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STEM EDUCATION AND THE WORKPLACE

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A scientific education provides knowledge and skills that are valuable in many careers. This paper examines those skills, and employer demand for the graduates in science, technology, engineering and mathematics (STEM) that possess them. It also considers how Australian universities can best prepare STEM graduates to take up roles in the wider economy, as well as in academic research.

Overview

- Science, technology, engineering and mathematics (STEM) education is well placed to teach skills that are relevant in the information-rich modern economy, such as problem solving and evidence-based thinking.
- The creative and analytical talents of STEM graduates can be harnessed in business and other sectors, as well as academic research. Australian STEM graduates in a wide range of careers report finding their STEM knowledge and skills helpful in their work, as well as in their personal lives.
- Universities can prepare students for a range of professional roles by considering how their curricula, teaching, and other practices contribute to developing skills that are valued by employers. This can include increased collaboration between employers, professional bodies, and universities.

Background

Innovation is essential to increase productivity and to create prosperity. The Organisation for Economic Cooperation and Development (OECD) credits research and development, both public and private, as among the largest drivers of productivity growth in Australia and other advanced economies[i]. At a time when economic success will increasingly depend on the creation and application of knowledge, STEM education instils graduates with valuable skills in rigorous evidence-based thinking and problem solving.

The *Health of Australian Science* report warned that enrolments in many Australian STEM university courses are flat or declining[ii], and this remains an issue of concern. But input quantity is not the only factor; output quality is also crucial. STEM graduates from Australian universities will be best prepared to contribute to innovative growth if they are equipped with skills that enable them to be effective in a range of professions, as well as in research.

The Business Council of Australia has argued that "to meet the nation's requirements [for skilled workers], it will be the quality of the outcomes from higher education that really count."[iii] Employers also have a role to play. It is timely for all participants in STEM education to consider how best to prepare and employ students, both for traditional roles in research and science-intensive industries, and for professions that require less scientific knowledge but where STEM skills still provide value.

The value of STEM education

STEM education focuses on preparing students with the knowledge and skills to function in scientific and technical roles. These are typically in "STEM core" settings such as academic research organisations and technology-intensive firms in engineering and computing.

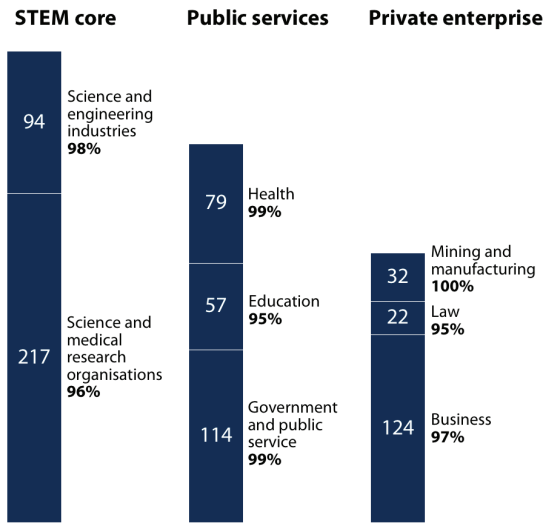
STEM knowledge can include specific, detailed content in key subject areas, as well as core scientific concepts that assist graduates in applying new information. STEM skills include problem solving, rigorous and sceptical analysis of evidence and theories, numeracy, and the development of logical arguments. The investigative nature of STEM fields also makes them ideal training grounds for developing objective and critical ways of thinking. Box 1 shows key capabilities valued by Australian graduates, in a 2012 study conducted by the Centre for the Study of Higher Education for the Australian Council of Deans of Science (ACDS) [iv].

Some skills are particularly well developed in STEM researchers. Completing a higher degree by research, or working as a researcher, provides opportunities to conduct independent and novel investigations and introduce the results to the scientific community. In the ACDS study, respondents classified as researchers were more likely to strongly agree that their background contributed to skills in solving problems, finding new information, and developing logical arguments [v].

Figure 1: Value of STEM skills

Bar heights show number of employees in each sector, within a sample of people with a STEM background.

Percentages show proportion of those employees who report using their STEM skills in their job.



Not shown are 66 respondents whose organisation was unclear or unstated, 100% of whom rated their science skills as useful.

Source: Australian Council of Deans of Science [vii]

Box 1: STEM capabilities

Key concepts in responses from STEM graduates to the question: "What do you value most from your background in science?"

- **Skills**: research, learning and enquiry; problem solving; technical skills including observation, experimentation and quantitative skills; presentation and other work practices.
- **Ways of thinking**: analytical, logical, critical thinking, systematic, structured; questioning, evaluative, independence, reasoning, sceptical; objective, evidence-based, rational; open-minded; innovative, creative, lateral.
- **Knowledge**: scientific method, science as a process; STEM subject knowledge; foundational STEM knowledge and vocabulary.

Source: Australian Council of Deans of Science [vi]

STEM in the workplace

Despite the educational focus on preparation for roles in the STEM core, STEM skills are valuable in a much wider range of careers. The ACDS study found that across sectors including government, business, law, education and health, at least 95% of employees with a STEM background find their STEM skills useful (Figure 1). Only about two in five Australian STEM graduates responding to the ACDS study worked in STEM core occupations. Similarly, in the UK, a study for the Department of Business, Innovation and Skills (BIS) confirmed that a diverse range of employers seek to attract STEM graduates, and cite numeracy, analysis, and problem solving as key skills of value [viii]. As technology transforms much of the economy, from manufacturing and retail to law and banking, STEM graduates will continue to be in demand in a range of sectors.

Employment demand also remains strong in the STEM core. In Australia, roughly half of all professional occupations with identified skills shortages are in STEM core areas such as engineering, and most of the rest are in the related area of health. There are also shortages of secondary school teachers in mathematics and science [ix]. In the UK, a survey of the Confederation of British Industry found that "raising the numbers and quality of STEM graduates" was rated as a high priority for government by 43% of all responding firms and 83% of science, engineering and IT firms [x]. BIS found that a large number of STEM core employers were "concerned about potential, and some actual, shortfalls of STEM graduates to fill their core functions" [xi]. In the US, jobs

in STEM core occupations are the fastest-growing sector after healthcare, with 2.4 million new job openings expected in the period 2008 to 2018 [xii].

Many countries are making efforts to boost STEM enrolments, to help meet the demand for STEM graduates across their economies. Figure 2 shows that STEM degree awards are expected to continue growing strongly, particularly in China and India. Governments in Australia, the United States, United Kingdom, and elsewhere, are investing in STEM education initiatives, demonstrating their recognition of the importance of STEM graduates in underpinning innovation and productivity growth. In this context, it is timely to consider not just the quantity of STEM graduates produced, but how they are prepared for the workforce.

Educating for success

Australian universities play crucial roles in attracting young people to STEM fields, training them in STEM skills, and influencing their career directions. There are several processes that universities can use to ensure that their degree programs are responsive to the broad range of occupations that STEM graduates may enter, in addition to academic research positions.

Curriculum setting is a particularly important process for universities. The former Australian Learning and Teaching Council recommended that universities map their science curricula against a set of 'threshold learning outcomes' which include many of the skills valued by employers [xiv]. As part of this process, curricula could explicitly embed training in STEM skills, rather than relying on implicit skill development during experimental work or other training. Employers can also engage with universities to ensure that degree accreditation schemes and curricula accurately reflect skill demands. In the UK, the House of Lords Select Committee on Science and Technology has emphasised the value of employers engaging with university boards and professional bodies to identify required skills [xv].

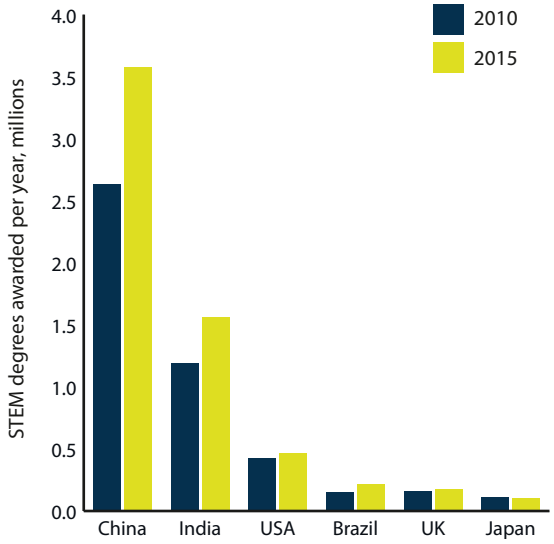
Box 2: STEM outside the workplace

Many social and personal issues are more easily navigated with the aid of scientific knowledge and skills. From understanding a medical diagnosis to interpreting media reports on climate change, scientific literacy is useful. In the ACDS study, 88% of respondents reported drawing on their science knowledge or skills in understanding contemporary issues in society; 83% in providing advice to friends and family; and 87% in their personal interests and pursuits.

Source: Australian Council of Deans of Science [xvi]

Figure 2: STEM degree projections

Awards of STEM degrees are projected to increase between 2010 and 2015 in many countries.



Source: Accenture Institute for High Performance [xiii]

Teaching methods are also central to developing student skills. In the US, the President's Council of Advisors on Science and Technology has recommended actions such as new methods of mathematics teaching and increased use of experimental discovery-based courses instead of traditional lab classes [xvii]. Australian universities should similarly continue to consider whether their teaching methods are effective and inspiring for students.

Some generic workplace skills are currently underdeveloped by STEM undergraduate or research degrees. Employers report finding research degree graduates relatively lacking in communication, teamwork, and planning, as well as knowledge of financial management, commercialisation, and intellectual property [xviii]. In the UK, BIS found that employers reported deficiencies in STEM graduates' skills in teamwork, communication, organisation, and commercial awareness [xix]. To address this issue, the Australian Government's Research Workforce Strategy argued for the need to "more explicitly embed the development of both 'soft' or generic skills and innovation capabilities in university research training programs to support students' productivity in a wide range of employment contexts" [xx]. Similarly, in the US, an advisory committee to the National Institutes of Health has recommended a shift away from degree programs "aimed almost exclusively at preparing people for academic research positions", to include diverse training in entrepreneurship, project management, and research translation [xxi]. Business-relevant STEM degree programs, such as the Professional Science Masters taught at some US institutions, provide examples of such a transition.

Students interested in pursuing STEM degrees should not be deterred by a false perception that a research career will be their only option. There are avenues at all stages of the student cycle to signal the possibilities that STEM capabilities unlock. As part of recruitment efforts for prospective students, and careers services for current students, universities can highlight the applicability of STEM skills to a wide range of professions and sectors. The UK House of Lords committee recommended that universities and employers collaborate to expose more students to the workplace through internships and other means[xxii]. In Australia, for example, the Cooperative Research Centres (CRC) program can provide an environment to foster industry-relevant skills.

Conclusions

The pace of modern economic competition dictates that no company or country can afford to stand still. Innovation, particularly through the application of science and technology, is central to maintaining productivity, economic growth, and our standard of living. In turn, preserving and improving our capacity for innovation depends upon a steady supply of STEM workers, both in STEM core occupations, and in other roles where their skills can add value.

STEM education can deliver value to the Australian economy by preparing STEM students for a range of careers. This includes ensuring the STEM skills that are in demand are effectively taught to students; equipping students with generic skills that will help them function in non-academic settings; and signalling that pathways outside academic research are valid options. Monitoring overseas initiatives on these topics can provide helpful lessons for our system.

In 1990, American science author Carl Sagan wrote that "We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology."[xxiii] The first part of the statement is undoubtedly still true. It is our collective task to ensure that the second part does not become true in Australia.

Further Reading

Harris K-L (2012), *A Background in Science: What science means for Australian society*. Centre for the Study of Higher Education, for the Australian Council of Deans of Science.

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Acknowledgements

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