

Lifting excellence in undergraduate and professional STEM education

Australia's STEM graduates must have deep discipline knowledge, critical thinking, creativity and leadership skills for a wide range of future career opportunities

The vision

Over the next decade, declining participation trends in science, technology, engineering and mathematics (STEM) education must be reversed to ensure that Australia has the technical capacity required to ensure its social, environmental and economic prosperity. STEM degrees will enrol higher proportions of talented Australian students, with progressively higher participation by women and Indigenous Australians. To achieve this, STEM degrees will need to be highly attractive to school leavers for both their content knowledge and prospective employability. Graduates will be key actors in innovation and for creating value in STEM-based businesses and other enterprises. They will be crucial members of teams contributing to solutions of challenging multi-disciplinary societal and environmental problems. To ensure quality while responding to growth in demand, STEM faculties will need to routinely benchmark their educational practices and materials against national and international standards.

The challenge

Well-educated STEM graduates are integral to the successful development of a knowledge economy in Australia. These graduates will form the core of a workforce that will tackle the economic, infrastructure, environmental, health and educational challenges ahead, as identified in the The Academy National Technology Challenges.

To increase the number of STEM graduates while maintaining their quality it is important to:

- » Ensure that STEM tertiary education, research and career training is able to meet future industry, social and economic needs
- » Adopt effective pedagogies and educational practices within STEM education at all levels
- » Support STEM school teachers to improve teaching of STEM and increase the STEM literacy of Australia's workforce

This statement focuses on measures to strengthen the take up of bachelor and professional master's degrees in STEM, while ensuring their high quality and continued relevance.

Australian universities' STEM faculties and departments have respected reputations for their teaching, and for their high quality evidence-based educational research and innovation. All STEM faculties operate outreach programs to prospective students, most have specific scholarships for women, and many are supported by industry. However, given that projections indicate that the majority of Australia's future jobs will require STEM skills, universities are not producing sufficient graduates from undergraduate and professional¹ degrees in many areas of STEM to meet national needs and aspirations. Specific items of concern include:

- » Australian enrolments into undergraduate science and engineering degrees only just kept pace with national higher education enrolment growth between 2001-2014
- » Enrolments in information technology (IT) degrees more than halved over the same period
- » Between 2006 and 2011, the number of STEM-qualified individuals in Australia grew by 15 per cent, while the number of non-STEM qualified individuals grew by 26 per cent
- » Women and Indigenous students are underrepresented in physical sciences, engineering and information technology degrees

STEM education must satisfy the increasing demand for enterprise skills in graduates, including creativity, critical thinking and leadership, to prepare them for increasingly complex contexts of application and practice. STEM degrees should offer opportunities for breadth of studies and project work in interdisciplinary teams. Diversity is also a key driver of innovation and has been consistently linked to improved organisational performance. Increasing the equitable inclusion of women and Indigenous Australians in STEM will have broad economic and social benefits.

The way forward

To progress towards this vision, STEM higher education programs will need to focus more strongly on career opportunities and introduce contextual knowledge and business skills into the STEM curriculum. STEM educators will need to use and share best-practice pedagogies, and authentic and contemporary material. The latter will be sourced from research environments, industry and business.

1. Professional degrees refer to those that qualify individuals to commence employment in specific occupations. For professional engineering, for example, this is either a 4 or 5 year BEng(Hons) or MEng degree.

Building stronger relationships with employers from all sectors of the economy will be essential.

The Academy calls for the following priority set of actions for STEM faculties, and their partners in industry, business, government and professional associations.

Area 1. Increase the employability and career focus of undergraduate and professional STEM degrees

All undergraduate and professional STEM degrees should:

- » Have clearly specified learning outcomes that enable students to build discipline-specific and generic knowledge and skills, self-confidence and self-efficacy
- » Include interdisciplinary and non-STEM course content and units that emphasise the broad contexts in which STEM skills are required (these may include ethics; entrepreneurship and commercialisation; social, environmental and economic sustainability; project and IP management; and other skills as relevant to the degree) and be presented in a learning environment that is designed to foster creativity and innovation
- » Include work-based experience (work integrated learning) that is assessed against agreed discipline and employment-related learning outcomes
- » Offer students opportunities for studies outside their principal STEM discipline through electives, double majors, and dual degrees study patterns
- » Be informed by regular input and feedback from industry and employer groups

For science, mathematics and IT, consideration should be given to:

- » formulating the curriculum (including elective sequences and double degrees) around a range of career occupations, including school teaching, with consideration to extending the duration of the standard degree to align with that of the Bachelor (Honours) degree in Engineering

Area 2. Adopt best-practice pedagogies and authentic material in undergraduate and postgraduate STEM coursework award programs

STEM faculties should ensure that:

- » All teaching staff have adequate initial training and continuing professional development in higher education teaching and learning methods for their discipline
- » Teaching staff maintain knowledge of the roles undertaken by STEM graduates in their discipline
- » Curricula exploit a suitably wide range of pedagogies (including inquiry-based and design-based projects) to stimulate analytical, creative and systems thinking, match the range of students' preferred learning styles, and adopt assessments that fully cover the intended learning outcomes

- » All students undertake at least one major individual project and a range of team-based project work in which they can experience different roles

- » All students and teachers have access to learning support software tools, and appropriate industry-standard and research-level software and simulations

Area 3. Ensure all capable students, especially under-represented groups including women and Indigenous Australians, are encouraged and given the opportunity to undertake undergraduate and professional STEM degrees in physical sciences, mathematics, engineering and IT

The Academy recommends that universities, industry and professional bodies provide continued support to in-school and community initiatives to increase the take-up of science, mathematics and technology subjects, and subsequent university study.

Increasing the participation of under-represented groups in STEM careers will require a concerted long term effort and cultural change across all levels of government, industry and academia. The national Science in Australia Gender Equity (SAGE) program is an important initiative to improve the environment and prospects of female STEM staff in universities and public funded research organisations.

The Academy recommends that government, industry and academia (including peak bodies, professional associations, Deans' councils and Learned Academies) commit to ensuring that:

- » Teachers, career advisors and parents are informed about opportunities in STEM and strategies to reduce practices that discourage women from entering STEM degrees
- » STEM faculties and employers provide training to their staff to mitigate gender bias in their organisation's recruitment, promotion and career development practices and to understand the benefits of gender equity (equal rights and opportunities for all regardless of gender) and diversity
- » STEM students, academics and employers are encouraged and empowered to increase the inclusivity and diversity of study environments and workplaces

These actions can also be applied to increase the participation of other under-represented groups, including Indigenous Australians. To increase the participation of Indigenous Australian school leavers and mature entrants in STEM specifically, The Academy recommends that:

- » STEM faculties develop their understanding of the value of STEM graduates and degree-level study towards addressing economic, infrastructure, environmental, health and education challenges for Indigenous Australians
- » Government bodies provide funding incentives that encourage universities to admit and support Indigenous Australian students in STEM courses