

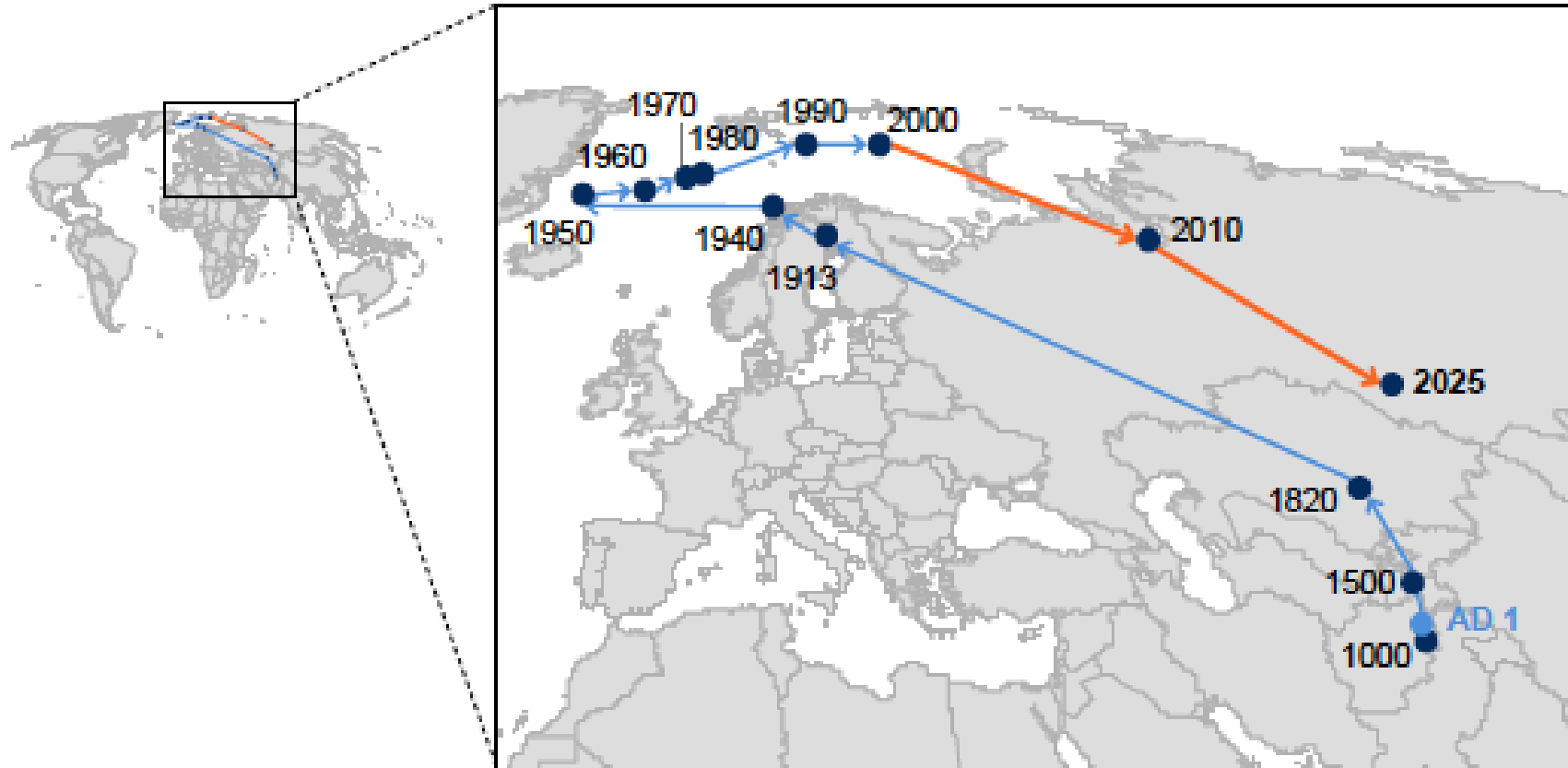


The 21st C Citizen

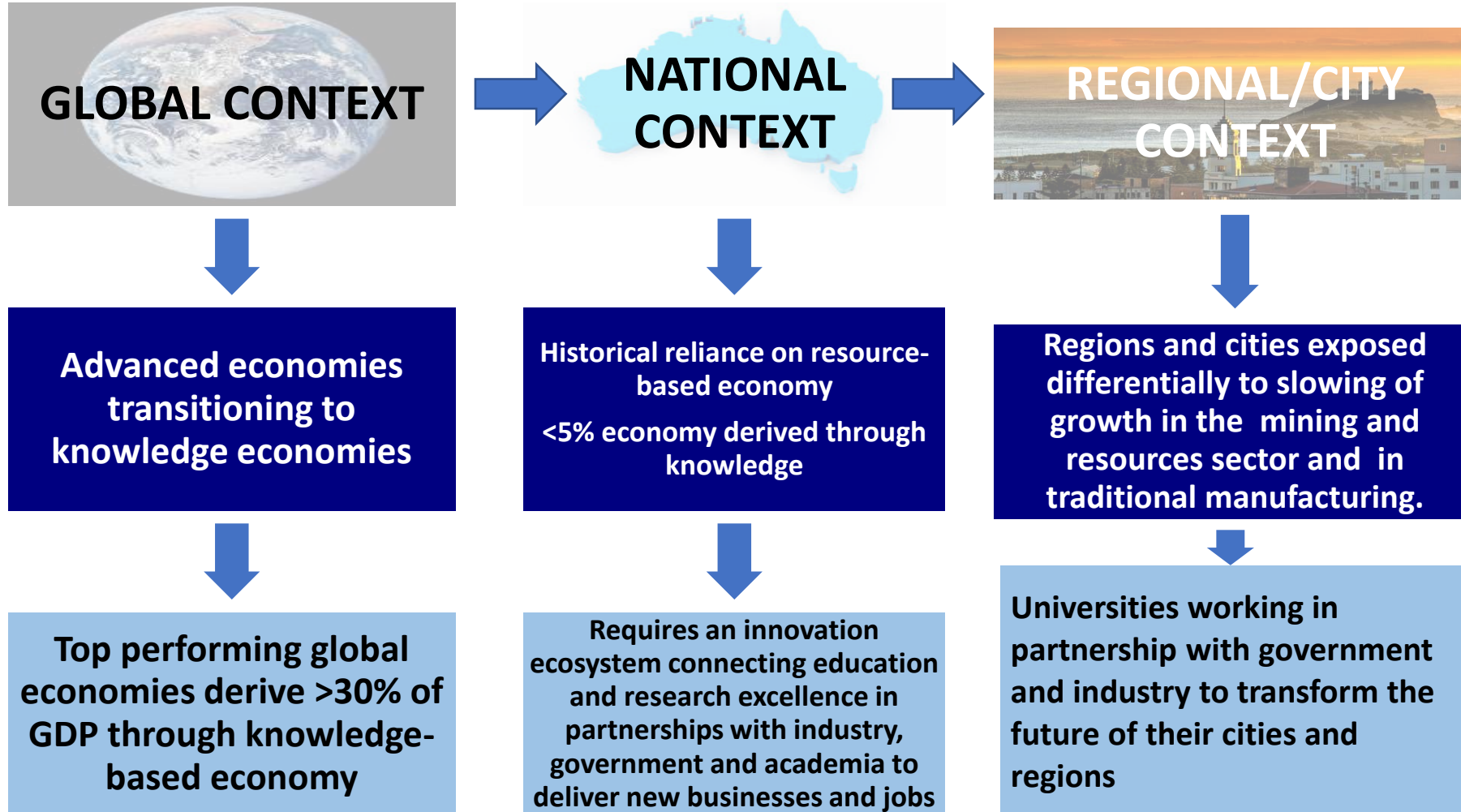
How is Maths the Key?

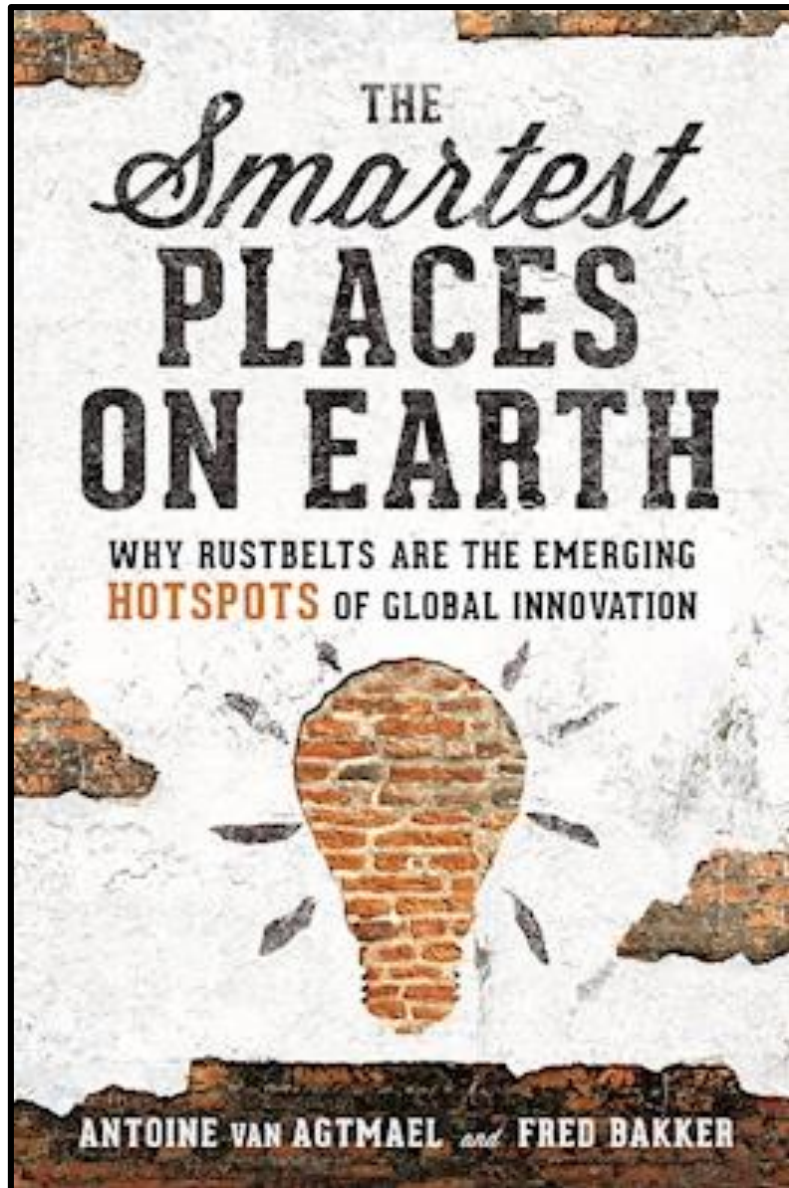
Professor Caroline McMillen
Chief Scientist for South Australia
[DIS.chiefscientist.sa.gov.au](https://dis.chiefscientist.sa.gov.au)

THE SHIFTING DYNAMICS OF THE EARTH'S ECONOMIC CENTER OF GRAVITY AD 1 TO 2025



SOURCE: McKinsey Global Institute, *Urban world: Cities and the rise of the consuming class*





Common features of ‘rust belts’ transformed into ‘brain belts’ through innovation ecosystems:

- strong universities as anchors
- visionary civic leadership
- governmental support for basic research
- research facilities with deep, specialist knowledge
- traditional manufacturing skills
- appealing work and living environments
- capital

“Companies have learned not to compete on price, since they can’t necessarily win against emerging markets, but making things smarter. Innovation is today's real competitive edge”.

Urbanisation and the Changing Purpose of Cities

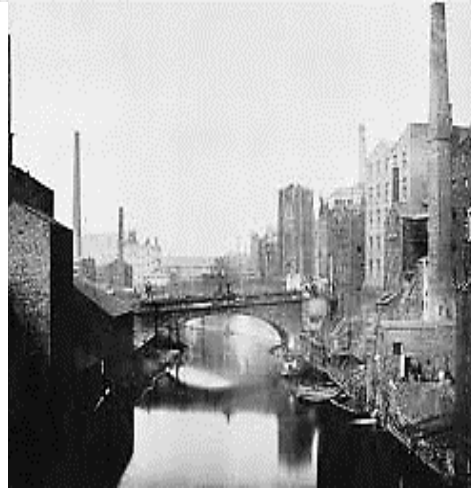
Emergence of 'Magnet Cities'

Cities built
on TRADE



200 BC onwards

Cities built
on INDUSTRY



1750s onwards

Cities built
on PEOPLE



2000s onwards

How Pittsburgh became a Magnet City.....

Steel



Robotics



Medicine



Quality of Life



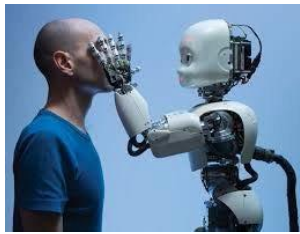
Bourbon



Press



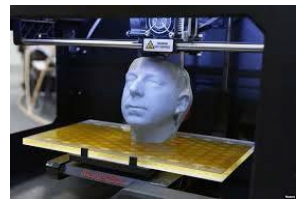
Magnet Cities are 'Sticky for Talent'



- A global KPMG study of 160 cities determined the characteristics of a magnet city using measures of annual jobs growth, GDP, R&D spend and population growth including the proportion of 'young wealth creators' measured using the number of patents/10,000 people as a proxy.



- The KPMG Report concluded that a *"relentless" focus on attracting young wealth creators, contributed directly to a city's economic growth* and that there was;



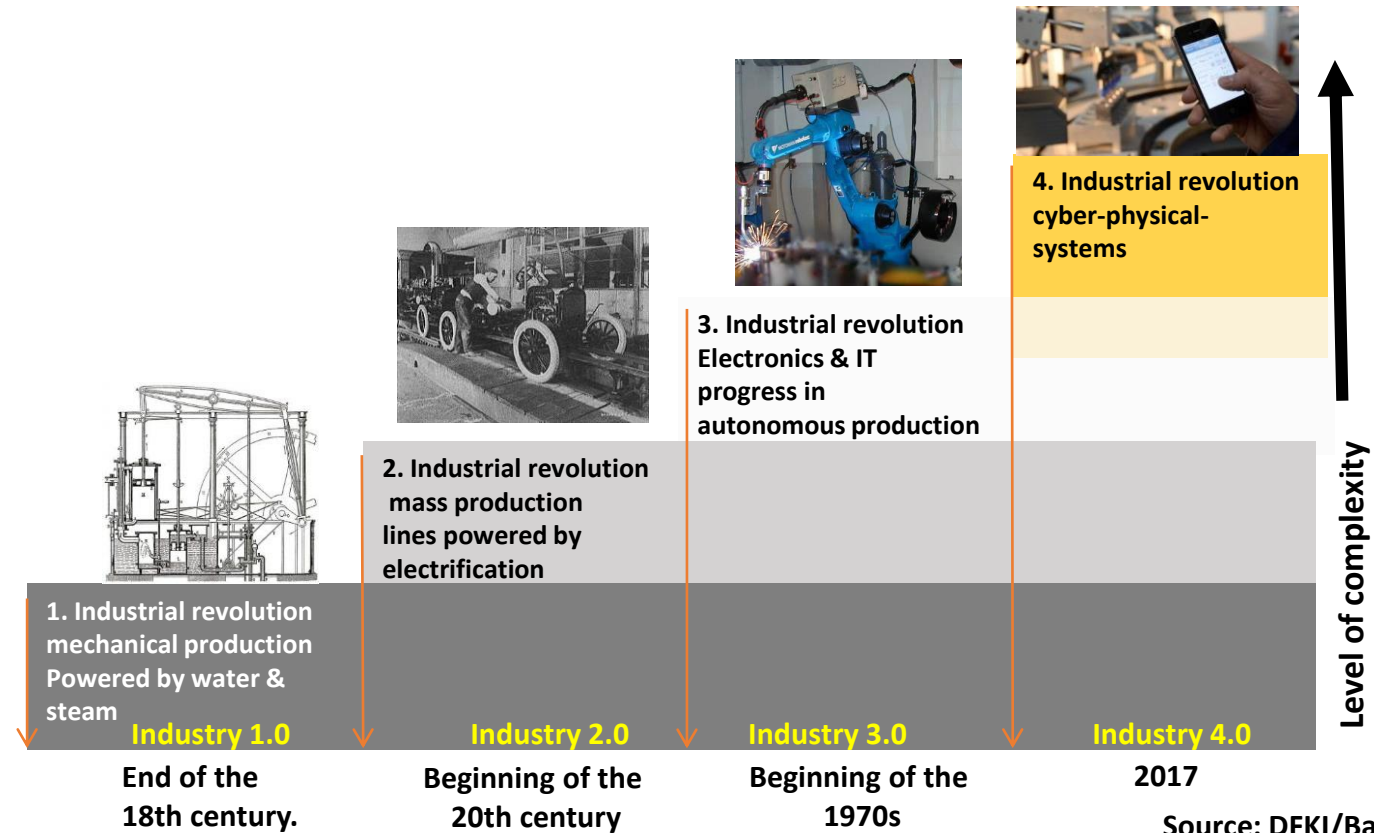
- *"a specific relationship between cities and the young wealth creators who chose to move there. These cities provided the physical cityscapes, social networks, peer groups, restaurants, houses, investors, transport links, restaurants and bars they needed to set up their companies.*



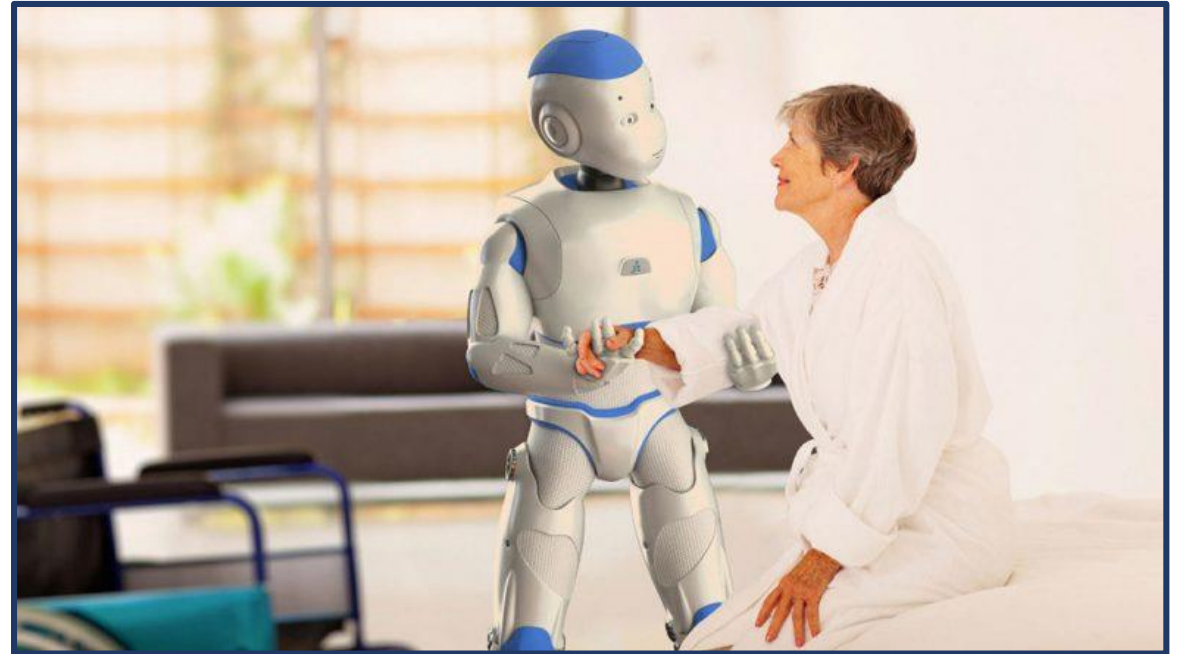
- *'Simply throwing up a start-up space and a couple of new apartment blocks will not draw new young people into a city that doesn't offer anything else....'.*

Industry 4.0

Driving Convergence of Data



What is different this time is that today's advances in digital technologies are remaking not just manual and manufacturing labour- the focus of past revolutions - but every sector of the economy and societyand the pace of change is much faster than ever before.



The Future Health Care Professional?

The Future of Health Care

Shared Challenges for all STEMM Disciplines

The Challenges

- chronic health conditions cause 70 % of deaths and account for > 85 % healthcare costs
- US health care expenditures are currently \$3 trillion p.a. (17.5% GDP) and projected to rise to > 19% GDP by 2024.

Need significant breakthroughs in:

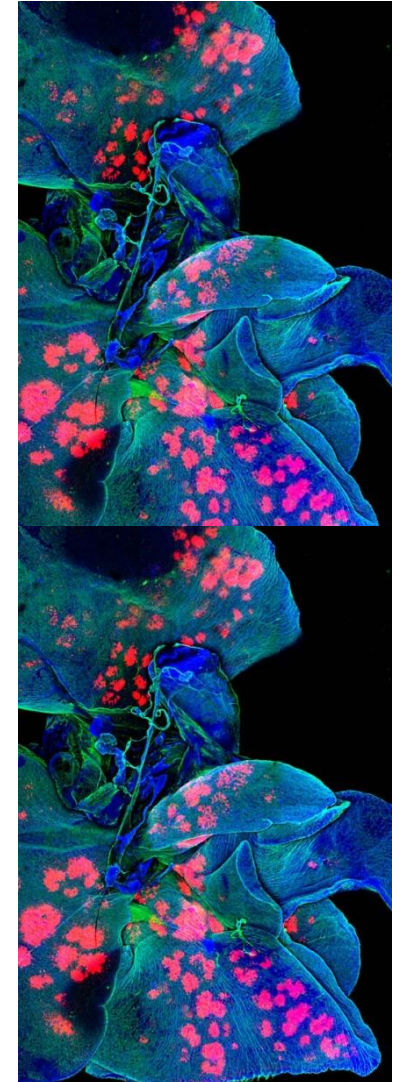
- early diagnosis
- addressing intergenerational transmission of poor health
- prevention through lifestyle changes or other interventions
- novel lower-cost diagnoses and treatments
- addressing pervasive health inequalities within and between nations

Convergence: The Future of Health Report MIT June 2016

The Power of 'Convergence' of Disciplines in Health Care

Convergence

- comes as a result of the sharing of ideas and methods by chemists, physicists, computer scientists, engineers, mathematicians, and life scientists across multiple fields and industries.
- forms comprehensive frameworks that merge areas of knowledge from multiple fields to address specific challenges.
- is different to interdisciplinary research - it goes beyond collaboration to integrate historically distinct disciplines and technologies into a unified whole to create fundamentally new opportunities for life science and medical practice.



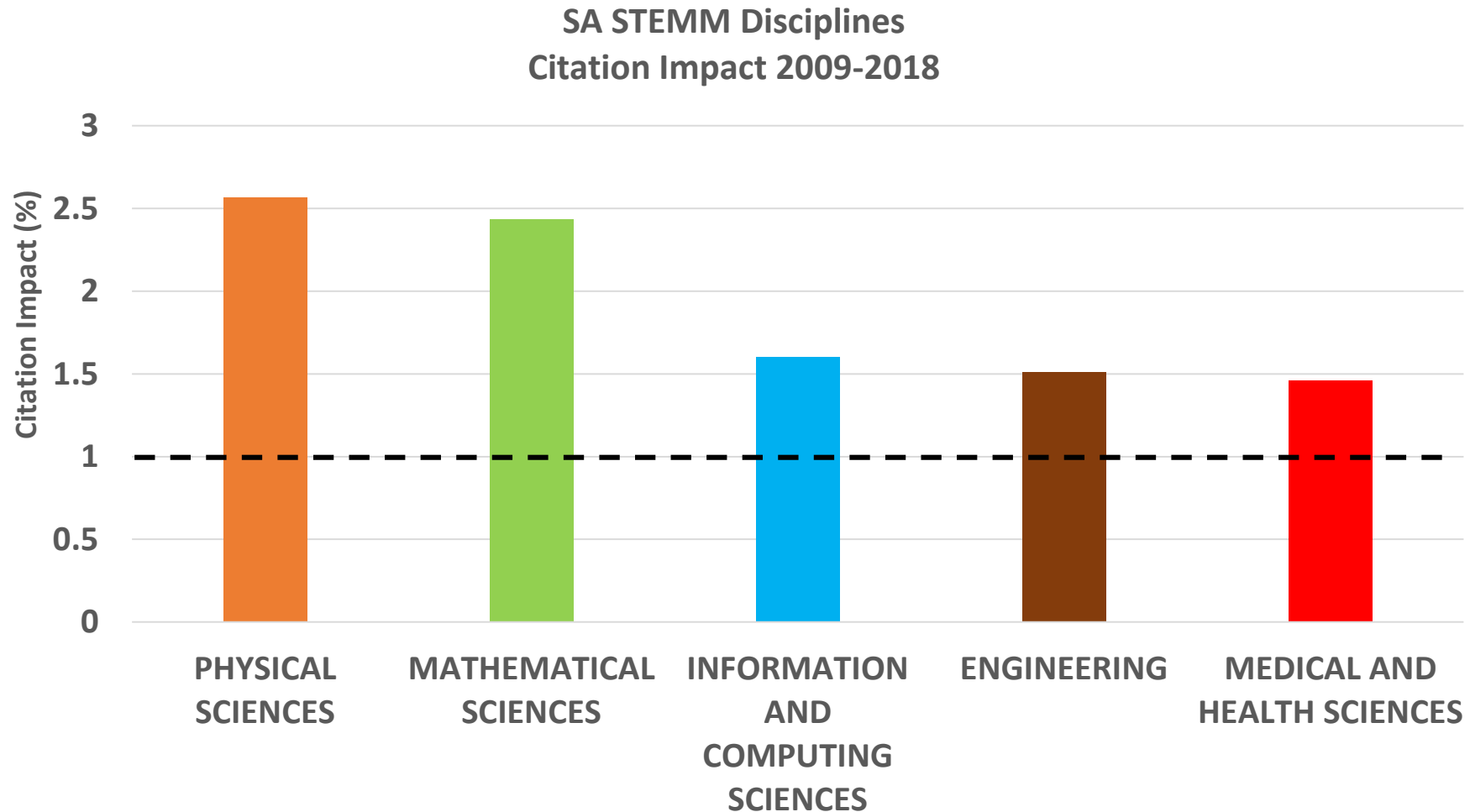
Building the Future: Universities 4.0 Structural and Cultural Challenges

- **Light touch' interdisciplinary structures may not deliver a transformative impact – a bold focus on convergence of disciplines may be required to transform the future of a university to align with the challenges of the 21 C.**
- **Overcoming 'drag force' of disciplinary rivalry set up in established Faculties, Schools, Departments over decades - requires cultural and structural transformation.**



Building on Maths and Science Excellence

The Convergence of Disciplines



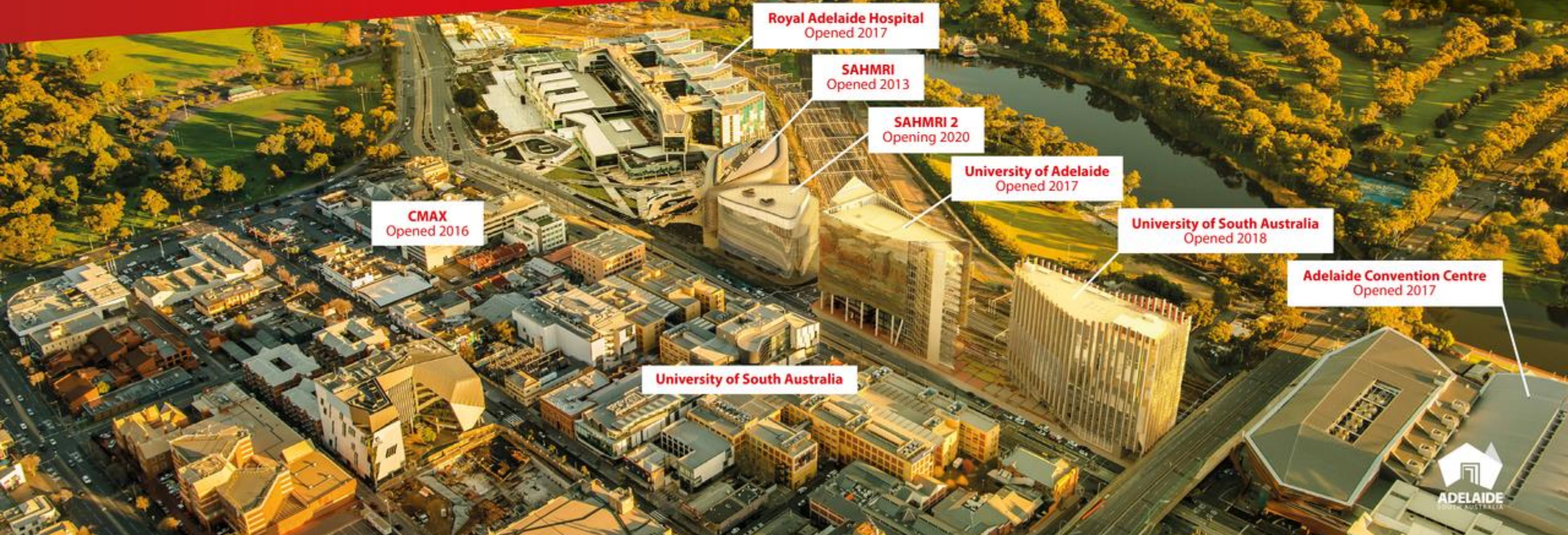
Building the SA Health Translation and Innovation Neighbourhood

\$3.8b Adelaide BioMed City

2,000 biomedical researchers

10,000 total staff

18,000 people

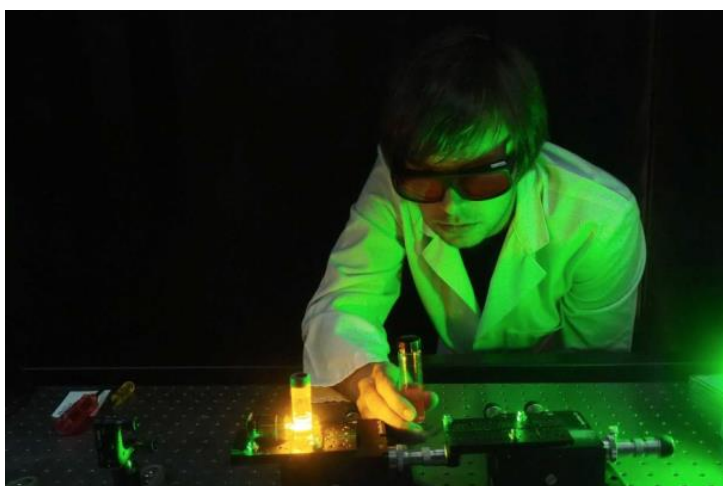
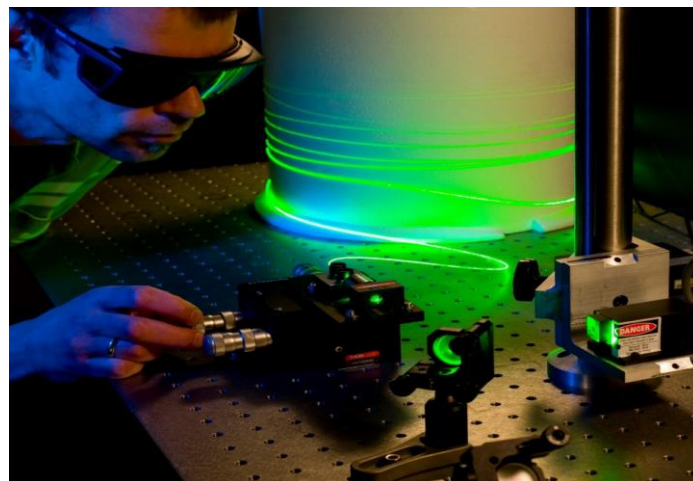
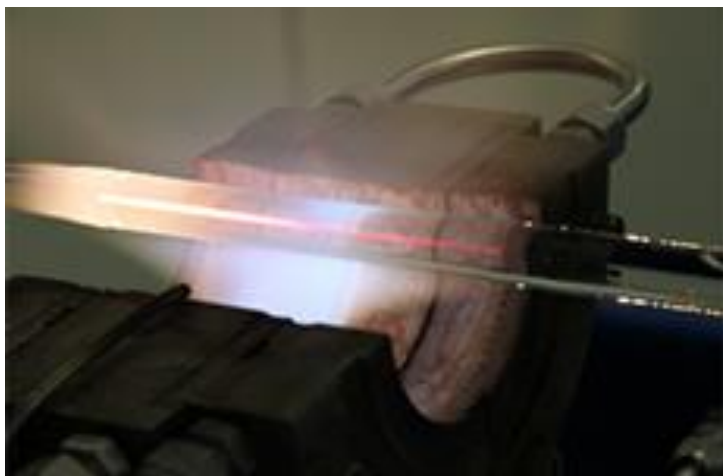


Medical devices

To the South The Tonsley Industry 4.0 Translation and Innovation Neighbourhood



East Adelaide Science, Technology and Engineering Translation and Innovation Neighbourhood



THE UNIVERSITY
of ADELAIDE

Australian Institute for Machine Learning



Disruptive Technologies World Economic Forum	Timing	Impact
Mobile internet and cloud technology	2015–17	rapid spread of internet-based service models
Advances in computing power and ‘big data’	2015–17	new systems and capabilities to harness massive datasets generated
New energy supplies and technologies	2015–17	new energy supplies/ technologies - economic geopolitical, environmental repercussions.
The Internet of Things	2015–17	use of remote sensors, communications, and processing power in industrial equipment and everyday objects
Advanced manufacturing, 3D printing	2015–17	on-demand production, major implications for global supply chains and production networks.
Crowdsourcing, peer-to-peer platforms	Current	the talent and resources companies can connect to, become a major knowledge resource
Advanced robotics and autonomous transport	2018–20	robots with enhanced senses, dexterity, and intelligence in manufacturing, service jobs encroaching into professions... Autonomous cars, trucks, aircraft, and boats.
Artificial intelligence and machine learning	2018–20	automate knowledge-worker tasks regarded as impossible or impractical for machines to perform
Advanced materials, biotechnology and genomics	2018–20	impacts on medicine and agriculture. synthetic molecules via bio-process engineering - pharmaceuticals, plastics and polymers, biofuels etc

World Economic Forum: Top Ten Emerging Technologies 2018

Augmented reality	Overlaying information and animation on to real-world images AR will help surgeons visualize tissues in 3D, contribute to assembly line processes and holographic guides.
Personalised Medicine	Advanced diagnostic tools detect and quantify multiple signs of a disorder to determine the risk of disease and tailor therapeutics for the individual
AI-led Molecular Design	Machine-learning algorithms analyse all known past tests to create new materials and drugs, discern patterns and predict what new drugs.
AI that can Argue and Instruct	The next generation of machine learning systems absorb and organize data from raw text, video, pictures, audio, emails) and autonomously compose advice – or debate an opponent.
Implantable Drug-Making Cells	Implantable cells engineered synthetic biology programmed to control drug release within tissues.
Lab-Grown Meat	The development of lab-grown beef, pork, poultry and seafood from cultured stem cells.
Electroceuticals	Treat conditions with electrical impulses using an approach delivering signals to the vagus nerve to treat migraines, obesity and rheumatoid arthritis.
Gene Drive	CRISPR gene editing, makes it easy to insert genetic material into specific spots on chromosomes has accelerated work in genetic engineering technology. A new approach that can change the traits of a population or species using gene drives
Plasmonic Materials	Creation of nano-antennas, solar cells and sensors for detecting chemical and biological agents including toxins. Nanoparticles can be concentrated inside a tumour and light delivered to result in the death of cancer cells only.
Algorithms for Quantum Computers	Powerful quantum computers could simulate nature and help design materials. Algorithms could enhance the design of new materials in areas from energy to health science.

Artificial Intelligence

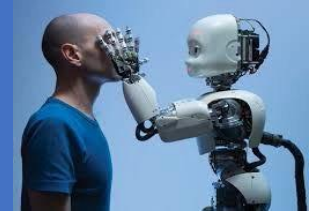
A Complex Ancestry and Limitless Future: Maths is the Key

The field of artificial intelligence is broad, dynamic, and rapidly evolving, and is producing technologies with global societal implications.

- advances in facial and speech recognition have produced virtual assistant technologies that are being integrated into daily life like Siri, Alexa, Google, iFLYTEK, and Baidu.**
- online search optimization and digital ad targeting.**
- medical image analysis for rapid and accurate diagnoses and treatment planning.**

Artificial Intelligence

Difficult for Human Intelligence to Synthesise....



At its simplest AI refers to the creation of machines that think and act like humans

- **weak AI, machines that can simulate thinking within a narrow context to accomplish a specific task**
- **strong AI intelligent machines that can reason.**

AI has absorbed basic techniques from many discipline fields:

- **logic, probability and statistics, optimization, photogrammetry, neuroscience, and game theory.....**

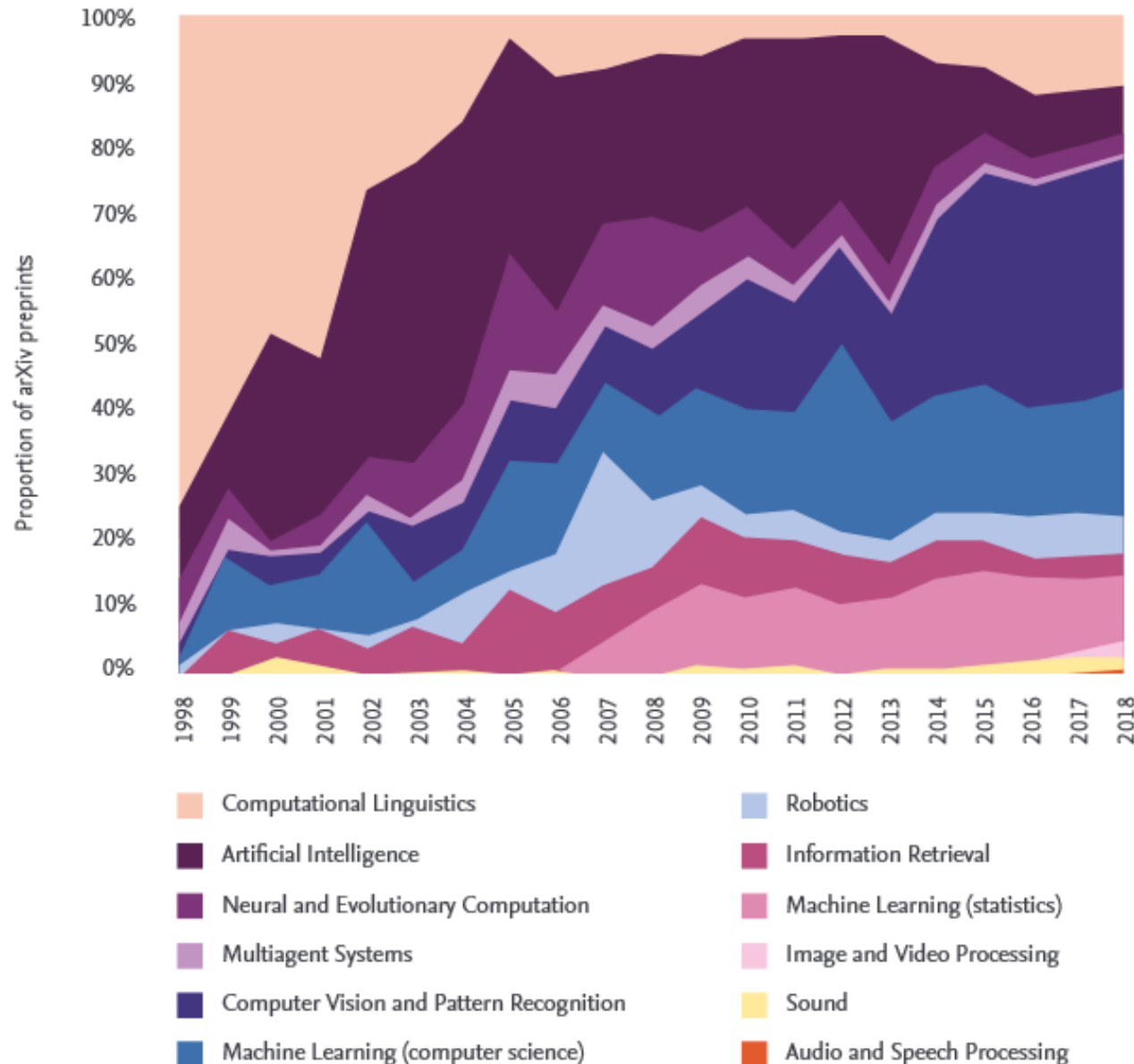
AI methods are also being applied across many other fields

- **speech recognition,**
- **computer vision,**
- **robotics,**
- **cybersecurity,**
- **bioinformatics,**
- **health**

Different societal standpoints:

- **Government: national competitiveness; national and international policies and strategies growing global AI research and innovation ecosystems.**
- **Industry: algorithms, efficiency, increasing productivity**
- **Community : loss of jobs, ethics, privacy, regulation, security..**

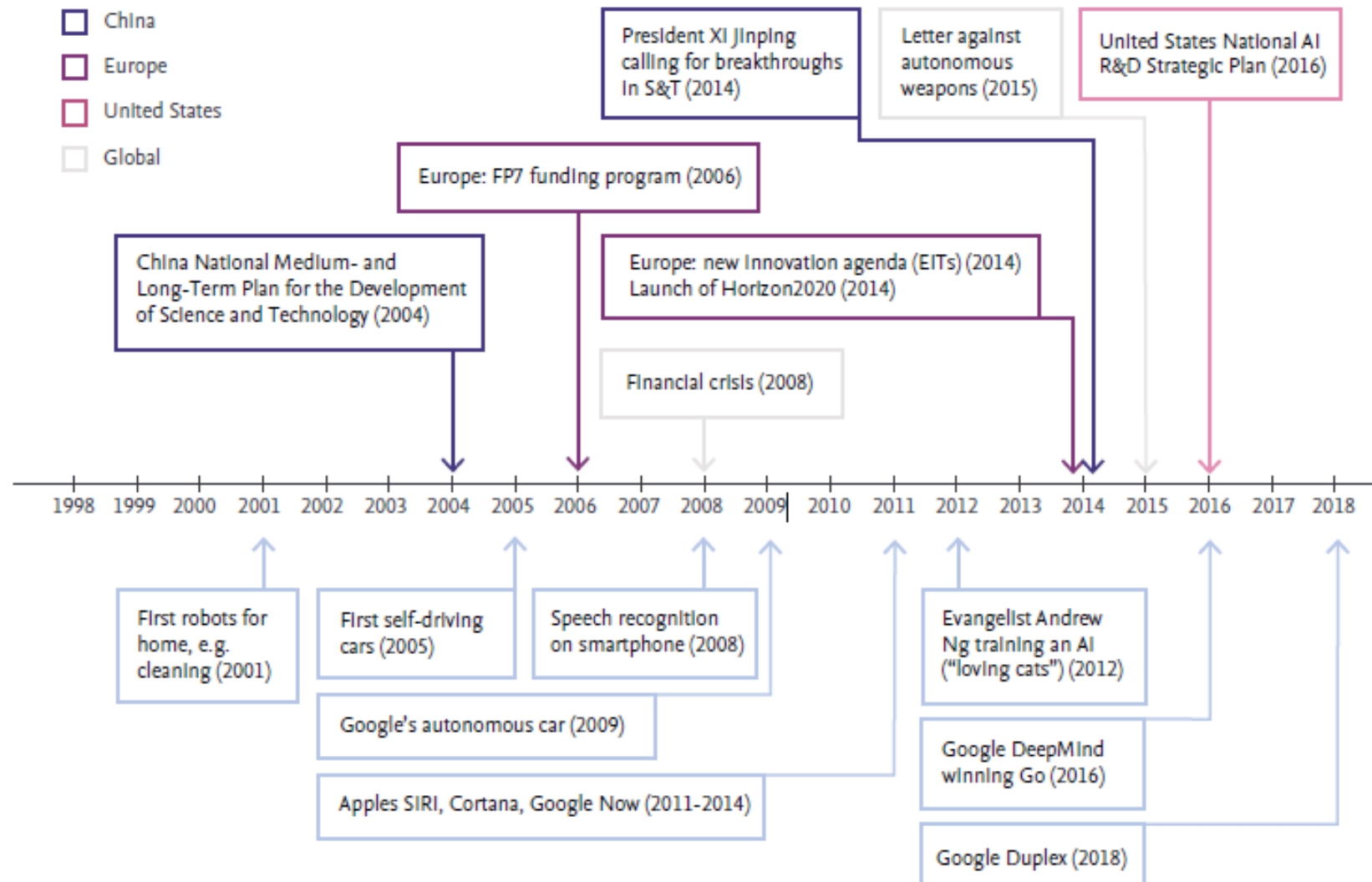
Changes in AI Researcher Focus 1998-2018



1998: computational linguistics & natural language processing research dominate.

2018: computer vision and pattern recognition and machine learning dominate

Interaction Between STEMM Knowledge Generation and Translation into Policy, Products and Services



Global Knowledge Creation: Who's Who

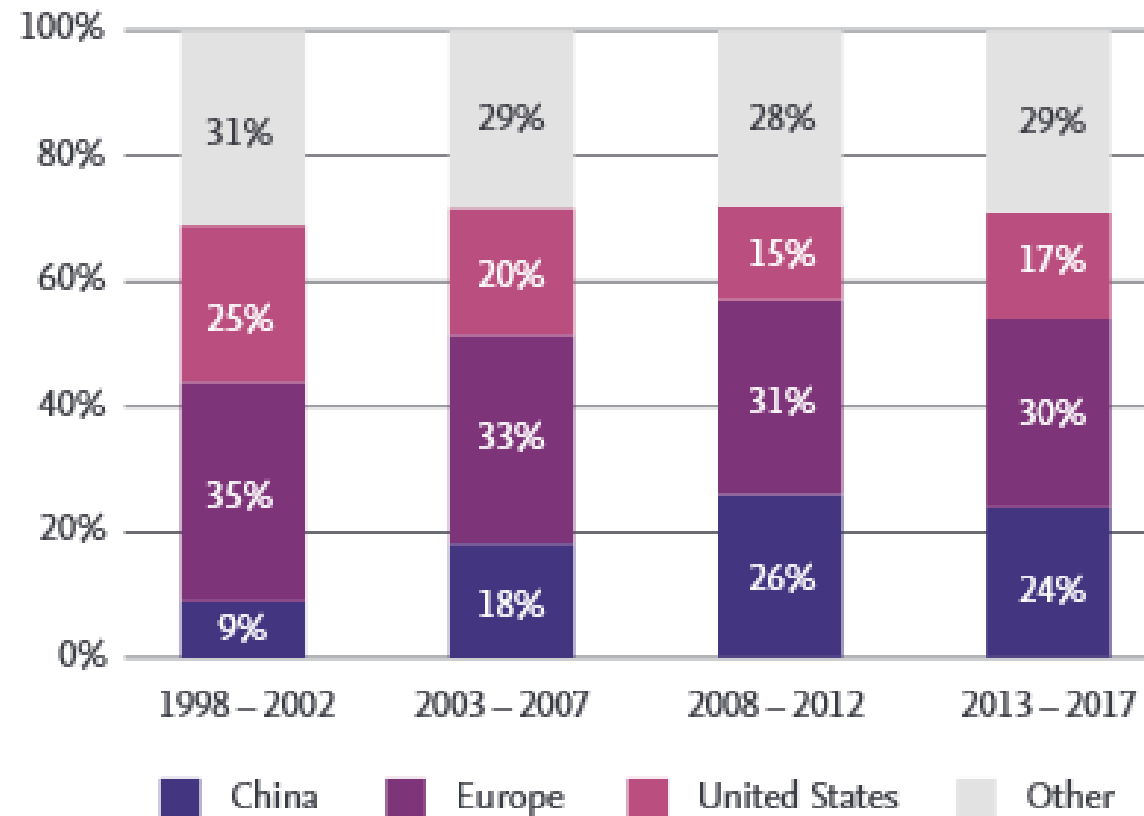


FIGURE 3.4

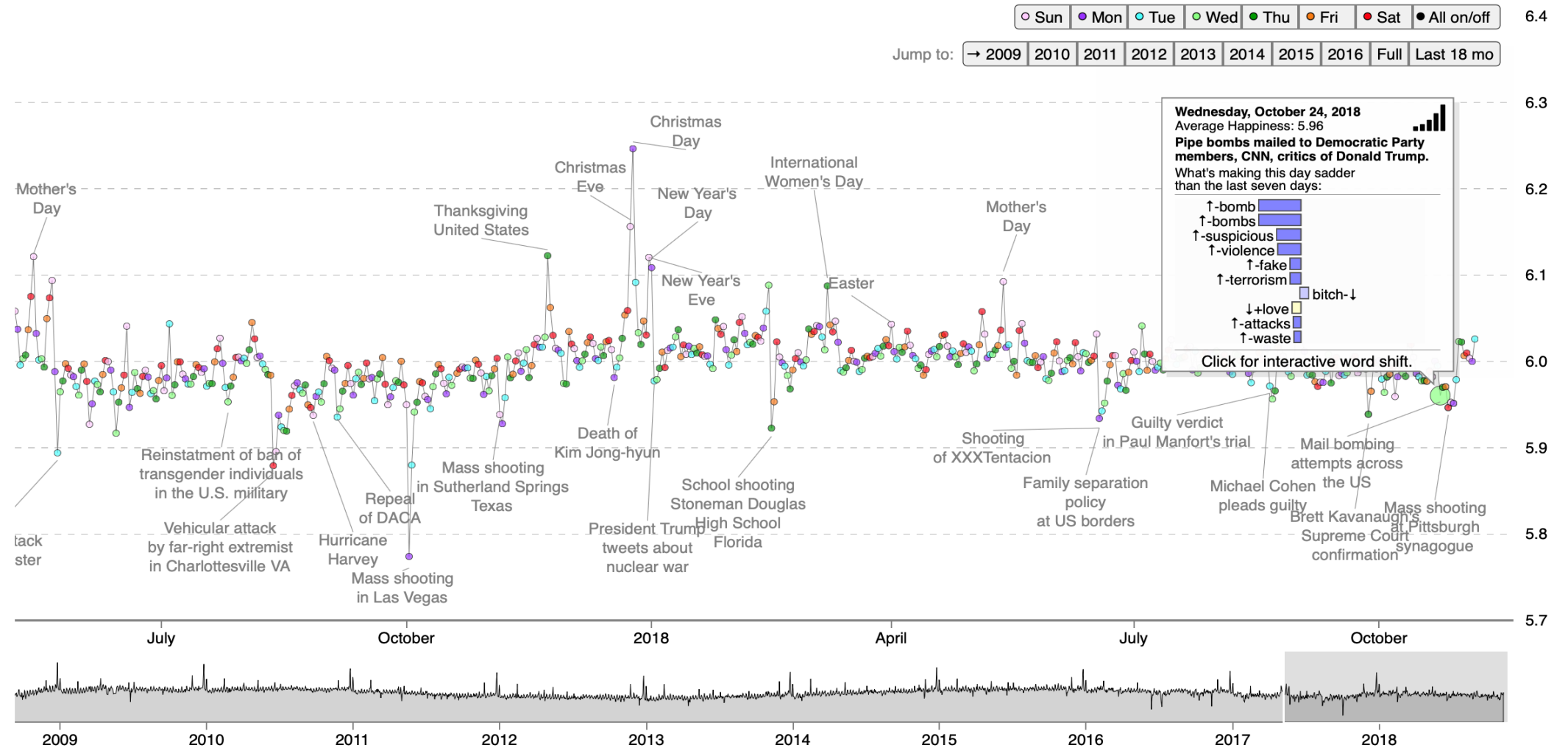
Share of global publication output in AI (all document types)
for periods 1998-2002, 2003-2007, 2008-2012, and 2013-2017,
per region; source: Scopus.

Maths- Understanding How Humans Work

Passively Measuring happiness online

hedonometer.org

Average happiness for Twitter



Maths: Understanding the Human Condition in the 21 C

Information flow reveals prediction limits in online social activity

- **Modern society depends on the flow of information over online social networks, and users of popular platforms generate substantial behavioural data about themselves and their social ties.**
- **However, it remains unclear what fundamental limits exist when using these data to predict the activities and interests of individuals, and to what accuracy such predictions can be made using an individual's social ties. This study shows 95% of the potential predictive accuracy for an individual is achievable using their social ties only, without requiring that individual's data.**
- **Information theory is well suited to data in the form of online written communication.**
 - **$n = 13,905$ users, comprising egocentric networks from the Twitter social media platform**
 - **total of $m = 30,852,700$ public postings**
 - **$= 927$ ego-networks consisted of one user (the ego) and their 15 most frequently mentioned Twitter contacts**

Maths: Understanding the Human Condition in the 21 C

Information flow reveals prediction limits in online social activity

- **Distinct temporal and social effects are visible by measuring information flow along social ties, allowing a better study the dynamics of online activity.**

Authors Conclude:

The results have distinct privacy implications: information is so strongly embedded in a social network that, in principle, one can profile an individual from their available social ties even when the individual forgoes the platform completely.

Nature Human Behaviour 2019 (James P. Bagrow, Xipei Liu and Lewis Mitchell)

Data Culture, Data Science, Business Intelligence

A Road Block

2019 Big Data and AI Survey (Vantage Partners 2019)

64 c-level technology and business executives representing corporations such as American Express, Ford Motor, General Electric, General Motors, and Johnson & Johnson.

72% have yet to forge a data culture

69% have not created a data-driven organization

53% not yet treating data as a business asset

52% not competing on data and analytics

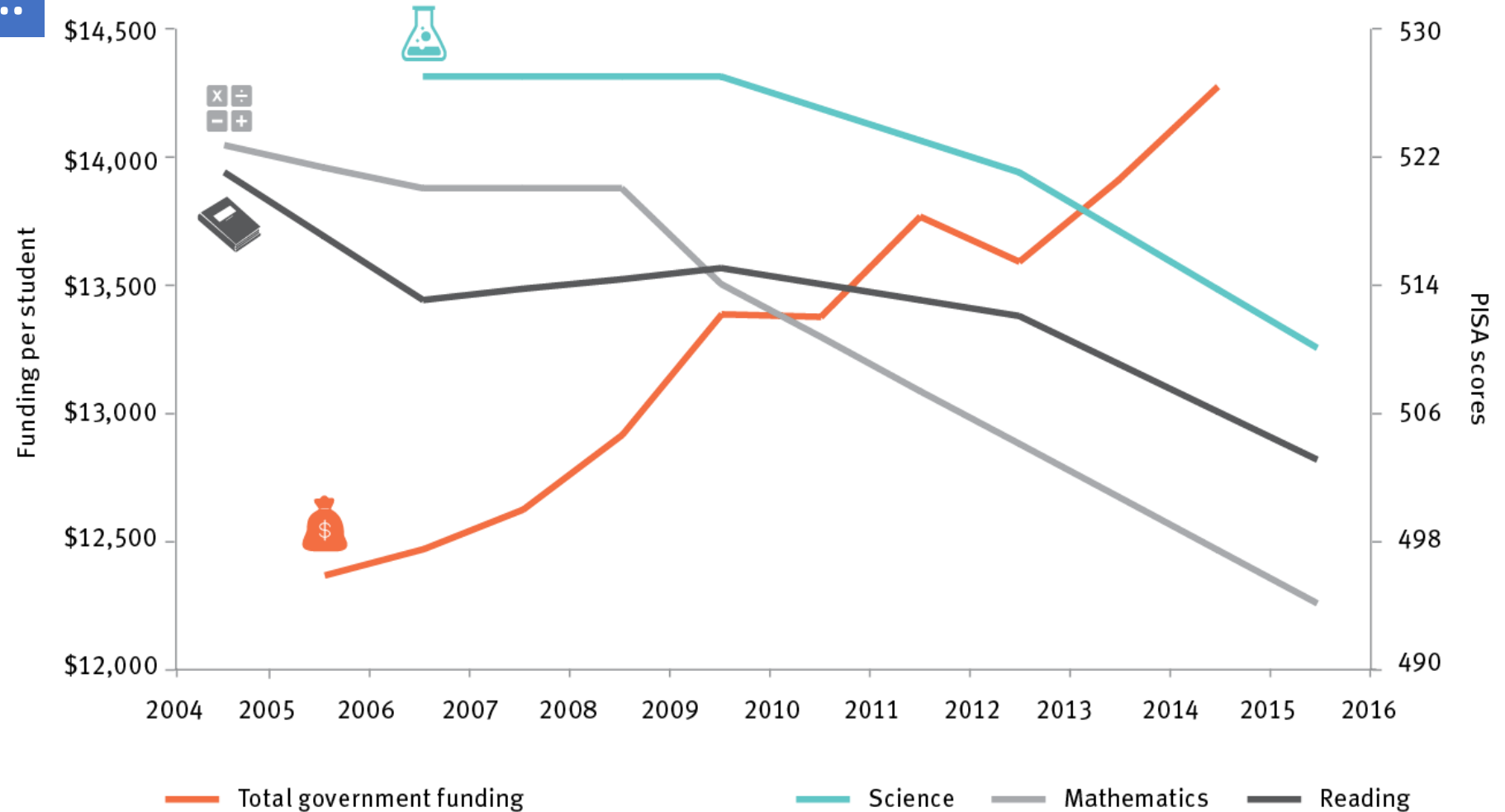
Firms identifying themselves as being data-driven:

2017	37.1%
2018	32.4%
2019	31.0%

Australia - The AI Challenge

- AI has the potential to increase global productivity by ~40%, and is projected to contribute up to \$15.7 trillion to the global economy in 2030, more than the current output of China and India combined.
- The impact on productivity will be competitively transformative – businesses that fail to adapt and adopt will quickly find themselves uncompetitive.
- 9% of Australia's listed companies are making sustained investments in AI, compared with more than 20% in the United States and nearly 14% in leading automation nations globally.
- 80% of Australian SMEs are delaying the adoption of technology that could deliver long-term benefits
- ACOLA Horizon Scanning Projects underway:
 - *Deployment of Artificial Intelligence and what it presents for Australia*
 - *The Internet of Things: Maximising the benefit of deployment in Australia*

meanwhile....



PISA scores, which from 2006–07 to 2015–16 have declined by 3% in scientific literacy; and by 5% in mathematical literacy and 3.5% in reading

and.....

- **The proportion of students choosing Year 12 advanced maths has declined by 20% from 2000 to 2015, and by 32% from 1995 to 2016**
- **Inequality in the maths performance of school students is worsening Most students who receive low numeracy achievement scores in Year 3 never catch up with their peers, falling further behind by Year 9**
- **Maths achievement is closely aligned to socioeconomic status**
- **Students who start off behind their peers due to socioeconomic factors never catch up**
- **Half of Australia's students in Year 8 dislike maths, significantly more than the international average**
- **Australia's international position in school maths performance has declined . The proportion of students choosing Year 12 advanced maths has declined by 20% from 2000 to 2015, and by 32% from 1995 to 2016**

Education Imperative: Respond to the changing nature of work by equipping all Australians with skills relevant to 2030

Strategic opportunity : Teaching of science, technology, engineering and mathematics and 21st-century skills can be improved through development for teachers and school leaders, and education inequality can be reduced through targeted interventions

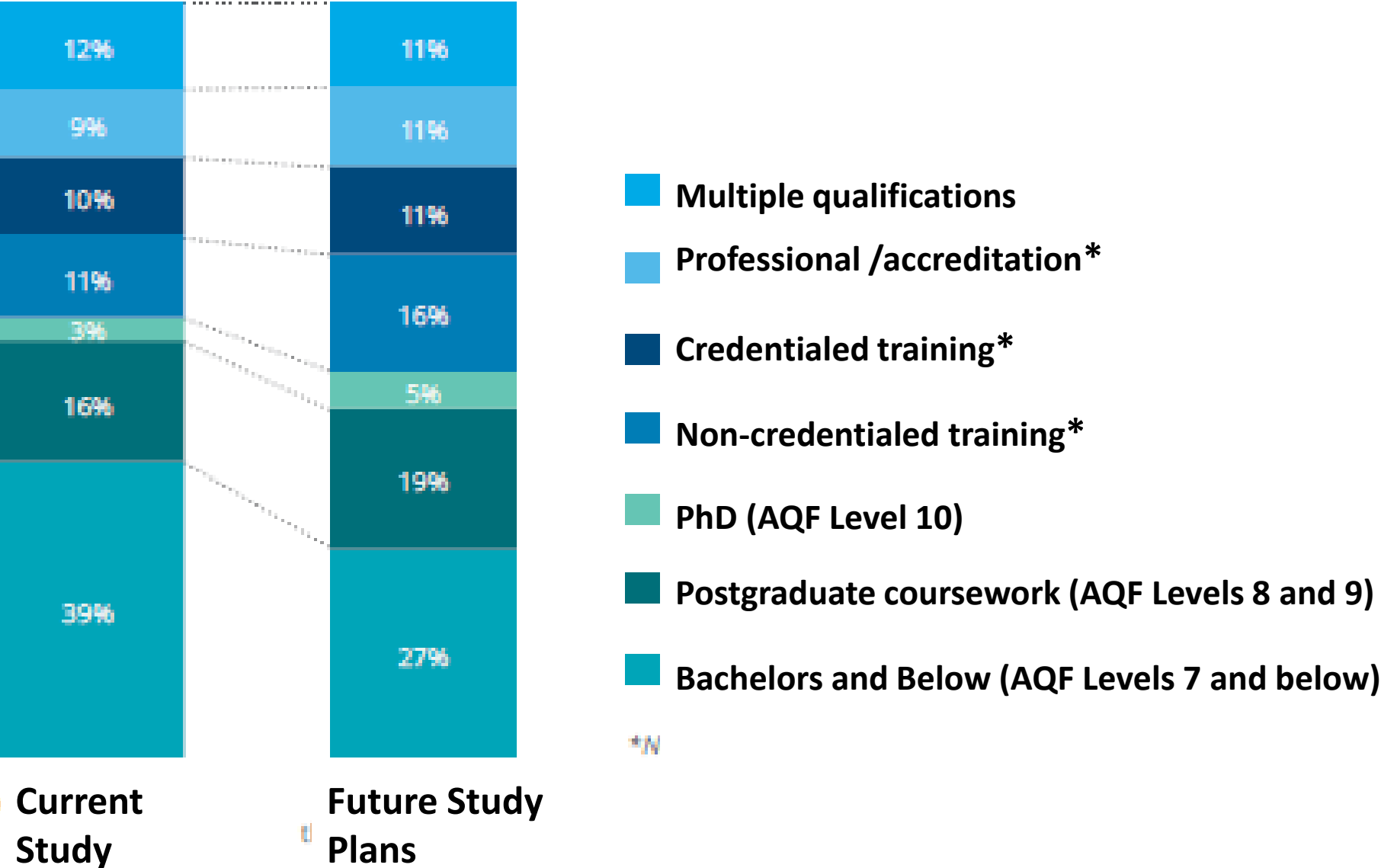
- **improving the pathway for STEM graduates into teaching to increase the pool of in-field teachers**
 - **supporting schools to access specialist teachers in mathematics, science and technology**
 - **review of Australian Curriculum should have a remit for bold changes and seek industry advice.**
 - **University prerequisites raised**
 - **STEM Partnerships Forum has been established to bring together key industry and education leaders and raise awareness of the importance of STEM education and the relevance of STEM skills to a range of careers**
- **Strategic opportunity 1.2: Australia's vocational education and training system can be made responsive to the new priorities presented by innovation**

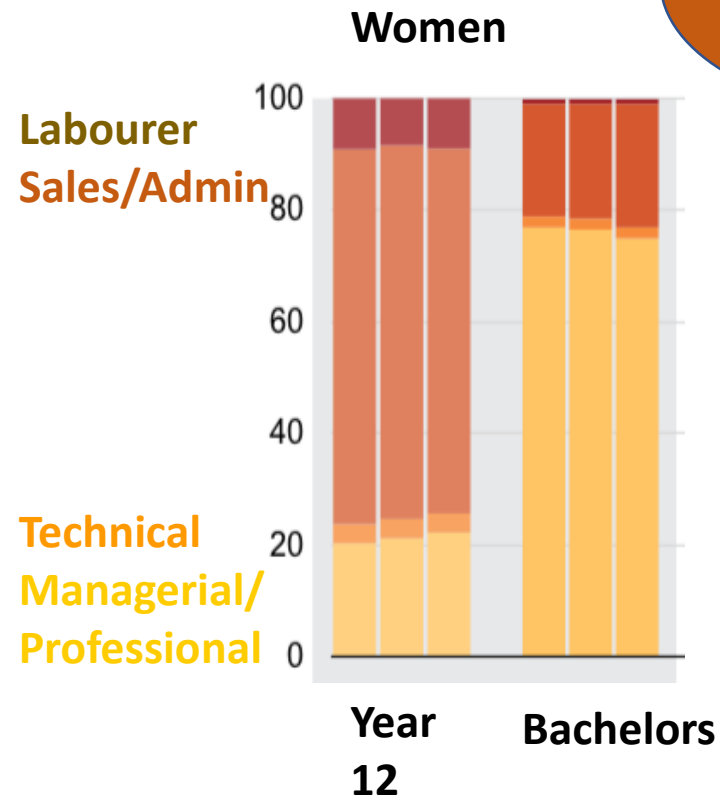
(Australia 2030: Prosperity Through Innovation Report 2017)

Study Plans of Current Australian Workers

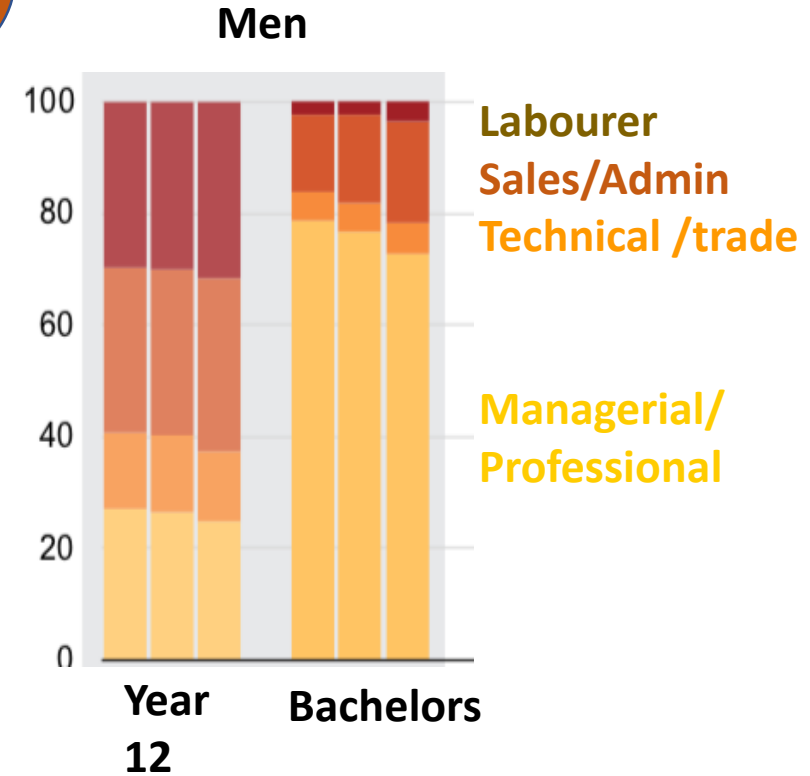
- **31% of Australian workers surveyed were currently studying**
- **37% plan to commence further study in the next 3 years – including formal and informal study. Younger and high-skill workers in technical industries more likely to be interested in further education and training.**
- **30% of study-interested workers expect education providers to collaborate with industry to deliver content.**
- **68% of study-interested workers place more importance on skill-based training than formal qualifications.**

Changing Future Study Preferences





**The
Graduate
Premium**



Differences in share of occupations for 25-34 yr old school leavers and graduates between 2006 -2016

The 21 C Citizen: The 2030 Agenda for Sustainable Development



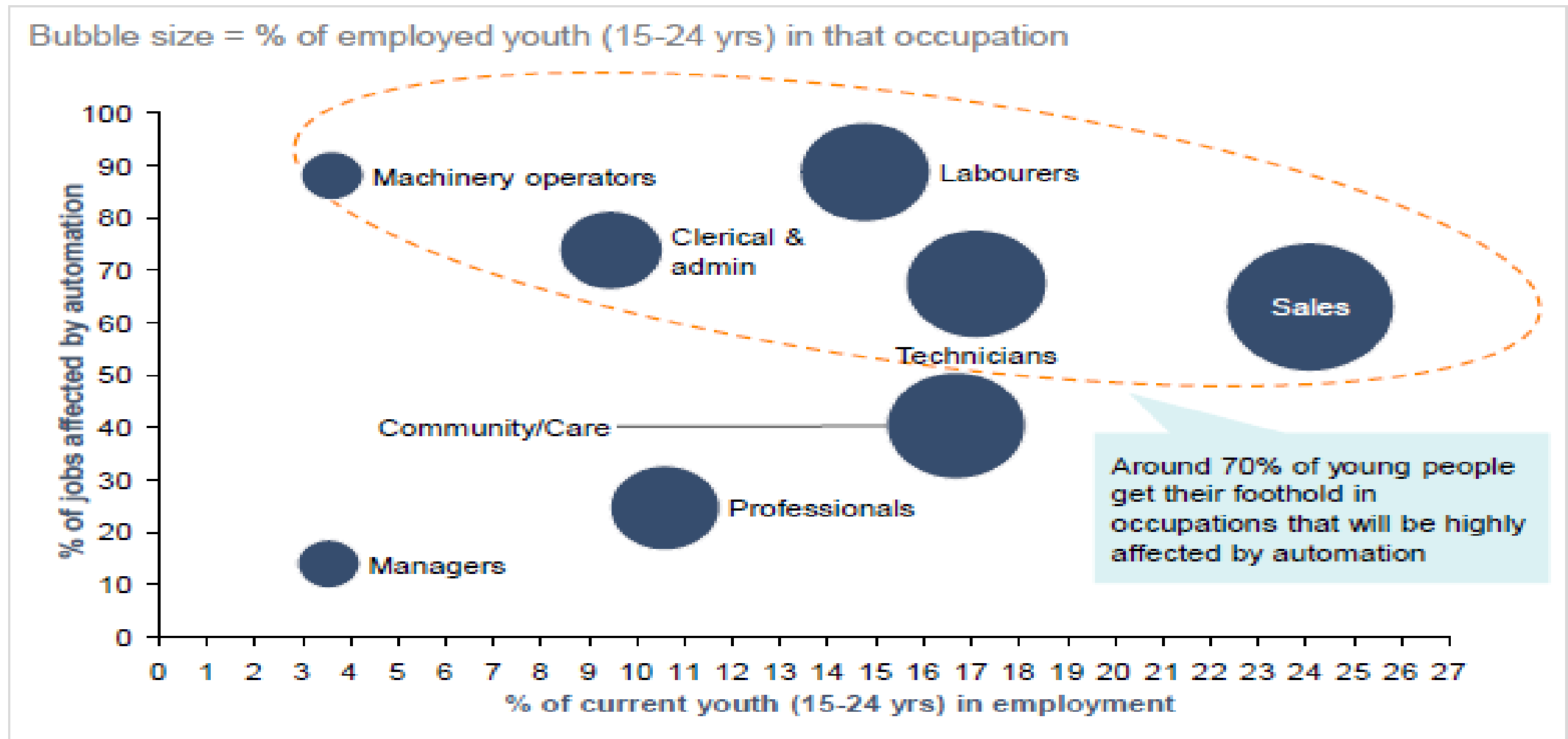
**SUSTAINABLE
DEVELOPMENT** **GOALS**

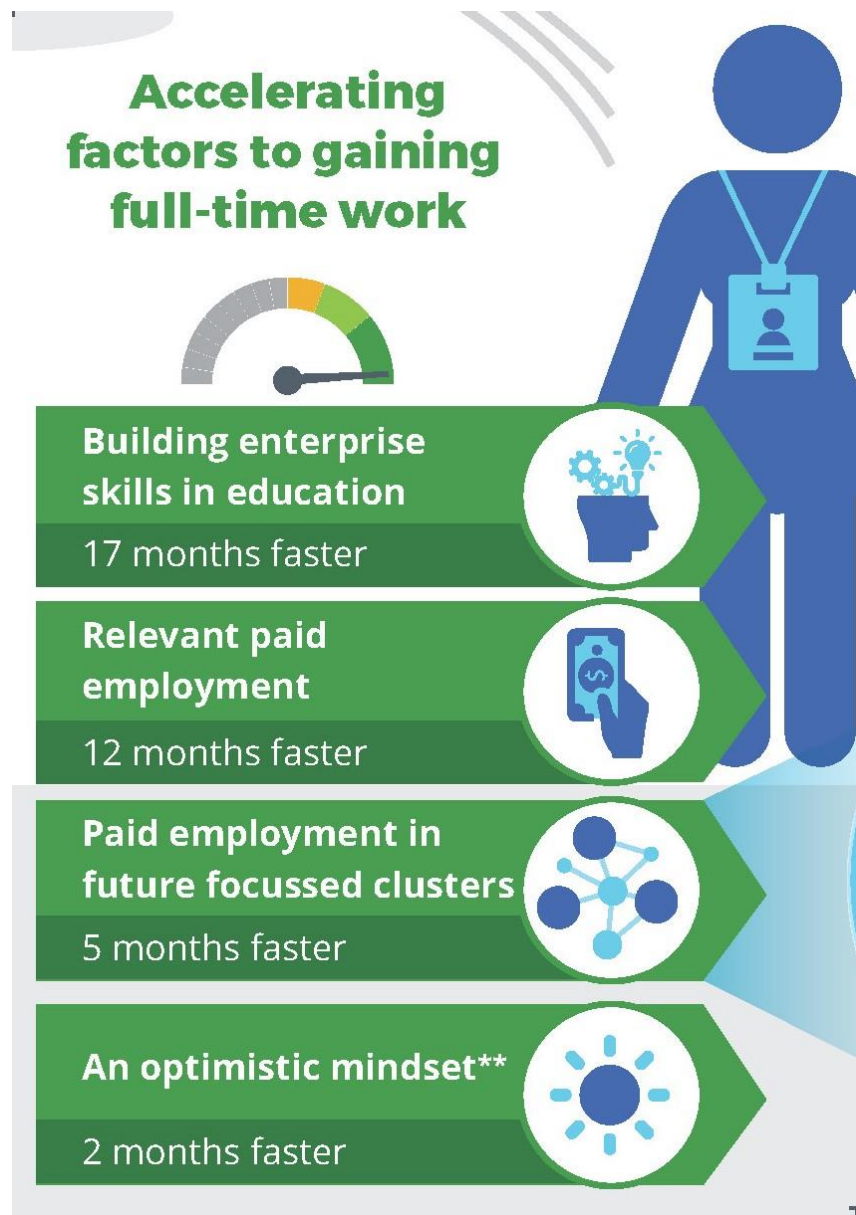
17 GOALS TO TRANSFORM OUR WORLD



AND

70% of young people currently enter the labour market in jobs that will be radically affected by automation





Building Employability

Accelerating the transition to full time work for 15-24 yr olds

Four key factors that affect time to work

- Enterprise skills
- Relevant, paid employment
- Paid employment in 'future focused' work clusters
- An optimistic mindset

Source: Foundation for Young Australians The New Work Reality 2018

Building the Future of Maths and Science Through Access

'Talent is Everywhere Opportunity is Not



- From Forklift driver to University Medal Winner in Science
- Worked in mines in WA
- Access pathway to Uni critical
- Currently enrolled in OhD

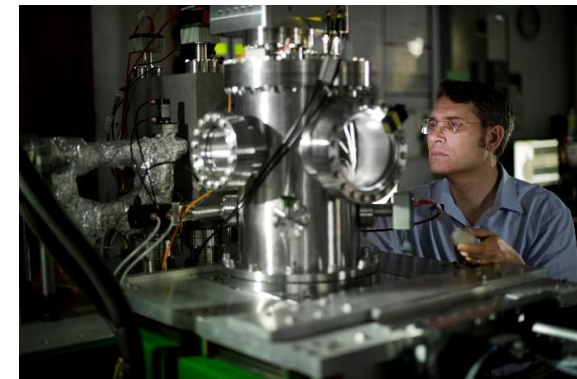
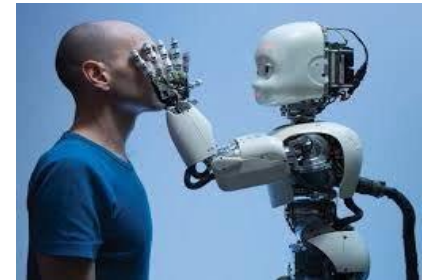
Photo credit: Mac Mason-Hubers, Newcastle Herald

.....Universities 4.0....

- *With conversations about the challenges brought about by the fourth industrial revolution being under way, the higher education community will have to start an imperative conversation and debate about how to reshape the education system into an adaptable, flexible and relevant social environment.*
- *An environment that allows the entire community across the world to pursue lifelong learning and gain the necessary skills and competencies to survive and contribute to a progressive society across different industrial revolutions.*

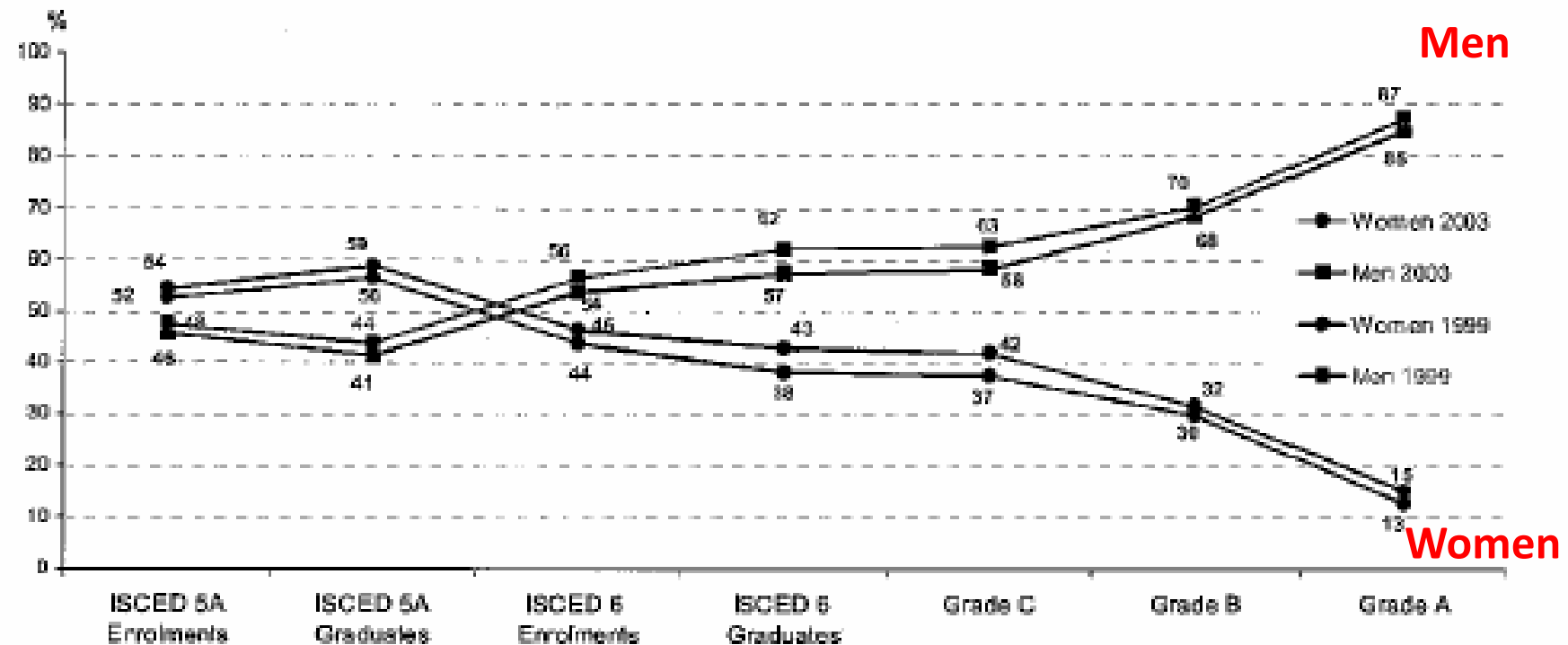
[QS Asia News Network](#)

January 4, 2018

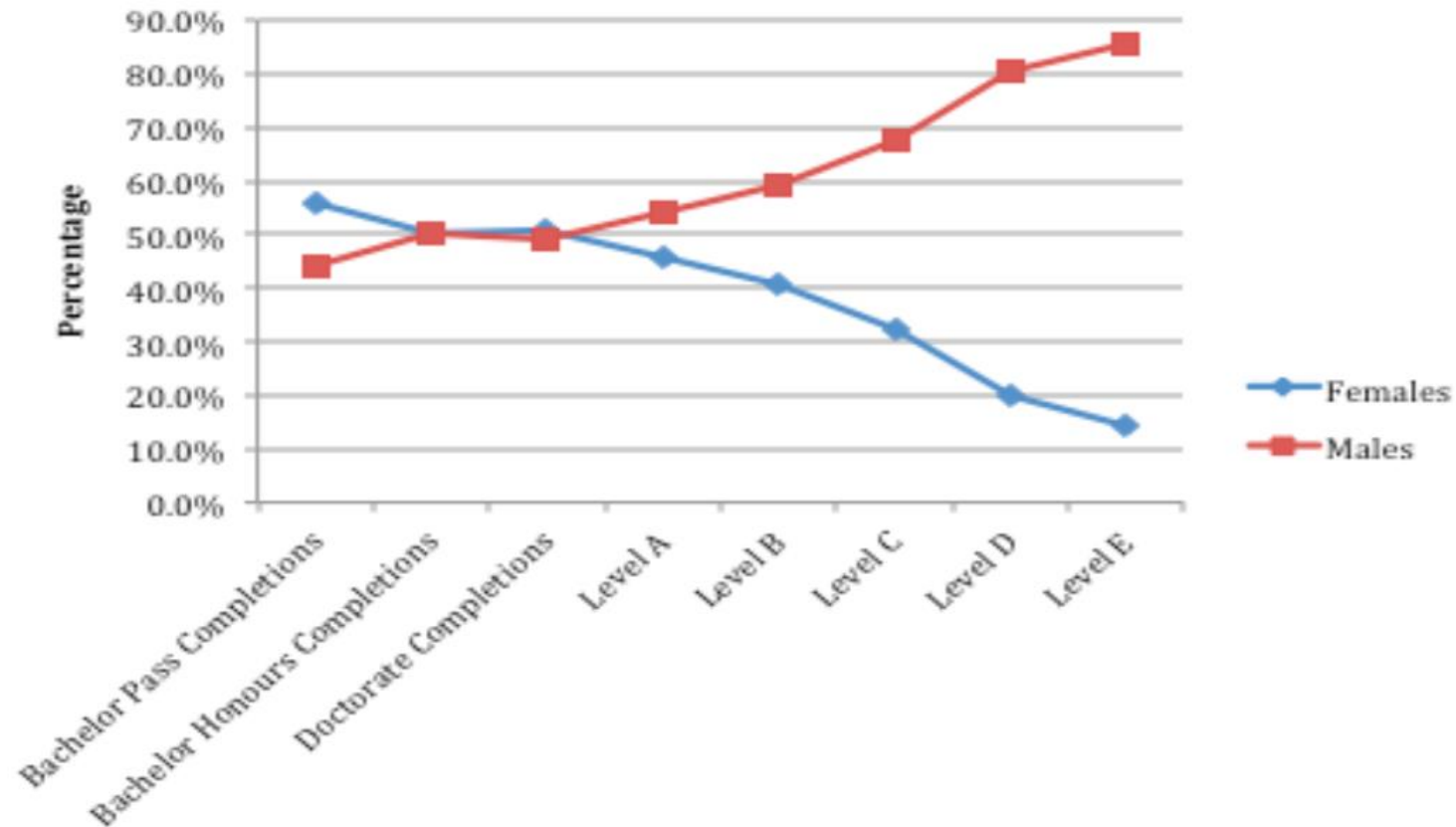


A Difficult Problem OECD 1999-2003

Figure 2.4. Relative share of women and men in a typical academic career EU-25, HC, 1999 and 2003

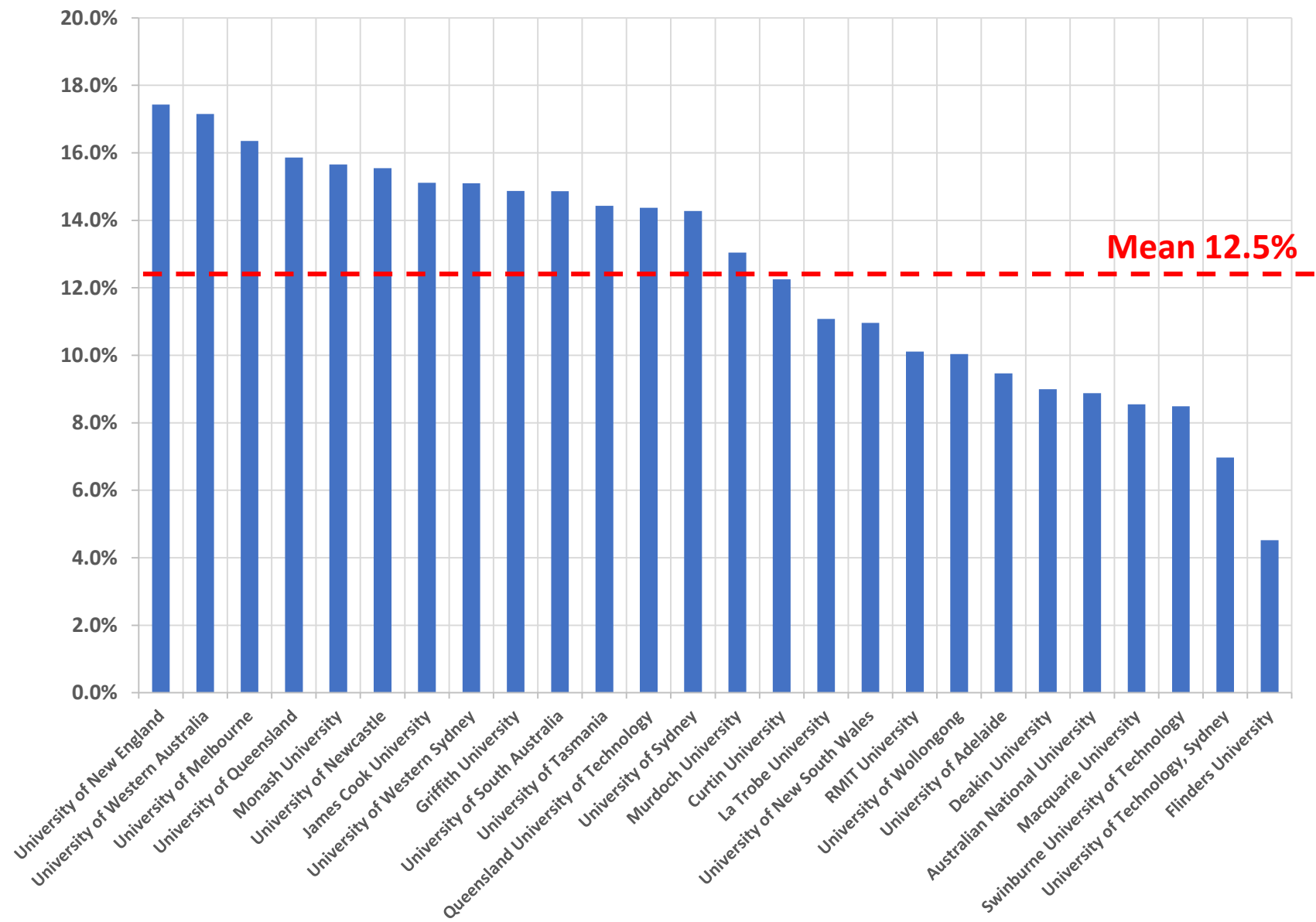


Gender representation by academic level in the natural and physical sciences Australia 2011



**Women in the Science Research Workforce:
Identifying and Sustaining the Diversity Advantage
ARC Linkage Project Report Bell & Yates 2014**

A Long Legacy: Proportion of Female Authorships on Research Publications in Mathematics and Computing 2014- 2017 in Australia



THE PIPELINE MYTH: THE US PERSPECTIVE

- **The pipeline myth is the persistent idea that there are too few women qualified (e.g., degree holding) for leadership positions.**
- **The data indicate that there are more than enough qualified women to fill available leadership positions. In fact, the pipeline is preparing women at a greater rate than it does men.**
- **Female students have earned half or more of all baccalaureate degrees for the past three decades and of all doctoral degrees for almost a decade.**

Johnson, Heather L. 2016. *Pipelines, Pathways, and Institutional Leadership: An Update on the Status of Women in Higher Education*. Washington, DC: American Council on Education.

Figure: Female 'Quit Rates' Across Science, Engineering and Technology



Each figure represents 10% of the total

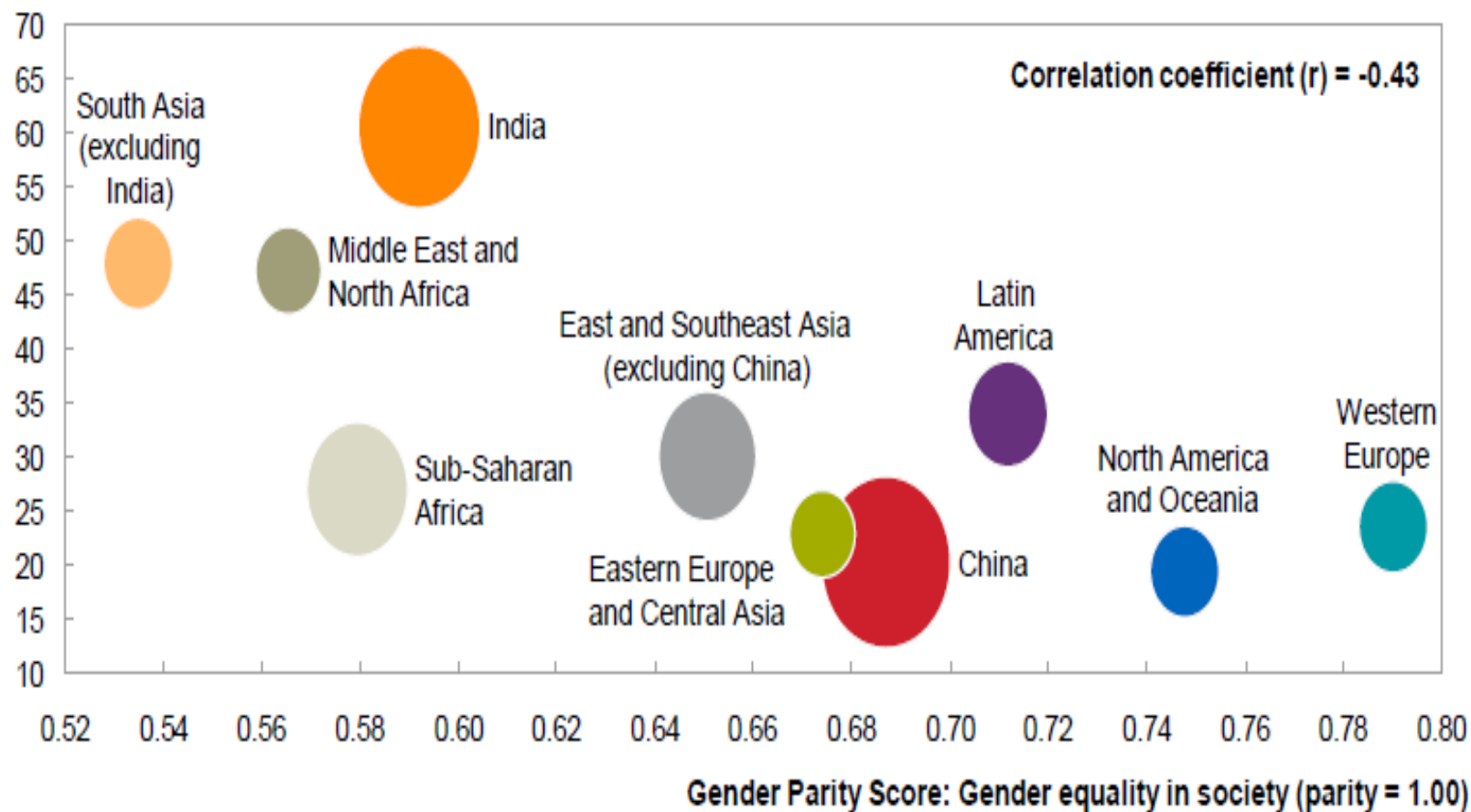
Source: Sharon Bell, *Women in the Scientific Research Workforce: Identifying and Sustaining the Diversity Advantage*

Regions with low gender equality in society can reap the highest potential economic gains from bridging the gender gap

Full-potential GDP opportunity

% incremental 2025 GDP in the full-potential scenario compared with the business-as-usual scenario

○ Size of circle represents size of country's female population in 2014

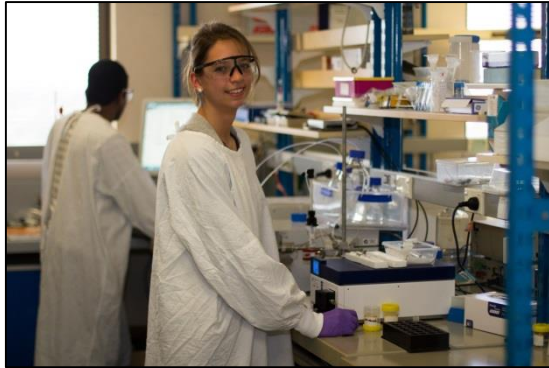


SOURCE: McKinsey Global Institute analysis

Source: McKinsey Global Institute, September 2015. *The power of parity: How Advancing women's equality can add \$12 trillion to global growth*



We cannot have confidence that existing strategies to support women 'adapt to the system' will work to deliver the innovation potential of women in STEMM



If women don't succeed in the system
....then let's change the system

Science and Mathematics as Professions – The Importance of Professional Bodies

Professional bodies:

- **mandates how standing within the profession is aligned to qualifications and experience**
- **ensure salary levels are consistent with professional standing**
- **lobbies on behalf of professionals to ensure recognition and security of employment and remuneration across a career**

When professions are insecure – employment conditions for women are impacted disproportionately....

