artwork of Elaine Chambers, a Koa (Guwa) and Kuku Yalanji woman.

Contents

Summary

The state of science in Queensland 2022 documents the status of science and research in Queensland at a point in time. This is the fifth publication in the Health of Queensland Science series.

It includes comparisons with other Australian jurisdictions, as well as international benchmarks. It encompasses engagement of Queenslanders in science, education in science, technology, engineering and maths (STEM) subjects, research performance, as well as investment in research, translation and commercialisation.

The report concludes with a review of projected future science-based industries, jobs and skills needed for Queensland to continue to thrive.

Opportunities for Queensland to excel

1. Engaging Queenslanders in science

- increase student participation in STEM subjects and promote STEM careers
- increase community participation in citizen science to grow scientific literacy and contribute to scientific discovery
- increase awareness of Queensland's world-class science and opportunities for engagement with scientists to grow community awareness of the value of science and the role it plays in everyday lives

2. Foundational science skills

- support STEM teachers to inspire student achievement and participation
- reduce barriers to entry so quality education is accessible to all
- promote foundational science skills as key to participation in society and necessary for highly skilled secure jobs

3. Research and development

- promote strong strategic investment to secure future research
- foster research funding success and diversity by providing support to researchers
- encourage a greater number of applications for research funding by Queensland institutions, given the high correlation between application number and rate of success

4. Research translation and commercialisation

- facilitate collaboration between research and industry
- support the development of innovation spaces and expand innovation hubs to other fields including environmental science

5. Future industries, jobs and skills

- support workers to translate their capabilities to a low carbon economy
- recognise that quality science education builds the knowledge economy of tomorrow
- address barriers to building a diverse and inclusive workforce

1. Engaging Queenslanders in science

A community informed by and engaged with science recognises the value and contribution of science in everyday lives. Increasing community involvement and participation in science, is the best way to increase interest and awareness of science, scientific capability, and therefore critical thinking (Figure 1). The Engaging Queenslanders in science strategy 2021–24[1] was published in 2021 to foster an engaged and scientific literate community (Figure 2).

Kantar report statistics 2021:

- four in five Queenslanders stated they are generally interested in science
- Queenslanders aged 18-24 years are less interested in science than other age groups
- four in five Queenslanders feel scientific development has a positive impact on society
- women are more likely to believe a career in science is easier for men
- Queenslanders' belief that science is critical to the economy is increasing (72 per cent in 2016, 72 per cent in 2018, 83 per cent in 2021)
- interest in science has been trending down (74 per cent in 2016; 68 per cent in 2018; 60 per cent 2021).[2]

Number of respondents in Kantar report: 2021 = 1219; 2018 = 1288; 2016 = 1200.

Citizen science

Citizen science involves public participation and collaboration in scientific research with the aim to increase scientific knowledge.[3]

Citizen science provides a unique opportunity for people who are not paid to be scientists, to experience hands-on scientific methods and contribute to real scientific work. Anyone can volunteer and participate in citizen science projects, that may lead to new discoveries and new and diverse members of Queensland's science community.

In 2021:

- almost one in four Queenslanders had heard of citizen science and one in ten Queenslanders had participated in a citizen science activity
- awareness of citizen science increased (3 per cent unprompted in 2018; 9 per cent unprompted in 2021) 44 per cent of people who had heard of citizen science had also participated in it
- while a large proportion of students reported to be aware of citizen science, relatively few had participated in an event.[4]

The Office of the Queensland Chief Scientist is working with the Australian Citizen Science Association, the Queensland Curriculum and Assessment Authority, Queensland Department of Education, and directly with citizen science groups, to support the growth of citizen science across Queensland. To assist teachers to incorporate citizen science in the classroom, the Office of the Queensland Chief Scientist, with support from stakeholders, has developed an online resource kit.[5]

1 https://www.chiefscientist.qld.gov.au/strategy-priorities/science-engage-comms-strategy.
2 Bishop, R and Day, C (2021) Queenslanders' Perceptions and Attitudes to Science, Kantar Public Research Report.
3 Australian Citizen Science Association https://citizenscience.org.au
4 Bishop, R and Day, C (2021) Queenslanders' Perceptions and Attitudes to Science, Kantar Public Research Report.
5 https://www.chiefscientist.qld.gov.au/stem-education/citizen-science

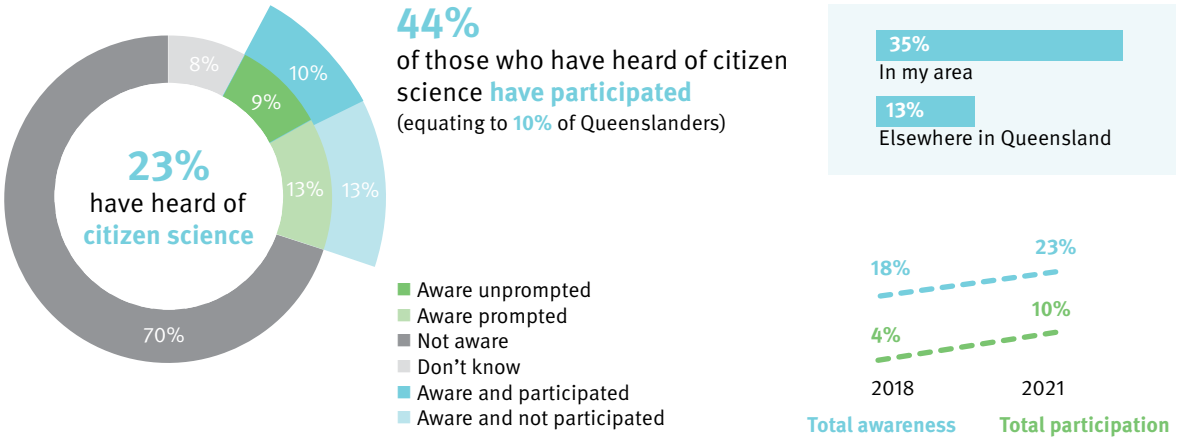

Figure 1: Citizen science awareness and participation in Queensland[6]

Since 2016, more than $2 million was invested by the Queensland Government in Engaging Science Grants across 189 projects (with more than half delivered in regional Queensland).

The Queensland Government has also allocated almost $1.2 million to 43 Queensland Citizen Science Grant recipients across the state for longer-term citizen science projects since 2019.

Opportunity for Queensland

Engaging Queenslanders in science:

- increase student participation in STEM subjects and promote STEM careers
- increase community participation in citizen science to grow scientific literacy and contribute to scientific discovery
- increase awareness of Queensland's world-class science and grow opportunities for engagement with scientists to grow community awareness of the value of science and the role it plays in everyday lives.

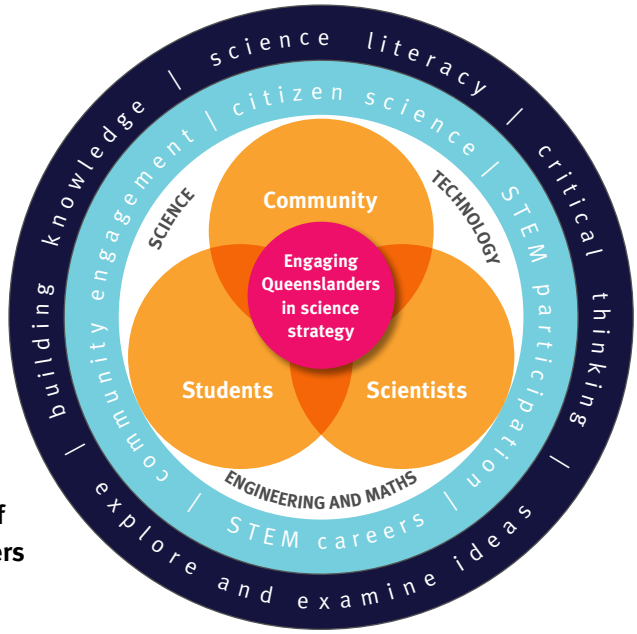

Figure 2: Key themes of Engaging Queenslanders in science strategy

6 Bishop, R and Day, C (2021) Queenslanders' Perceptions and Attitudes to Science, Kantar Public Research Report (p.48)

Case study

Wildlife Queensland: citizen science grant recipient

Wildlife Queensland's PlatypusWatch Network secured nearly $27,000 in citizen science funding from the Queensland Government to survey and document platypus populations and distribution within the upper Dawson River and tributaries around the Taroom region.

The 'PlatypusWatch and eDNA in the Dawson River' project harnesses local community knowledge and people power to protect our native monotremes in that region. Participating citizen scientists are trained in both observational survey and environmental DNA collection procedures before collecting community-based observations and conducting environmental DNA surveys.

Members of the project team work closely with Wildlife Queensland Upper Dawson Branch, the society's local branch in the Dawson River catchment.

Conducting platypus environmental DNA surveys in western Queensland, Matt Cecil, Wildlife Queensland

2. Foundational science skills

A quality STEM education contributes positively to building an engaged and informed community. It improves appreciation of science, provides skills to consider evidence objectively, weigh up information to solve problems and identify opportunities.

> The skills gained in a high-quality STEM education will be essential in many of the new jobs in the years ahead. STEM jobs are being created at 1.5 times the rate of non-STEM jobs. Yet the STEM-qualified workforce is growing at only half the rate of the non-STEM-qualified workforce.[7]

STEM in schools

The Queensland Department of Education provides resources and professional learning to promote systematic curriculum delivery, effective teaching practices, and expert teaching teams to support implementation of the *Australian Curriculum: Science*. Through *Advancing STEM* in Queensland state primary schools, the Queensland Government has committed $81.3 million to enable access to expertise, resources and partnerships required to improve student outcomes in STEM subjects. Regional STEM champions are a valuable component of this initiative. Local ambassadors provide support to schools by fostering partnerships with industry, guiding strategic planning and co-ordinating professional learning.[8]

In contrast to other Australian jurisdictions, Figure 3 shows participation by Year 12 students in Queensland has increased between 2012–19 in five of the eight STEM subjects (exceptions were information processing and technology, information technology systems, and Maths A).

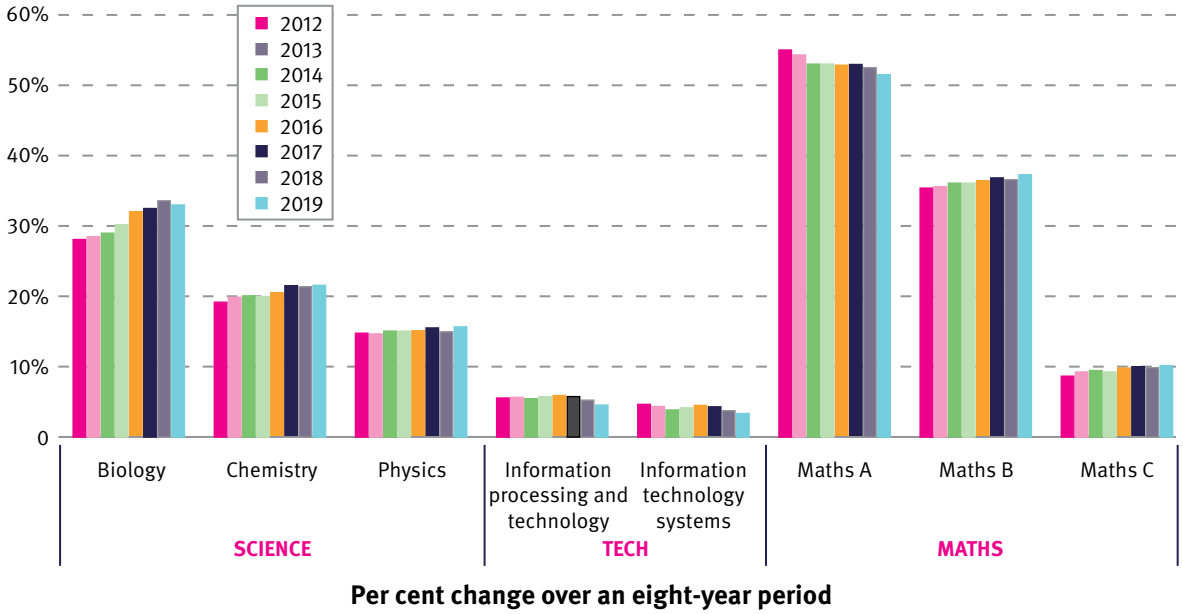

Figure 3: Per cent of Year 12 students participating in STEM subjects over time (2012–19)[9]

7 Science and Technology Australia. (2021). Australia as a STEM superpower: Policy Vision. Canberra, ACT: Science and Technology Australia. Retrieved from https://scienceandtechnologyaustralia.org.au/wp-content/uploads/2021/06/Policy-Vision-Document-2021.pdf (p14).

8 https://www.advancingstem.com.

9 Queensland Curriculum and Assessment Authority—analysed by Queensland Department of Education and the Department of Tourism, Sport and Innovation.

Diversity and inclusion

Reducing participation barriers to science subjects is important to increase diversity and creativity in Queensland's STEM graduate workforce. Initiatives and investments by both the Queensland and Australian governments are targeted to achieve outcomes of attracting female students, minority groups, Aboriginal and Torres Strait Islander students, and students with a disability.

Across Australia, more students are undertaking tertiary training and a greater share of the Australian workforce now holds post-school qualifications.[10]

Since 2011, female participation in STEM units at a tertiary level is gradually increasing (Figure 4). Conversely, male STEM enrolments have experienced flat or negative growth since 2015. The proportion of Aboriginal and Torres Strait Islander students studying STEM in Queensland universities, is higher than that for the rest of Australia (Figure 5) but still below non-Indigenous percentages.

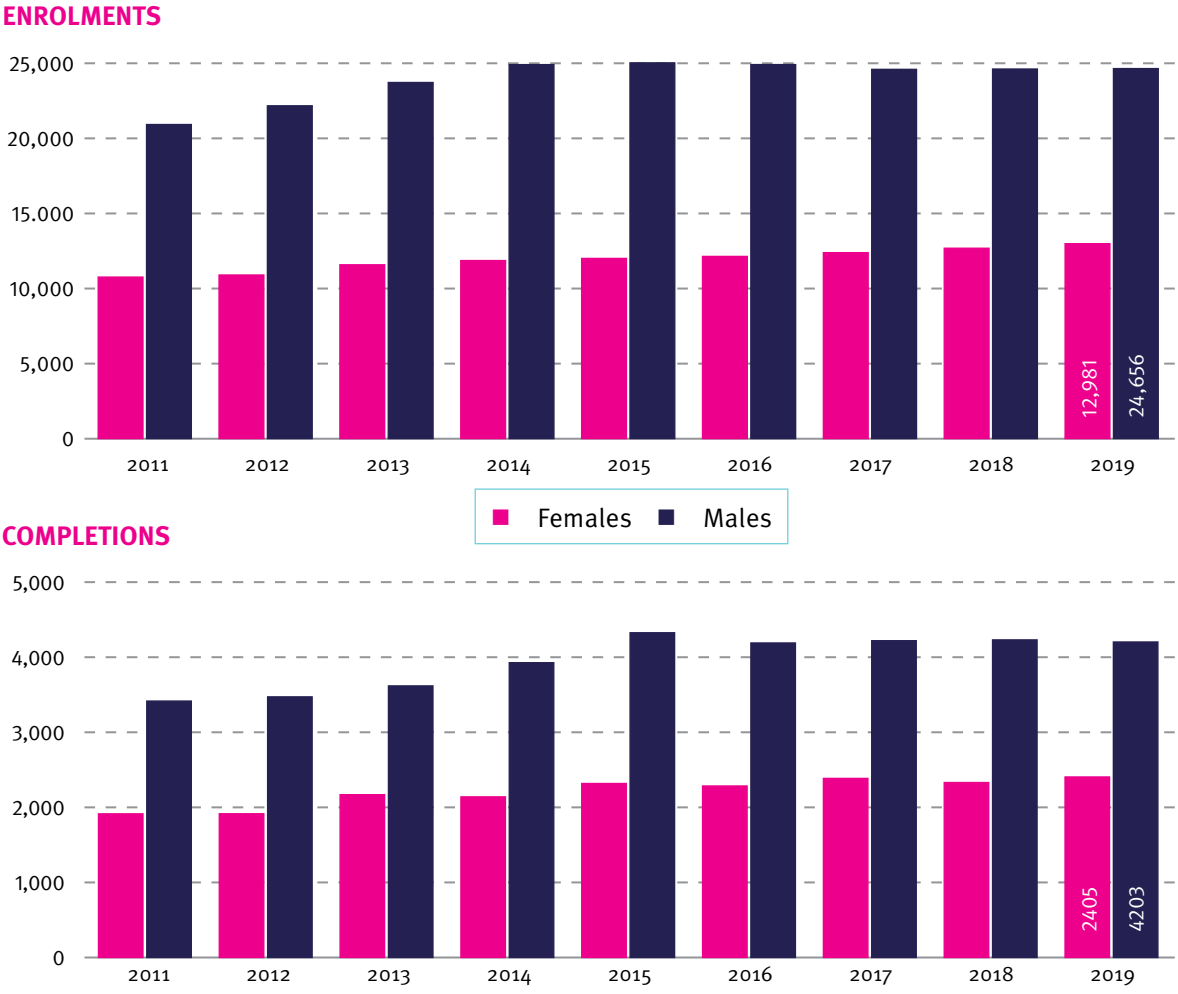

Figure 4: Number of domestic university STEM enrolments and completions in Queensland by gender (2011–19)[11]

10 https://www.dese.gov.au/employment-research-and-statistics/resources/australian-jobs-publication

11 University statistics, Department of Education, Skills and Employment – analysed by the Department of Tourism, Sport and Innovation

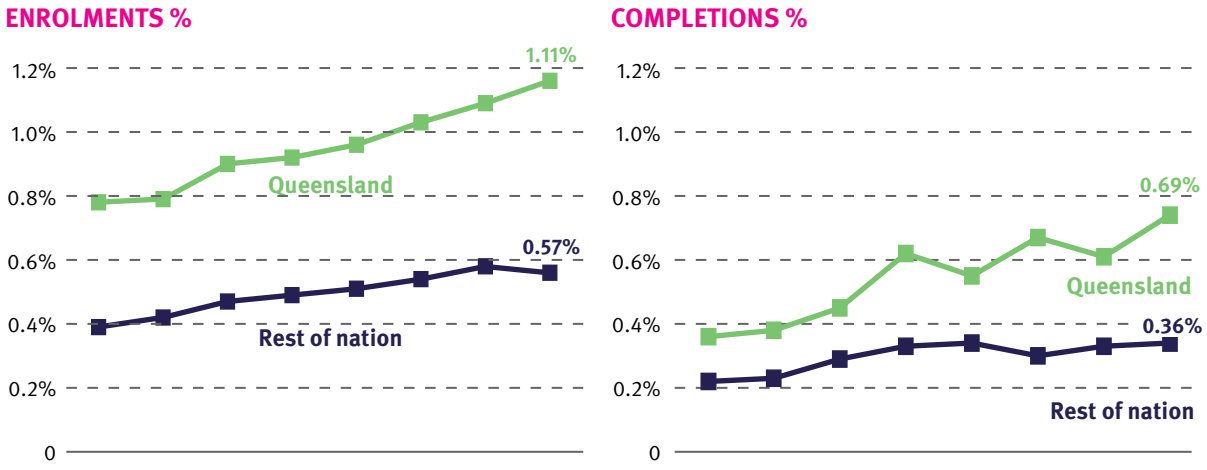

Figure 5: Proportion of Aboriginal and Torres Strait Islander students studying STEM in Queensland universities[12]

Opportunity for Queensland

Foundational science skills:

- support STEM teachers to inspire student achievement and participation
- reduce barriers to entry so quality education is accessible to all
- promote foundational science skills as key to participation in society and necessary for highly skilled secure jobs.

12 University statistics, Department of Education, Skills and Employment—analysed by the Department of Tourism, Sport and Innovation

Case study

Science and maths can take you anywhere

As the former Queensland Tertiary Admission Centre's (QTAC) resident statistician, Marco Lombardi holds both a bachelor's degree in statistics and information management, and a master's degree in biostatistics and experimental statistics.

Having worked as a statistical analyst in both Italy and Australia, Marco was responsible for determining the calculation methodology and subsequent calculation of the first Australian Tertiary Admission Ranks (ATAR) in Queensland in December 2020.

ATAR scores are the primary mechanism used for university admissions decisions in Australia and are recognised internationally.

In 2020, over 26,000 Queensland students received an ATAR based on Marco's work, which included a statistically robust process to compare different results in different subjects and qualifications fairly.

Other fields of work he previously contributed to range from probabilistic and mortality models used in spatial and environmental statistics, to sample designs and modelling used in transport, mobility and travel surveys.

Marco is now setting his sights towards developing data-driven methodologies at the Bureau of Crime Statistics and Research in New South Wales by undertaking statistical analysis and modelling initiatives that inform and improve wide policy development.

Marco is living proof that STEM is a global pursuit and with science and maths under your belt you really can go anywhere.

Case study

Women science communicators inspiring tomorrow's innovators

Fiona Holmstrom received a Queensland Women in STEM Prize in 2021. With a particular passion to ensure equity in education for girls in STEM, Fiona is director and co-founder of STEM Punks, a Queensland company providing STEM education to school children.

Her company transformed in response to COVID-19 by bringing STEM education to global audiences through a variety of online and in-person classes for students at home or in schools, as well as a magazine and an online learning platform.

Fiona supports a girls' digital literacy project overseas, offers scholarships for under-represented minority groups in Queensland to access STEM education for free, and is keen to see more girls enter STEM fields.

Her mission to make STEM education more accessible was recognised by the AusMumpreneur Awards where she won Gold in the 'Making a Difference in Education' category in 2020. Fiona also won a 2021 Women in Technology award.[13]

Sally McPhee is Griffith University's STEM Outreach Manager. Sally champions STEM for students at all levels by providing STEM pathways, leadership and engagement opportunities for students and improving teacher confidence and capability in science. Under her leadership, Science on the GO! has engaged over 100,000 people in the last three years.

Sally also showcases STEM researchers through her science communication initiatives to help break down stereotypes about women in STEM, as well as being the founder of the Griffith University STEM Squad. Her initiative provides a vehicle for undergraduate and postgraduate STEM and education students to lead science outreach activities for schools and across the community.

Her marine science and education background helps her to foster a scientifically literate community and inspire school students to stay in STEM subjects.

Fiona Holmstrom, Director of STEM Punks

Sally McPhee, Griffith University

13 https://wit.org.au/awards/2021-wit-awards-winners/

3. Research and development

Research excellence

Queensland has 68* highly cited researchers, which is approximately consistent with our share of the national population but higher than our share of national higher education research and development expenditure (16.4 per cent in 2018— ABS 8111.0) (Figure 6).

Queensland is recognised for its extensive investment in medical research and environmental sciences including reef health. These priority areas are reflected in the Queensland Government agencies' expenditure on research and development. The highest expenditure is from Queensland Health, followed by the Department of Agriculture and Fisheries (including Biosecurity Queensland), and thirdly, the QIMR Berghofer Medical Research Institute.[14]

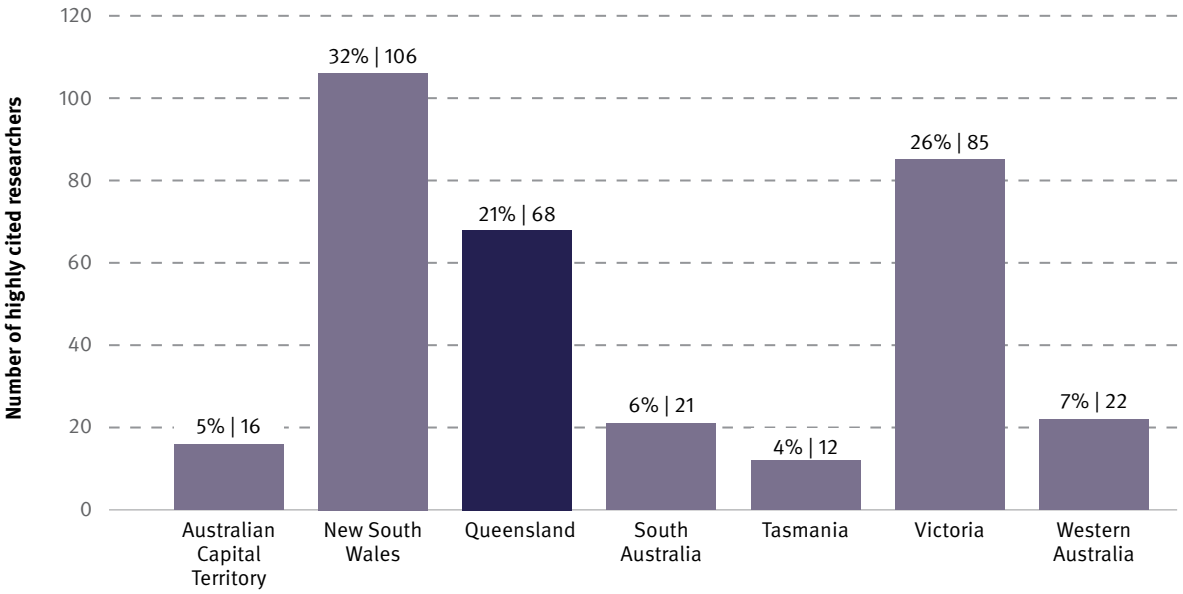

Figure 6: Number of highly cited researchers by Australian state/territory[15]

> Research and development is defined as 'creative and systematic work undertaken in order to increase the stock of knowledge—including knowledge of humankind, culture and society—and to devise new applications of available knowledge'.[16]

Two-thirds of Queensland's highly cited researchers have The University of Queensland as their primary affiliation institution as evidenced in Figure 7 showing disparity between The University of Queensland and all other Queensland research institutions.

Further, two of CSIRO's highly cited researchers are based in Queensland. CSIRO's presence in Queensland attracts further talent.

---

* Queensland has three researchers who are each listed against two topics, hence 68 highly cited researchers translates to 65 unique researchers.

14. Queensland Government research and development expenditure report https://www.chiefscientist.qld.gov.au/publications/rnd-expenditure-reports/report-2019-20

15 Clarivate data allocated to states and territories by the Queensland Department of Environment and Science

16 OECD (2015), Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris

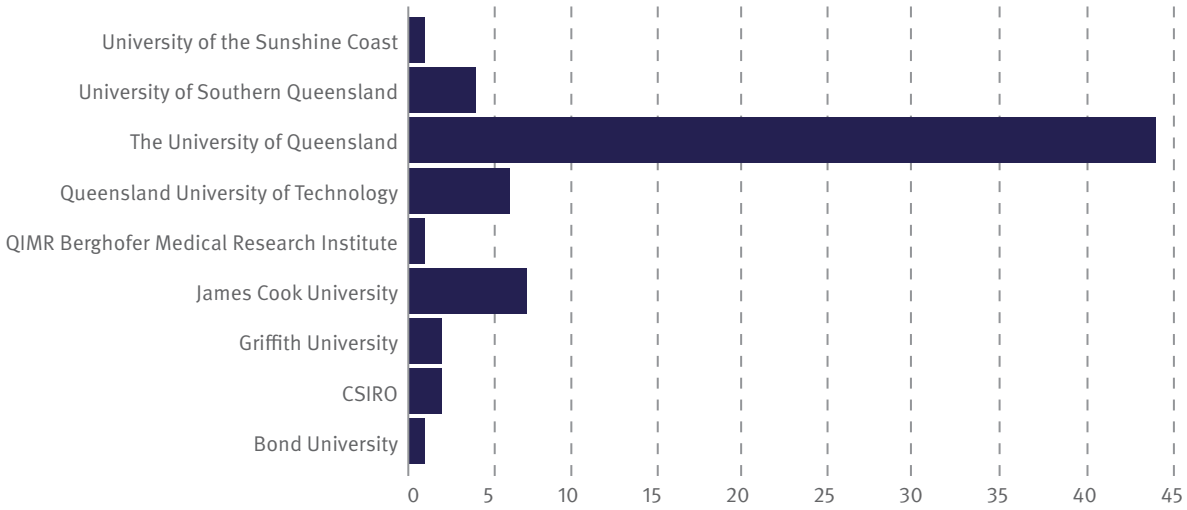

Figure 7: Number of highly cited researchers by Queensland institution[17]

Analysis of publications shows the prevalence of the life sciences (medical and biological) at the two-digit level (further reflecting the priority areas for research and development expenditure). Public Health is the most prevalent category overall, closely followed by Physical Chemistry.

Research funding

Although Queensland represents 20 per cent of the Australian population, it rarely secures a full 20 per cent of Australian Government research funding. For example, in 2019, Queensland received 17 per cent of the total Australian Research Council funding, down from 19 per cent in 2018 (Figure 8). Queensland's low share of funding is also reflected by jurisdictional allocations to the Medical Research Future Fund, Cooperative Research Centre program, and the National Health and Medical Research Council (NHMRC). For NHMRC, Queensland has attracted a considerably lower share of national funding for over a decade (Figure 9).

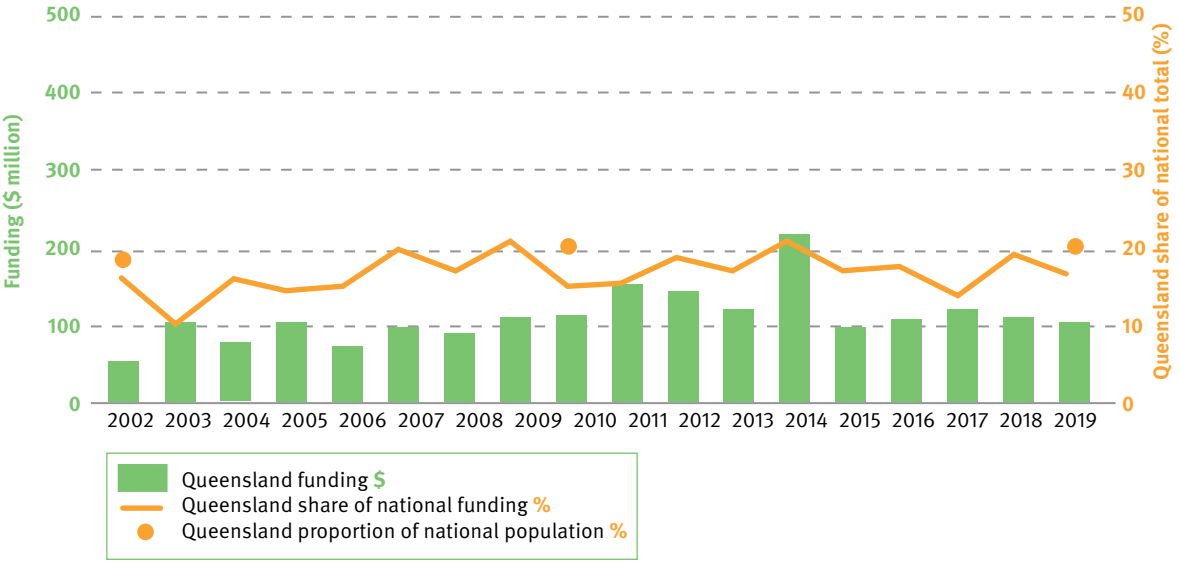

Figure 8: Queensland approved Australian Research Council grant funding by year as a share of national total[18]

17 Clarivate data allocated to Queensland institutions by the Queensland Department of Environment and Science

18 Australian Research Council. (2021). National competitive grants dataset. Retrieved from https://www.arc.gov.au/grants-and-funding/apply-funding/grants-dataset

Although Queensland attracts a lower proportion of research funding compared with our share of population, we could do a lot better if more applications were submitted.

For example, the success rate for submissions to the Australian Research Council by Queensland applicants ranked third across all states and territories (Figure 10).

For a greater share of funding, a higher volume of applications need to be submitted. Success in securing research funding means providing the time, support and resources for application development.

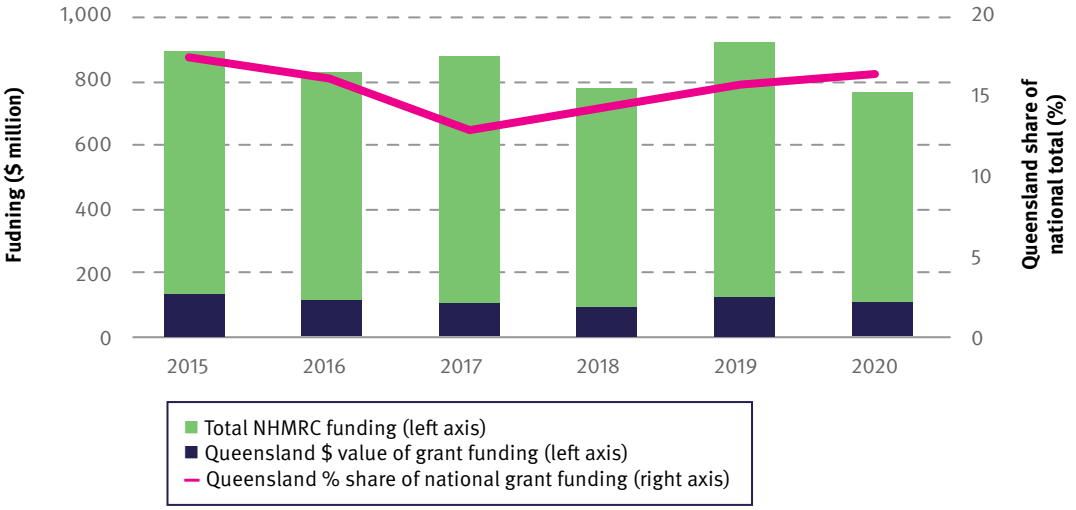

Figure 9: Queensland share of National Health and Medical Research Council funding[19]

State/territory	Success rate (per cent)	Number of applications submitted	Per cent of total applications	Number of submitted applications approved
Australian Capital Territory	28.3	7,648	7.8	2,162
Northern Territory	24.7	267	0.3	66
Queensland	**23.7**	**16,210**	**16.5**	**3,848**
Victoria	23.6	25,441	25.7	5,999
New South Wales	23.4	31,990	32.5	7,480
South Australia	22.0	7,134	7.2	1,569
Tasmania	21.9	1,973	2.0	433
Western Australia	21.1	7,841	8.0	1,651
All	23.6	98,504	100	23,208

Figure 10: Success rate for applications by state and territories for Australian Research Council scheme grant rounds commencement 2005–20[20]

19 NHMRC. (2021). Summary of the results of the NHMRC 2015–2020 Grant Application Round. National Health and Medical Research Council, Australian Government. Retrieved from https://www.nhmrc.gov.au/outcomes

20 Data Requests and Analysis Team, Australian Research Council (13 July 2021)

Spending on research and development by the Queensland higher education sector as a proportion of gross state product ranked sixth, ahead of Western Australia and the Northern Territory (Figure 11).

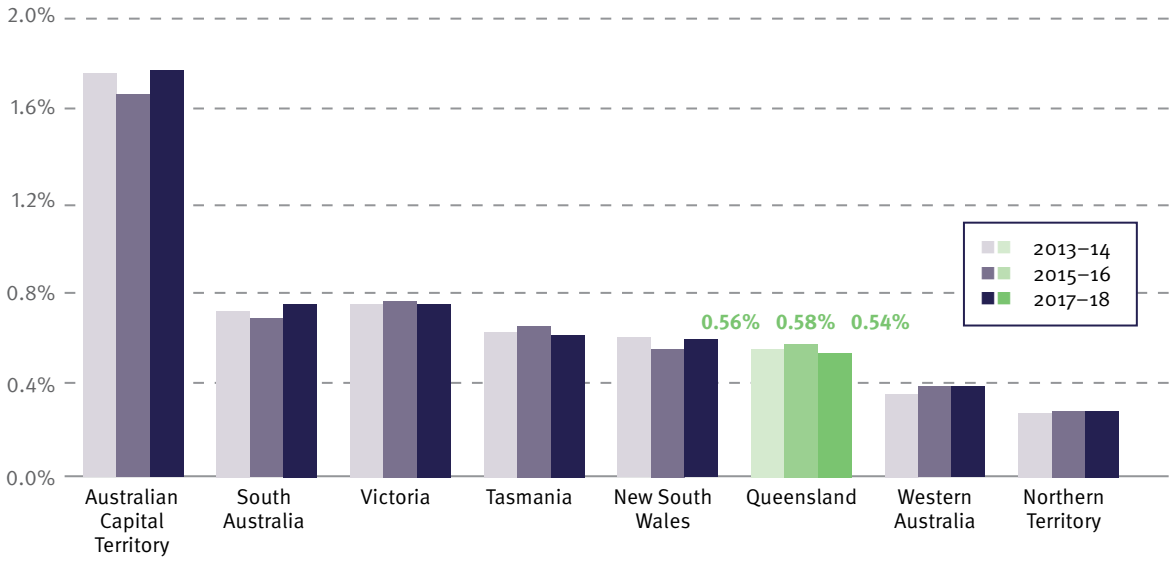

Figure 11: Higher education expenditure on research and development as per cent of gross state product[21]

Funding allocations from the Linkage Infrastructure, Equipment and Facilities scheme, which enables researchers to participate and share in high capital projects along with industry, is shown in Figure 12. The amount awarded to Queensland (15%) is proportionally lower than if the allocation was made as a percentage of population or gross state product (20%).

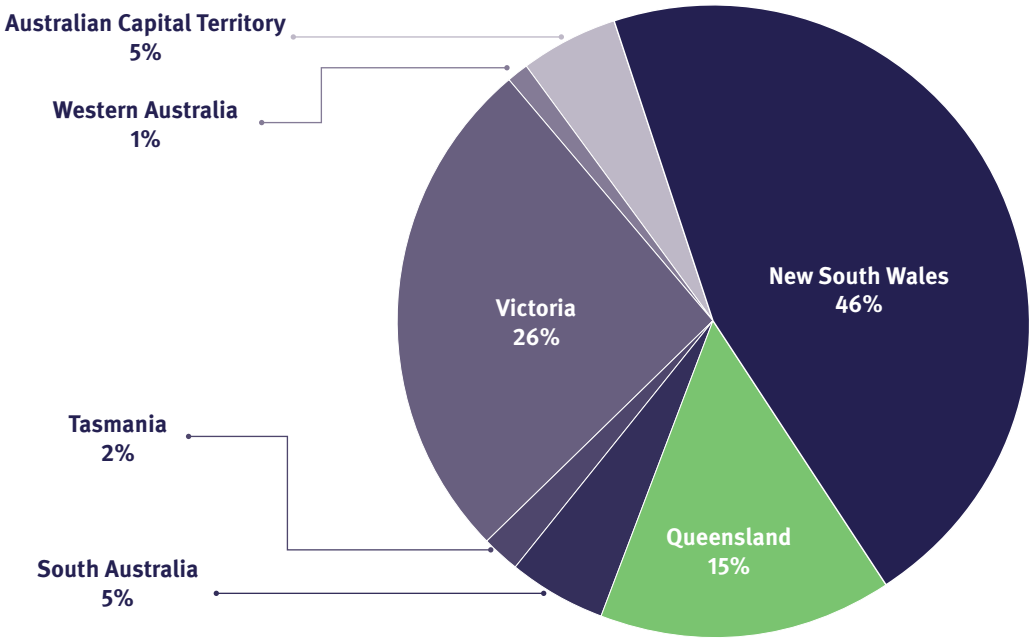

Figure 12: Linkage Infrastructure, Equipment and Facilities funding share by jurisdiction[22]

21 Australian Bureau of Statistics, Research and Experimental Development, Businesses, Australia 2017–18, 2015–16 and 2013–14 financial years. Higher Education Organisations, Australia Cat. 8111.0, 2008–2016. Analysis by Department of Tourism Innovation and Sport.

22 ARC (2021) ARC NCGP projects dataset, Retrieved from https://www.arc.gov.au/grants-and-funding/apply-funding/grants-dataset, ABS (2021) 3101.0 National, state and territory population.

Investing in Queensland science

The Queensland Government continues to support science, research, and innovation across the state. With sustained investment in infrastructure, a solid foundation has facilitated the outstanding research conducted in Queensland. In 2020–21, the Queensland Government invested over $444 million in research and development across departments, hospital and health services, statutory authorities, universities, and research institutes. The three agencies with the highest expenditure were Queensland Health ($152.7 million), Department of Agriculture and Fisheries ($101.5 million) and QIMR Berghofer Medical Research Institute ($44.5 million). Figure 13 shows the annual Queensland Government's investment in research and development since 2004.

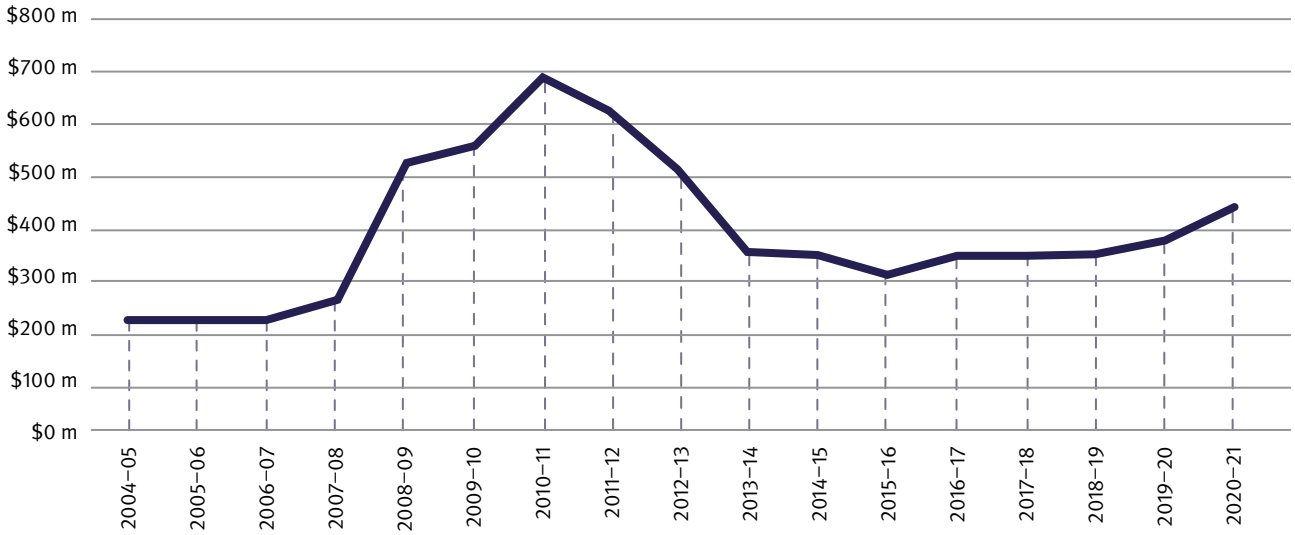

Figure 13: Queensland Government total expenditure on research and development over time[23]

Note: The spike in the period from 2008–09 to 2013–14 reflects the significant Queensland Government investment in research infrastructure.

> Science and Technology Australia advocates for a strong balance between 'discovery' and 'applied' research. Discovery research enables us to make major breakthroughs in new knowledge and capabilities. Translational research takes those breakthroughs and applies them to create new products, services, processes, and startups—often in close partnership with industry. The two parts of the research system enhance and rely on each other.[24]

23 The Queensland Government research and development expenditure report 2020–21.

24 Science and Technology Australia (2021). Australia as a STEM superpower: Policy Vision, Canberra, ACT: Science and Technology Australia. Retrieved from https://scienceandtechnologyaustralia.org.au/wp-content/uploads/2021/06/Policy-Vision-Document-2021.pdf

Opportunity for Queensland

Research and development:

- promote strong strategic investment to secure future research
- foster research funding success and diversity by providing support to researchers
- encourage a greater number of applications for research funding by Queensland institutions, given the high correlation between application number and rate of success.

Case study

Recognising Queensland science excellence

Queensland Women in STEM Prize 2021

The Queensland Women in STEM Prize is in its sixth year. The award is funded by the Queensland Museum Network in collaboration with the Queensland Government and recognises women who are making a difference to the world in STEM fields.

In 2021, five outstanding women were recipients of the prize. The Judges' Award was given to Ms Chloe Yap. Chloe is using big data to help develop earlier autism diagnosis. Currently, without any biological 'tests', diagnosis is a major bottleneck that determines whether a child with autism is adequately supported as early as possible to give them an opportunity to thrive.

Queensland Women in STEM Prize 2021 *L–R: Queensland Chief Scientist Professor Hugh Possingham, Queensland Museum Network CEO Dr Jim Thompson, Kate Kingston, Vice-Chancellor and President QUT and Chair Queensland Museum Board Professor Margaret Sheil, Sally McPhee, Fiona Holmstrom, Christabel Webber, Claire Yap (representing Chloe Yap)*

Case study

Young Tall Poppy Science Awards

Twelve outstanding scientists were recognised for their research excellence and community engagement efforts at the Queensland Young Tall Poppy Science Awards ceremony held in July 2021. From the 12 award winners, Dr David Flannery, a lecturer on Earth and planetary sciences at QUT, was announced as the 2021 Queensland Young Tall Poppy of the Year. Dr Flannery and his team designed and built sensors that are used in orbiters and rovers to investigate the ancient habitable environment on Mars.

Young Tall Poppy Science Awards *L–R: Professor Hugh Possingham Queensland Chief Scientist, Dr Fabio Costa The University of Queensland, Dr Amanda Rebar CQUniversity, Dr Yaqoot Fatima The University of Queensland and James Cook University, Dr Soniya Yambem QUT, Dr David Flannery QUT, Dr Laura Diamond Griffith University, Dr Aideen McInerney-Leo The University of Queensland, Dr Adam Frew University of Southern Queensland, Acting Professor Divya Mehta QUT and Acting Professor Lauren Ball Griffith University.*

Absent: Dr Adam Taylor Griffith University and Dr Hayley Letson James Cook University

Case study

Parasites in the wild

The CQUniversity Parasites in the Wild citizen science project in Emerald was awarded a Queensland Citizen Science Grant of $26,134 to study the ornate kangaroo tick (*Amblyomma triguttatum*). The tick can be found feeding not only on kangaroos but also on cattle, horses, dogs, goats, and humans.

The project involved livestock producers, game meat harvesters and wildlife carers collecting and analysing ticks. In addition, 116 school children were introduced to a range of science, technology, engineering, arts and maths principles and approaches through participating in this project.

The citizen scientists helped to find some key scientific outcomes including:

- a subspecies that was new to the region (*Amblyomma triguttatum queenslandesis*)
- an entire genus new to the region (*Ornithodoros gurneyi*)
- the absence of another subspecies previously reported in the region *(Amblyomma triguttatum ornatissimum*).

CQUniversity researcher Saba Sinai and producers Glenda Henry and Colin Valler

4. Research translation and commercialisation

Collaboration between science and industry brings fresh perspectives and approaches to research that can lead to breakthroughs in discovery. These partnerships accelerate transformation of knowledge into innovations with potential to deliver economic benefits to Queensland, including creating new economies, new jobs, and inspiring current and future leaders.

In 2021, Australia ranked 25 out of 132 countries listed in the Global Innovation Index.[25] This position signals a small decline in performance from having been ranked 20 in 2018, 22 in 2019, and 23 in 2020. In 2018, New South Wales and Victoria had more startups emerging from research institutions than Queensland.[26]

The Queensland Government encourages researchers to collaborate with industry. This support will be continued through upcoming funding programs such as the Partner Up Queensland Regional Science and Innovation Network and the Ignite Ideas Fund. The network will initially be centred around regional hubs that provide an effective, local means of enabling science and innovation engagement and contribute to sustainable community development across Queensland. The Fund supports Queensland small-to-medium enterprises to commercialise innovative products and services.

The Advance Queensland suite of programs has helped innovators, innovative businesses and the broader innovation ecosystem to build capability, foster collaboration, and increase investment. It has also supported Queensland businesses to scale for jobs and growth and build Queensland's knowledge economy. This includes support for female, Indigenous, and regionally based innovators and entrepreneurs.[27]

The business sector is driving a significant proportion of this investment, followed by the higher education sector. Most private, not-for-profit expenditure occurs in Victoria and New South Wales.[28]

Figure 14 provides an insight into total government research and development expenditure (Australian Government, state and territory governments combined expenditure on research and development) by jurisdiction. New South Wales, Victoria, and Queensland recorded the largest total government expenditure on research and development. A higher allocation was correlated with state population. This reflects the three states with the three highest populations in Australia. Total government research and development expenditure in Tasmania, Australian Capital Territory and South Australia is primarily through the Commonwealth Government (98 per cent, 96 per cent and 75 per cent, respectively), whereas Queensland, Western Australia and the Northern Territory have the lowest proportions of Commonwealth Government funding (all approximately 45 per cent).

25 World Intellectual Property Organization (2020) Global Innovation Index. Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021.pdf

26 https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021/au.pdf

27 Queensland Department of Tourism, Innovation and Sport (2021) Advance Queensland, https://advance.qld.gov.au/entrepreneurs-and-startups

28 IISA. (2020). Driving effective government investment in innovation, science and research—Appendices. Australia: Australian Government. Retrieved from https://www.industry.gov.au/sites/default/files/2021-01/appendices-government-investment-in-innovation-science-and-research.pdf

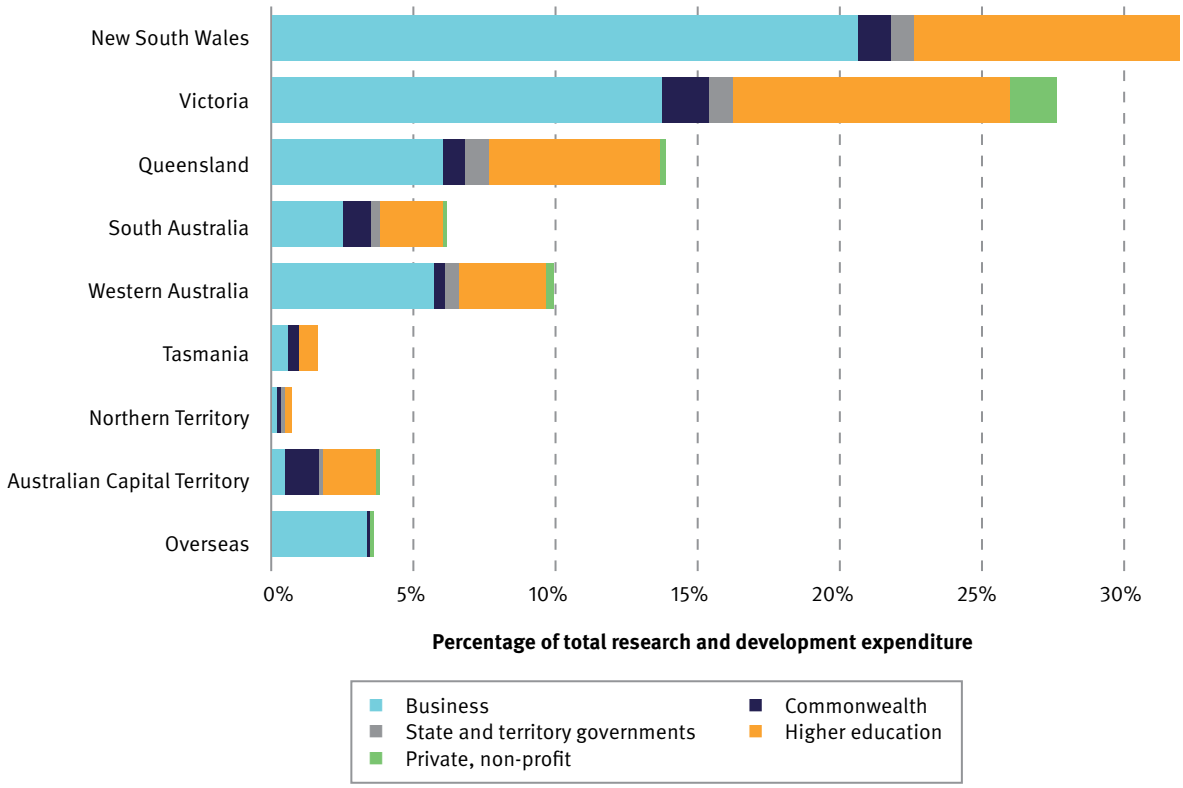

Figure 14: Research and development expenditure by jurisdiction and sector, 2016–17[29]

> Never stand still, ongoing funding for clever initiatives is one of the keys to our future post-COVID-19. That is why it was so pleasing to see the Queensland Government pledge $20 million to establish a Translational Manufacturing Institute at the Translational Research Institute in Brisbane as part of a move to boost the state's vaccine manufacturing and development capacity. The funding for the project at Princess Alexandra Hospital is part of the $1.84 billion Queensland Jobs Fund announced in June 2021. The funding will also support job-creating industries such as renewable energy, hydrogen, resource recovery, business, manufacturing, and catalytic infrastructure.
>
> Queensland Chief Scientist, Professor Hugh Possingham

29 https://www.industry.gov.au/sites/default/files/2021-01/appendices-government-investment-in-innovation-science-and-research.pdf

The Australian Government's research and development tax incentive is designed to encourage Australian companies to innovate. Queensland firms have the opportunity to increase the amount of research and development claimed via the scheme (Figure 15). A possible reason for low participation include ineligibility due to corporate structure, are service-based companies which do not provide innovation services, or are not aware that it is an entitlement scheme. Research and development conducted in Queensland by firms headquartered in other parts of Australia may have contributed to a relatively higher registration of research and development by those jurisdictions.

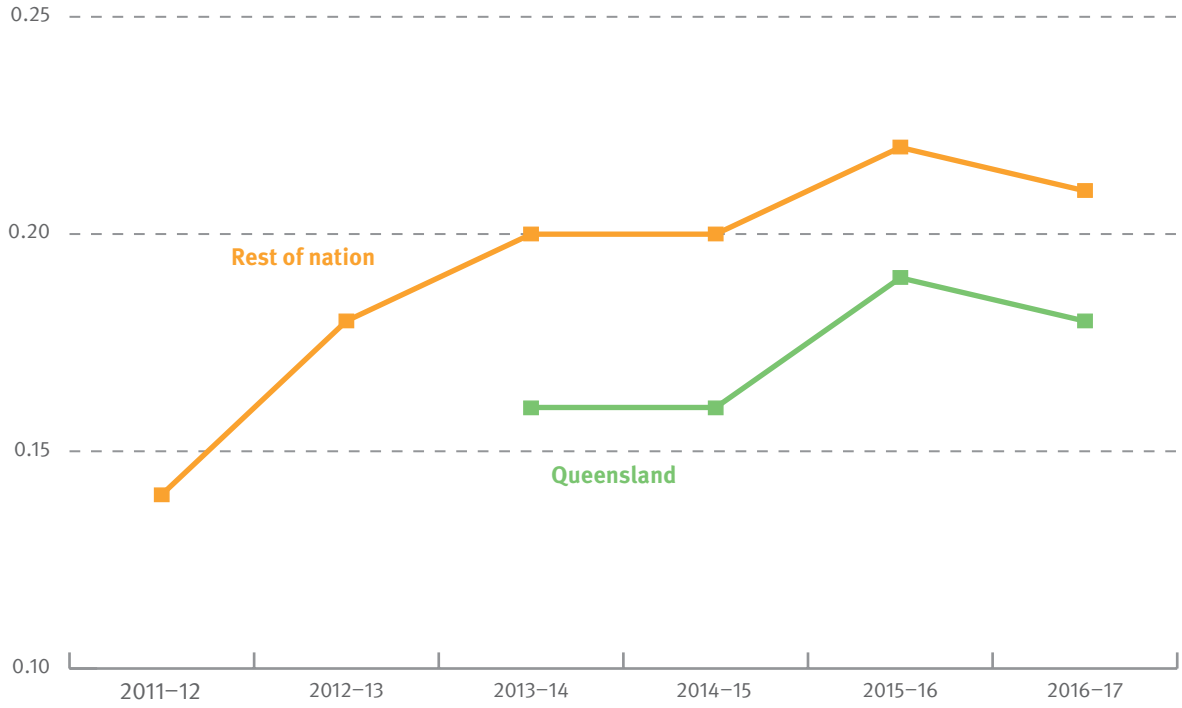

Figure 15: Proportion of firms claiming a research and development offset (per cent)[30]

Opportunity for Queensland

Research translation and commercialisation:

- facilitate collaboration between research and industry
- support the development of innovation spaces and expand innovation hubs to other fields including environmental science.

30 Business Longitudinal Analysis Data Environment (BLADE), (2001–02 to 2016–17FY). Detailed Microdata, DataLab. Findings based on the use of ABS Microdata. Analysis by Department of Tourism, Innovation and Sport *NOTE Missing data due to confidentiality protection as required by ABS

Case study

Strategic visualisation tool connecting research experience

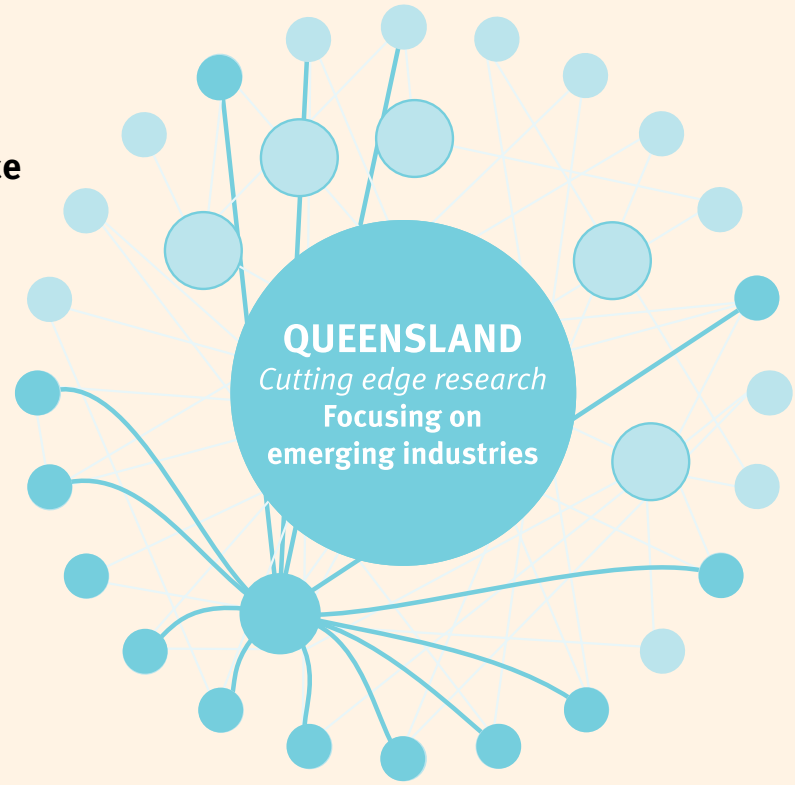

Figure 16: Strategic visualisation tool

According to Reuters' Hot List of the world's top climate scientists, 10 of the top 100 are from Australia.[31] The online Strategic Visualisation Tool helps users identify Queensland's research strengths and capabilities in seven emerging industries with global growth potential.[32] The tool also contributes to:

- *enabling collaboration between research and industry:* delivering opportunities for researchers to work outside university environments or establish relationships with industry to create new and varied opportunities. Successful research and development agencies and countries around the world, have a strong research presence outside the academic sector, and as a result, productive working relationship are established, and greater translation of results is something Queensland can learn from and emulate.
- *expanding traditional translational research hub models to other fields including agricultural and environmental science:* diversifying translational research hubs into other disciplines enables Queensland to have a broader breadth of expertise in different fields to attract talented researchers.

31 https://www.reuters.com/investigates/special-report/climate-change-scientists-list/
32 https://science.des.qld.gov.au/investment/scienceemergingindustries

Case study

Startups on the money

Queensland's strength in supporting startups is no overnight success story. Its origins were part of the Smart State campaign more than two decades ago. Queensland universities and investors realised a change to the economic mix was needed, a generation of new industries to complement 'rocks and crops' mining and agriculture. This continues today, evidenced in the $755 million Advance Queensland program that is driving innovation and helping to promote Queensland as an attractive investment destination. The funding supported the growth of startups, including:

- Luina Bio (developing biopharmaceutical solutions)
- AnteoTech (revolutionising battery design and rapid COVID-19 tests)
- Implicit Bioscience (using immunotherapy to treat life-threatening diseases)
- WearOptimo (creating wearable devices to diagnose and monitor health disorders)
- Protagonist Therapeutics (developing novel peptide-based drugs to transform existing treatments for patients with unmet medical needs)
- Inflazome, acquired by Roche in 2019 (making oral drugs to target inflammatory diseases)
- Spinifex Pharmaceuticals, acquired by Novartis in 2015 (creating treatments for chronic pain).

> The Queensland Chief Scientist Professor Hugh Possingham believes that to grow startups and maintain momentum, we need to keep investing in the state's science and innovation community.

Some Queensland businesses making their mark globally, include:

- *Tritium* whose fast charging technology for electric vehicles has earned it a place as a publicly listed company on the NASDAQ stock exchange
- *RedEye* has developed software-as-a-service solutions to help complex infrastructure operators improve asset safety and performance
- *Go1* in Logan near Brisbane, curates the world's second-biggest digital learning library, recently valued at more than $1 billion
- *Gilmour Space Technologies*, a Gold Coast pioneer of hybrid propulsion technologies, is preparing to send a small launch vehicle called Eris into space in 2022
- *SwarmFarm* is the brainchild of a Central Queensland couple whose agricultural robots autonomously slash grass and spray weeds in orchards and farms
- *Ellume* started with an Ignite Ideas grant from the Queensland Government and recently secured a United States Government deal for US$262 million to assist with the development and production of its COVID-19 home test.

The common thread is that these businesses received direct funding support from the Queensland Government.

In addition to the significant funding allocated to Queensland's startup ecosystem, the Chief Entrepreneurs—Mr Mark Sowerby, Mr Steve Baxter, Ms Leanne Kemp, and currently, Mr Wayne Gerard, have all been integral to encouraging Queensland's innovation and entrepreneurial culture. Their networks of innovation involve participation by government, business, investors, and the community, as well as collaboration between scientists, universities and other scientific institutes.

SmartFarm is delivering innovative agricultural robots

The pillars of Queensland's science and innovation success are well established:

- generous funding
- a culture of innovation
- powerful science and business networks.

These elements contribute to ensuring momentum is maintained, and great startup ideas turn into business reality. As the economy rebounds from the COVID-19 pandemic, Brisbane prepares to showcase its status as a location for sport innovation in the lead up to the 2032 Olympic and Paralympic Games.

Case study

Forging partnerships in the region

The Partner Up Queensland Regional Science and Innovation Network is set to be delivered in 2022 by the Office of the Queensland Chief Scientist in collaboration with the Department of Tourism, Innovation and Sport. It will initially be delivered in three regions, Darling Downs and South West, Central Queensland, and North and Far North Queensland.

It aims to create a network of locally driven regional clusters of scientists and innovators, to increase scientific capability and leverage collective strengths, ultimately providing all Queenslanders the opportunity to engage with science and innovation in meaningful ways. This in turn will help to drive science and innovation outcomes. By connecting researchers with local authorities, regional universities, local citizen science groups and businesses, Queenslanders have an opportunity to be creative and innovative to deliver solutions to current and future problems.

5. Future industries, jobs and skills

Science skills and jobs today

Science and STEM skills are vital to a vast number of today's jobs and industries. Many people are utilising their unique skillsets in surprising ways, such as chemical sciences graduates running vineyards, electrical engineers working in finance, and information technology graduates teaching at primary schools.[33]

For people with vocational education and training STEM qualifications in Australia, the top three industry divisions of employment are construction (16 per cent), manufacturing (15 per cent), and other services (10 per cent), which includes industries relating to repair, maintenance, and personal services (Figure 17).

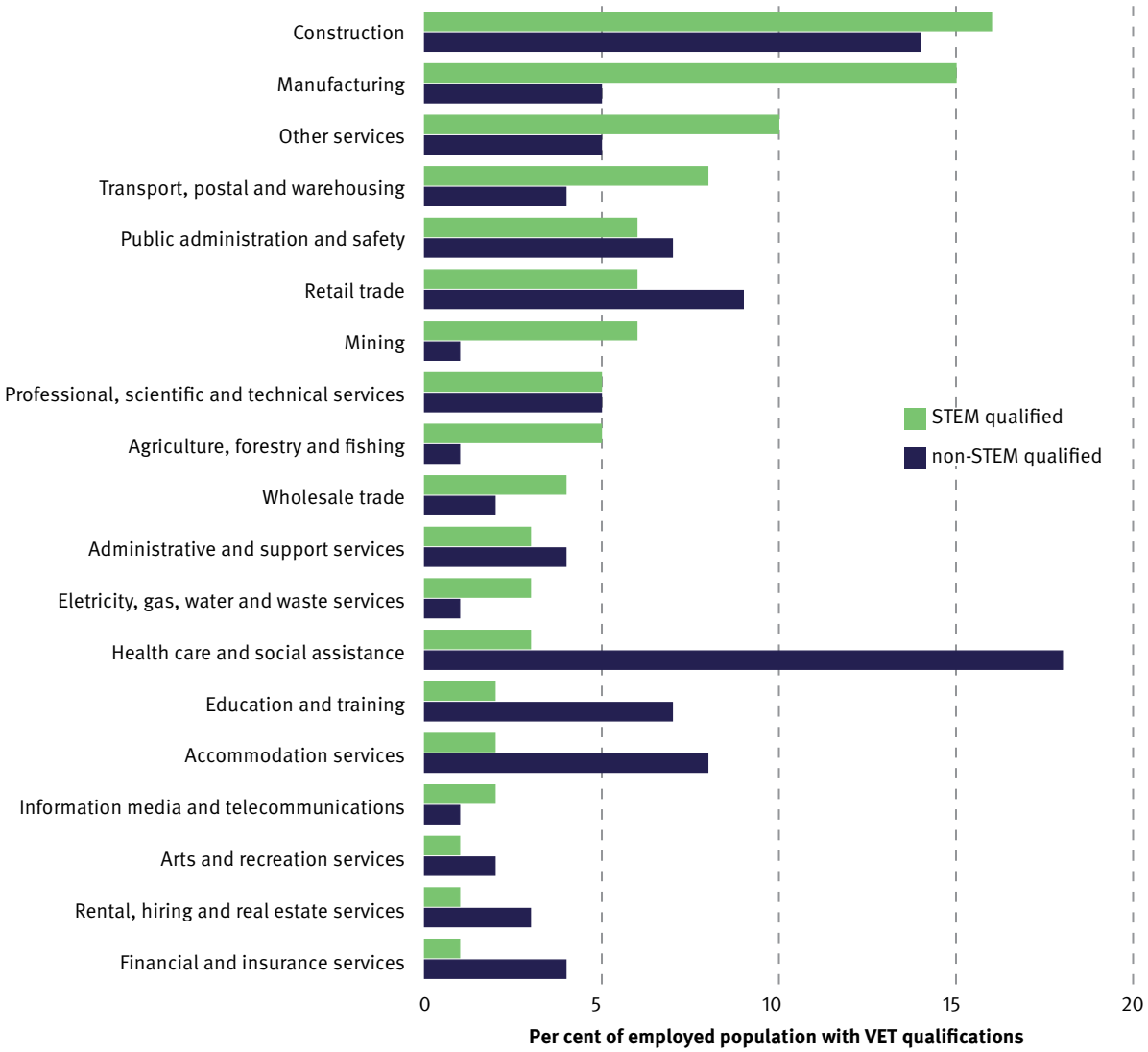

Figure 17: Industry divisions of employment of vocational education and training qualified population, by field[34]

33 https://www.chiefscientist.gov.au/news-and-media/2020-australias-stem-workforce-report
34 https://www.chiefscientist.gov.au/news-and-media/2020-australias-stem-workforce-report

For people with university STEM qualifications, the top three industry divisions of employment in 2016 were professional, scientific, and technical services (23 per cent), education and training (10 per cent), and (9 per cent) public administration and safety (Figure 18).

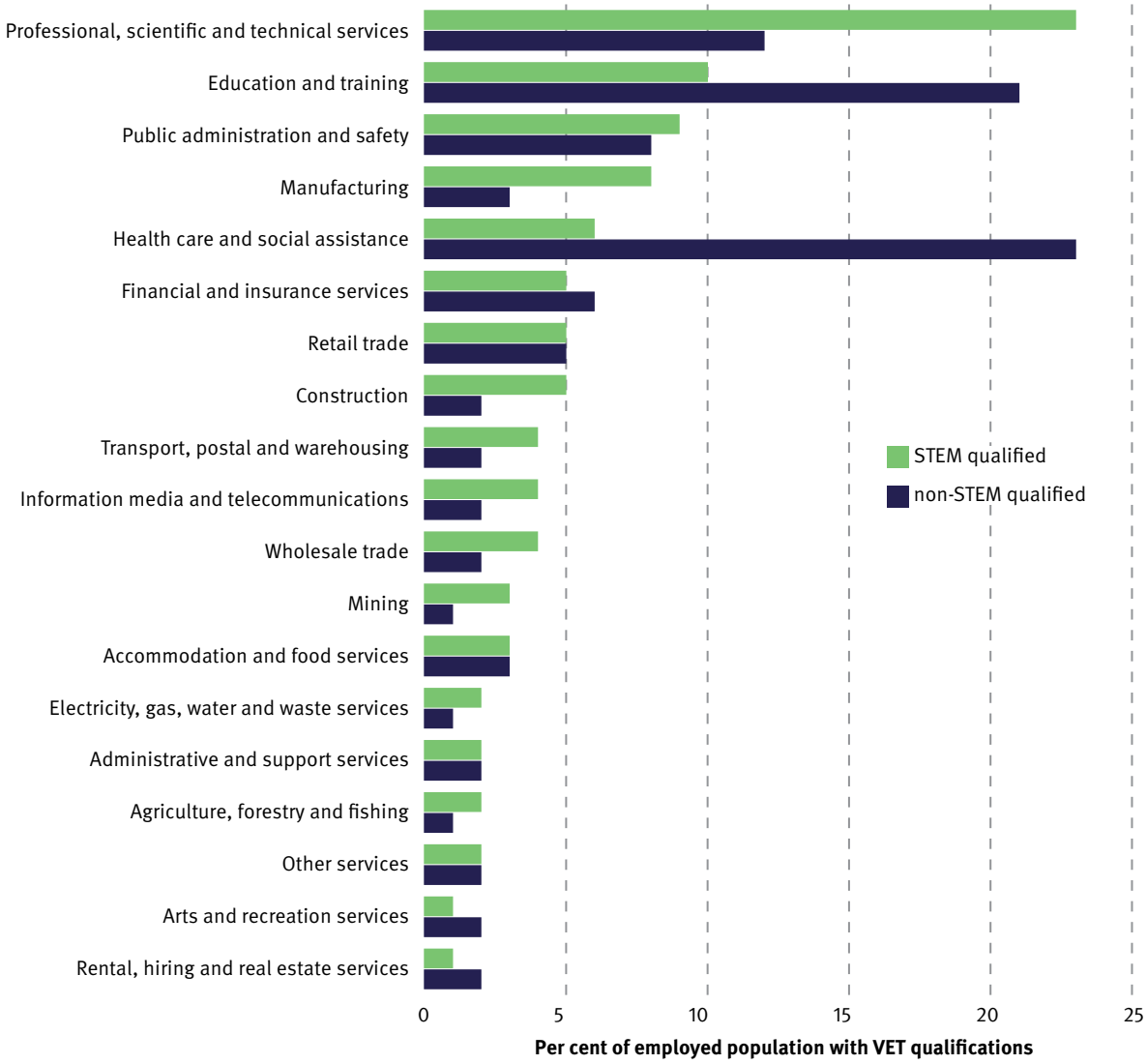

Figure 18: Industry divisions of employment of university qualified population, by field[35]

STEM skills are generally required for various industries as outlined above. In Queensland, STEM skills are critical for our largest employing industries (Figure 18). Queensland ranks third in the total number of employees in the professional, scientific, and technical service industries (Figure 19).

35 https://www.chiefscientist.gov.au/news-and-media/2020-australias-stem-workforce-report

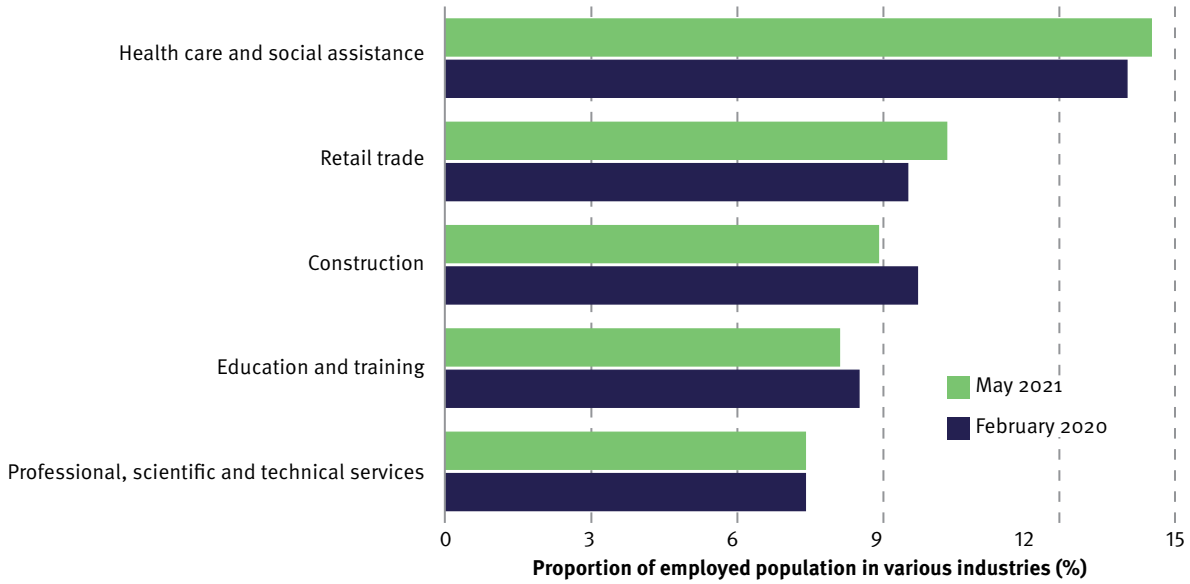

Figure 19: Queensland's largest employing industries, May 2021[36]

Health care and social assistance is the industry in which most Queenslanders are employed (354,700 workers in 2019–20). After mining, it was the largest contribution to the Queensland economy in 2019–20, accounting for $29.2 billion (8.6 per cent). The health sector has also been one of the major contributors to the Queensland economy over the last decade, growing by approximately 66 per cent in real terms. As our population ages and the demand for health services increases, job opportunities in this sector are expected to increase.[37]

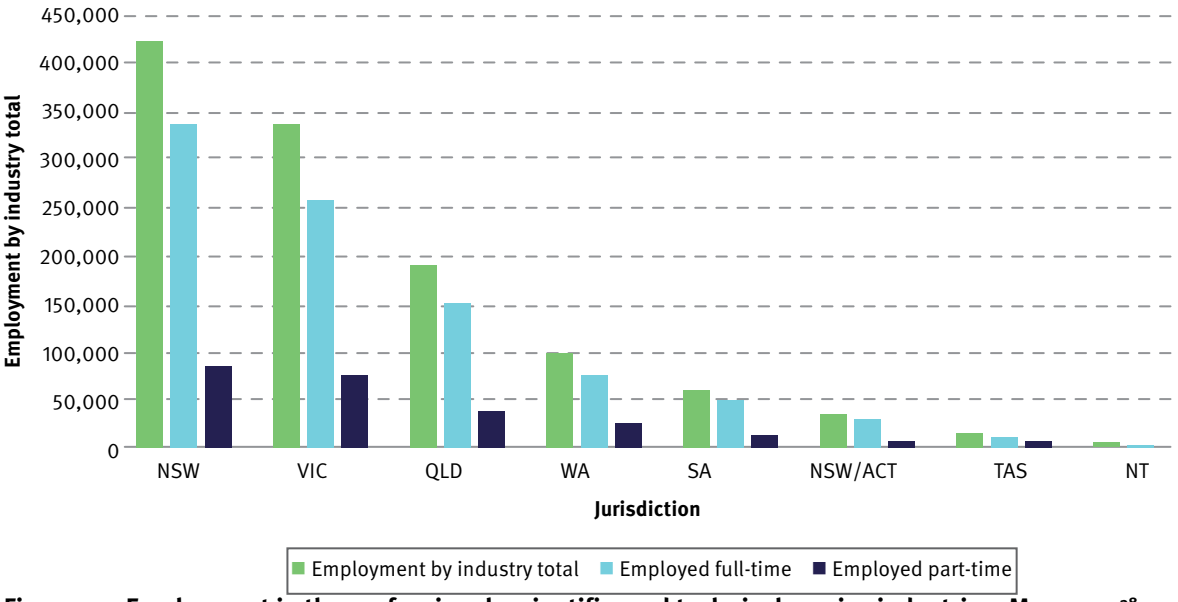

Figure 20: Employment in the professional, scientific, and technical service industries, May 2021[38]

36 Australian Government regional labour market data Queensland; ABS, Labour Force Survey, Detailed, four quarter average data, May-21 quarter. Retrieved from: Welcome to the Labour Market Information Portal. (lmip.gov.au)
37 https://www.treasury.qld.gov.au/queenslands-economy/about-the-queensland-economy/.
38 ABS Labour Force Survey, four-quarter average except for Australian Total Employment, Australian Five-Year Growth and Australian Employment Distribution, which are seasonally adjusted data. Retrieved from: Employment by Industry (Excel)

Employment in professional, scientific, and technical services is projected to increase by 131,100 (11 per cent) over the five years to November 2025, reflecting ongoing strength in demand for the services of qualified and highly educated workers throughout the economy[39].

Major contributions to the employment growth are expected to come from:

- computer system design and related services by 47,200 (16 per cent)
- architectural, engineering and technical services by 25,700 (9 per cent)
- legal and accounting services by 25,300 (8.6 per cent).[40]

New and emerging industries

Queensland's economy, like many other advanced economies, has seen significant shifts over the past decades. Technological advances, ongoing climate change, adjustments in consumer preferences, and globalisation, have all contributed to a focus on the value derived from knowledge-intensive industries.[41]

Embracing these changes will support Queensland to grow, diversify, and build future industries. Technological advances combined with existing research capabilities, and changes in local, national, and international markets, all present opportunities for knowledge-intensification of existing industries.[42]

The net zero emissions target from the Conference Of the Parties (COP) summit could have enormous implications for future jobs.

It is estimated that the national cost of effective emissions reduction to be $35 billion from 2019 to 2030. This equals 0.14 per cent of the aggregate gross domestic product (GDP) over that time.[43]

However, the transition to clean energy is expected to generate 10.3 million net new jobs globally by 2030.[44] Most of the anticipated job gains are likely to be in electrical efficiency, power generation and the automotive sectors.

Additionally, the environmental, social and governance priorities of corporations will change the way in which business will be conducted in the future.

---

39 National Skills Commission (2020) Industry Employment Outlook Five year to November 2025. (p.3) Retrieved from: 2020 Employment Projections—for the five years to November 2025 | National Skills Commission

40 Ibid

41 Naughtin C, H. J. (2019). New smarts: Supporting Queensland's knowledge-intensive industries through science, research and innovation.

42 Queensland Government Department of Environment and Science website. Emerging Science-based industry. Retrieved from: Emerging science-based industries | Science | Department of Environment and Science, Queensland (des.qld.gov.au)

43 https://www.sgsep.com.au/assets/main/Australias_Clean_Economy_MSSI_Issues_Paper12.pdf (p8)

44 World Economic Forum (2022) How many jobs could the clean energy transition create? 25 March 2022 https://www.weforum.org/agenda/2022/03/the-clean-energy-employment-shift-by-2030/

In 2019, the Department of Environment and Science commissioned CSIRO's Data61 team to identify eight emerging knowledge-intensive industries for Queensland (Figure 21), the New Smarts report. A subsequent report was commissioned, A New Chapter, to identify opportunities to seed new industries for Queensland in the coming decade (Figure 21).

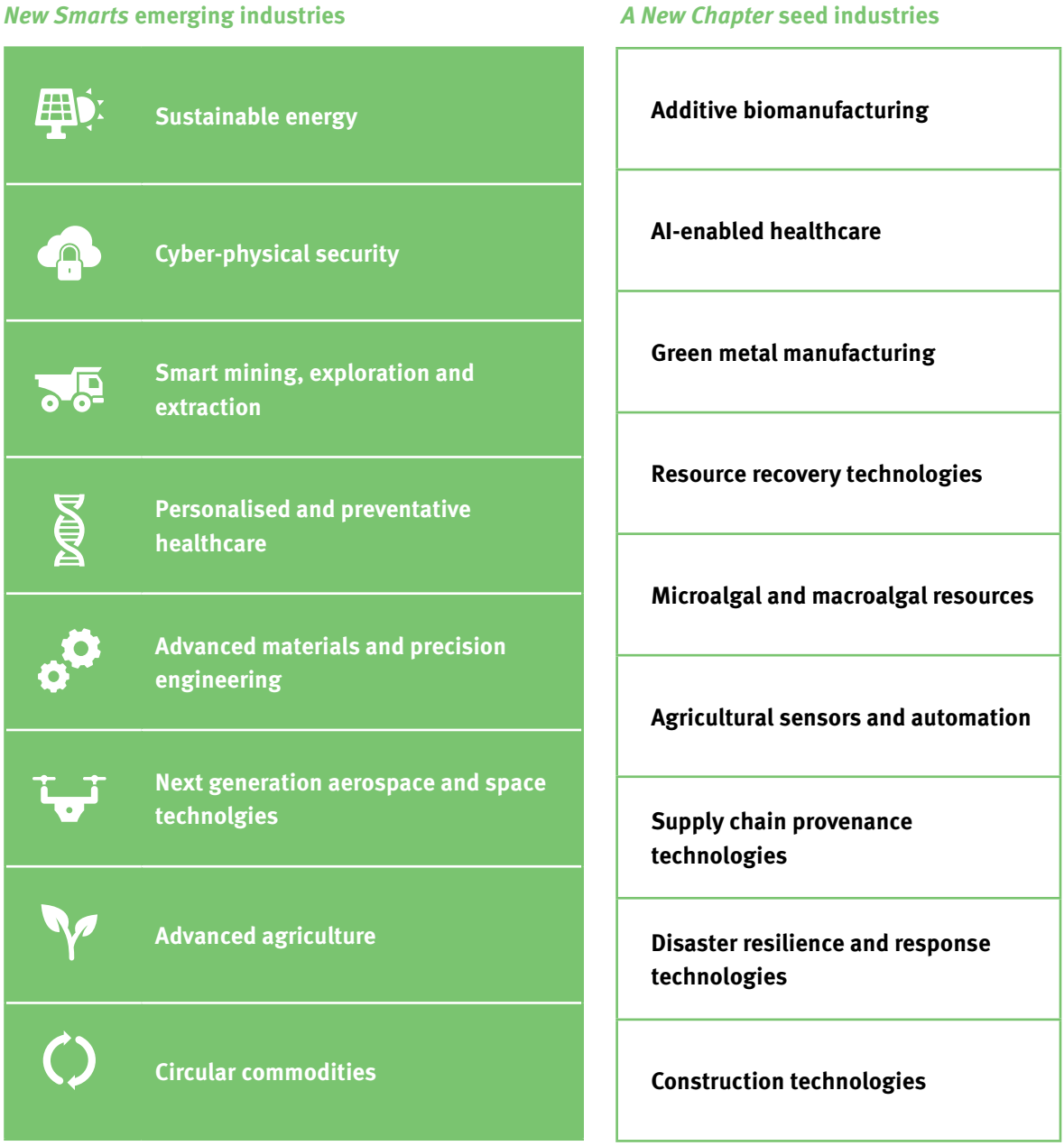

Figure 21: Knowledge intensive industries (seed and emerging) identified as important to Queensland's future [45, 46]

45 Naughtin C, Horton J, Pham H. (2019). New smarts: Supporting Queensland's knowledge-intensive industries through science, research and innovation. CSIRO Data61: Brisbane, Australia. https://data61.csiro.au/~/media/D61/Files/New-Smarts-Communications-Report.pdf

46 Naughtin, C., Moyle, C., Pandey, V., Renando, C., Poruschi, L., Torres de Oliveira, R., Doan, N., Schleiger, E. (2021). A new chapter: Opportunities to seed new industries for Queensland over the coming decade. Brisbane, Australia. CSIRO and Queensland University of Technology (p.3).

Each industry presents innovative and feasible opportunities for Queensland to leverage existing, currently underutilised, innovation and knowledge to create jobs (Figure 22). As Queensland recovers from the COVID-19 pandemic, we can leverage our competitive advantages to significantly accelerate the growth of key seed industries and drive new sources of job creation and economic prosperity while supporting the state in transitioning to a zero-carbon economy.

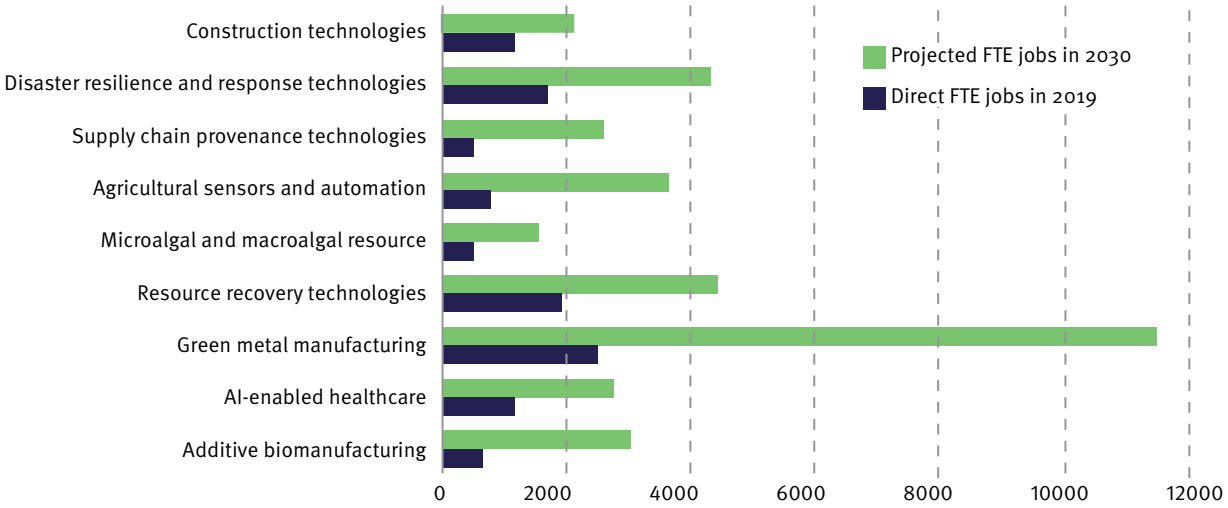

Figure 22: Projected full-time equivalent jobs growth for Queensland's seed industries [47]

Science skills and jobs of the future

Currently STEM jobs are being created at 1.5 times the rate of non-STEM jobs, and the STEM-qualified workforce is growing at only half the rate of the non-STEM-qualified workforce.[48]

Queensland would benefit from a committed strategy to boost STEM skills and STEM graduates, to ensure we have the skilled workforce we need to seize future opportunities.[49] To deliver the strongest possible STEM capability for Australia and Queensland we need to draw on the widest talent pool that includes both within Australia and internationally. To attract more students to study STEM, the Australian Government implemented an initative that increased university fees by 28% for law and commerce degrees, and by around 113% for humanities.[50]

47 Naughtin, C., Moyle, C., Pandey, V., Renando, C., Poruschi, L., Torres de Oliveira, R., Doan, N., Schleiger, E. (2021). A new chapter: Opportunities to seed new industries for Queensland over the coming decade. Brisbane, Australia. CSIRO and Queensland University of Technology (p.3).

48 Science and Technology Australia. (2021). Australia as a STEM superpower: Policy Vision. (p.17) Canberra, ACT: Science and Technology Australia. https://scienceandtechnologyaustralia.org.au/wp-content/uploads/2021/06/Policy-Vision-Document-2021.pdf.

49 Science and Technology Australia. (2021). Australia as a STEM superpower: Policy Vision. (p.17) Canberra, ACT: Science and Technology Australia. https://scienceandtechnologyaustralia.org.au/wp-content/uploads/2021/06/Policy-Vision-Document-2021.pdf.

50 https://www.theguardian.com/australia-news/2020/jun/19/australian-university-fees-arts-stem-science-maths-nursing-teaching-humanities.

Promoting equity, diversity and inclusion in STEM

A wide and growing body of research confirms diverse teams and organisations innovate more readily, turning diversity of insights and questions into stronger design-thinking.[51] Improving diversity contributes to avoiding bias in data, as well as ensuring that scientific research questions are representative of the broader community.[52] This better representation leads to products and services designed with stronger safety and efficacy for a wider audience.[53]

The following programs are designed to promote better equity, diversity and inclusion:

- Queensland women's strategy
- The Queensland Government's SOLID Pathways Program[54]
- Queensland Women in STEM prize[55]
- Queensland Queers in Science[56]
- Indigenous Girls' STEM Academy[57]
- Science in Australia Gender Equity (SAGE)[58]
- Ally networks at universities across Australia[59]
- Women in STEM Decadal Plan[60] and initiatives listed in the Reflecting on Catalysing Gender Equity: one year on report[61]

Future workforce and challenges

Queensland's future workforce depends upon education, training, social support and upskilling pathways to support translation of workforce capabilities, to create a healthy pipeline of new talent and graduates.[62]

By focusing on developing skills relevant to future challenges and innovative solutions, students and workers are likely to become more purposeful, engaged, productive and capable.

51 Science and Technology Australia. (2021). Australia as a STEM superpower: Policy Vision. Canberra, ACT: Science and Technology Australia. (p.18)
52 Naughtin, C., Horton, J., Pham, H. (2019). New smarts: Supporting Queensland's knowledge-intensive industries through science, research and innovation. CSIRO Data61: Brisbane, Australia (p.20). https://science.des.qld.gov.au/__data/assets/pdf_file/0030/97176/DATA61-NewSmarts-report-summary.pdf.
53 Science and Technology Australia. (2021). Australia as a STEM superpower: Policy Vision. Canberra, ACT: Science and Technology Australia. (p.18)
54 https://education.qld.gov.au/about-us/budgets-funding-grants/grants/state-schools/core-funding/solid-pathways
55 https://www.chiefscientist.qld.gov.au/science-comms/programs-events/qld-women-in-stem-prize
56 https://queersinscience.org.au/
57 https://www.niaa.gov.au/indigenous-affairs/education/indigenous-girls-stem-academy
58 https://www.sciencegenderequity.org.au/
59 Science and Technology Australia. (2021). Australia as a STEM superpower: Policy Vision. Canberra, ACT: Science and Technology Australia. (p.19)
60 https://www.science.org.au/support/analysis/decadal-plans-science/women-in-stem-decadal-plan
61 https://www.stemwomen.org.au/sites/default/files/inline-files/CGE%2B1%20report_April2021.pdf
62 Naughtin, C., Moyle, C., Pandey, V., Renando, C., Poruschi, L., Torres de Oliveira, R., Doan, N., Schleiger, E. (2021). A new chapter: Opportunities to seed new industries for Queensland over the coming decade. Brisbane, Australia. CSIRO and Queensland University of Technology (p.3).

Queensland's education system can respond, particularly for courses in transitioning industries that are becoming more knowledge-intensive to upskill workers (mining, manufacturing, and agriculture):

- school-based programs and organisations could expose prospective students and workers to new career options in knowledge-intensive industries, helping shift away from outdated career perceptions[63]
- the education sector has a role to play in ensuring their curricula are responsive to industry needs[64]
- reducing barriers to participation for women, First Nations peoples, people with culturally and linguistically diverse backgrounds, the LGBTQIA+ community, and people with disability
- collaboration between education sectors, government, and businesses ensures that Australia's training systems deliver a talent pool that meets industry needs.

Employers can achieve this by:

- enhancing engagement in public-private partnerships and industry consortia
- setting their own skills development strategy and collaborating with government to shape curricula and delivery of education and training
- directly delivering training programs outside traditional pathways, for example, using co-created or open online education platforms and work trial programs.[65]

Opportunity for Queensland

Future industries, jobs and skills:

- support workers to translate their capabilities to a low carbon economy
- recognise that quality science education builds the knowledge economy of tomorrow
- address barriers to building a diverse and inclusive workforce.

63 Naughtin, C., Horton, J., Pham, H. (2019). New smarts: Supporting Queensland's knowledge-intensive industries through science, research and innovation. CSIRO Data61: Brisbane, Australia (p.20). https://science.des.qld.gov.au/__data/assets/pdf_file/0030/97176/DATA61-NewSmarts-report-summary.pdf.

64 Ibid. (p. 18)

65 CSIRO Futures. (2020). Value of science and technology. Australia: CSIRO. (p. 30).

Case study

Is Queensland quantum systems ready?

Queensland has an established and innovative quantum science network that fosters collaboration and partnerships to promote innovation. Queensland is host to the Australian Research Council (ARC) Centre of Excellence (CoE) for Engineered Quantum Systems. Since its inception in 2011, the only dedicated quantum engineering centre in Australia, has developed a range of quantum related facilities and agencies that include:

- ion-trap quantum computing laboratory
- quantum photonics facilities including the world's highest-efficiency entangled photon source, integrated photonic circuits, and highly efficient cryogenic calorimeters that can be used count individual photons
- fabrication facilities for silicon chip based ultra-high quality optical microcavities, and cryogenic facilities allowing operation of quantum devices at termperatures as low as 0.3 degrees Kelvin.

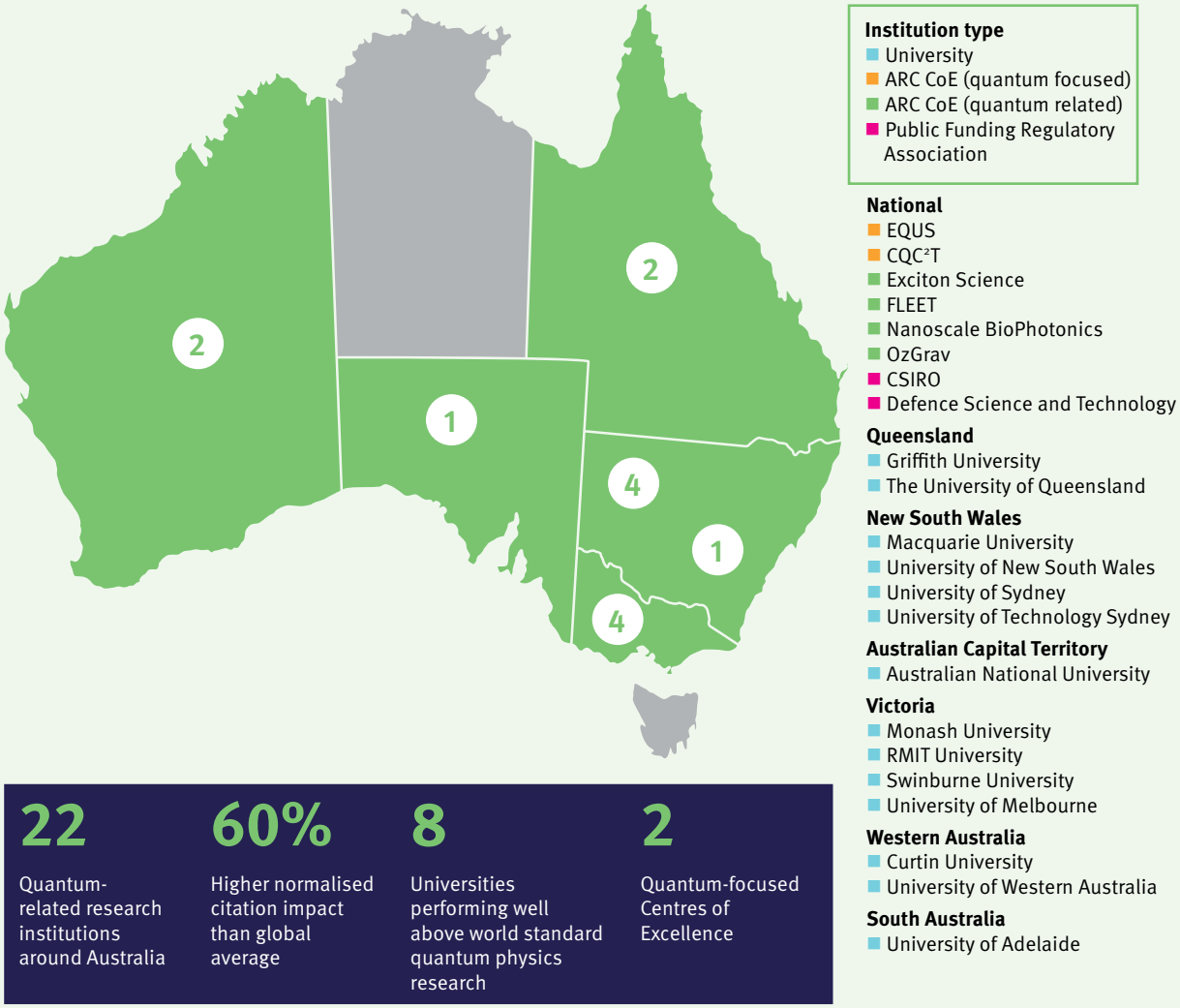

Figure 23: Quantum research and development institutions in Australia [66]

66 CSIRO Futures (2020) Growing Australia's Quantum Technology Industry. CSIRO, Australia.

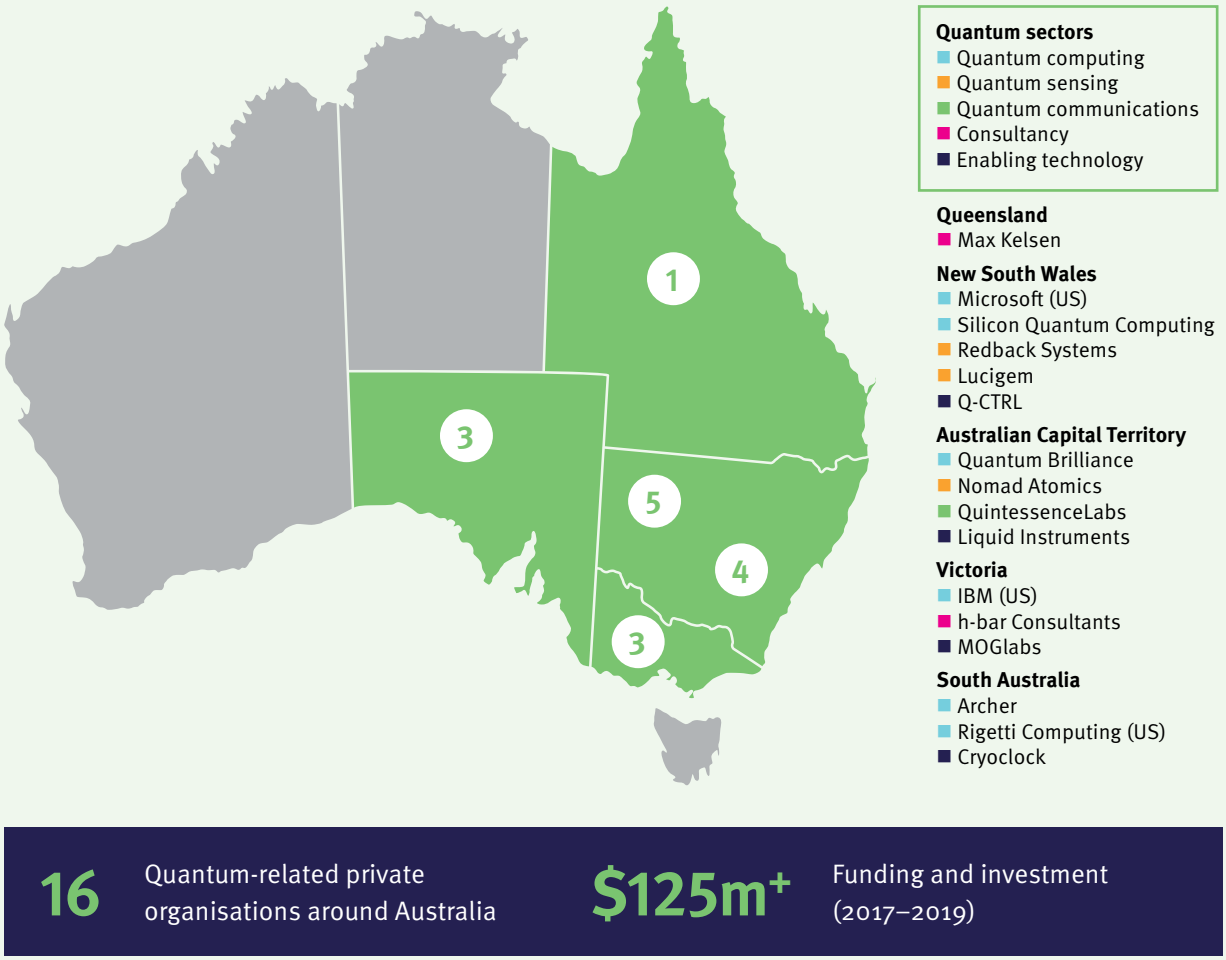

Figure 24: Quantuym industry activity in Australia [67]

67 CSIRO Futures (2020) Growing Australia's Quantum Technology Industry. CSIRO, Australia.

For more information about the Office of the Queensland Chief Scientist:

www.chiefscientist.qld.gov.au

+61 7 3199 7423

info@chiefscientist.qld.gov.au

@qldscience

department-of-environment-and-science

Level 31, 400 George Street
Brisbane QLD 4000
Australia