Position Statement   February 2019

Mathematics Requirements for Engineering Education

Clarifying the mathematics background required of students commencing professional engineering degrees will contribute to both engineering education and school education

The Vision

ACED's member institutions will continue to specify good attainment in mathematics as a requirement for direct entry from secondary school into Bachelor degrees in engineering. The required level is at least that of the national curriculum Year 12 *Mathematical Methods* subject.

ACED members' institutions will also provide pathways and support for students who are motivated to study engineering but who do not meet the minimum mathematics requirement, or who fail to demonstrate adequate mathematics on entry to their program.

ACED and its members will promote to school students, teachers, careers advisors and the broader community, the a wide range of career opportunities, including engineering, that is open to school students who take the higher levels of senior secondary mathematics.

ACED will encourage more Australian school students – and especially women – to include higher levels of mathematics in their senior secondary certificate.

Background and concerns

Good understanding of mathematical concepts and quantitative reasoning is essential to both engineering education and engineering practice. All tertiary engineering programs include mathematics subjects, and all require graduates[1] to possess mathematical knowledge and skills well beyond those taught at secondary school.

All ACED member institutions publish the level of mathematics on which their engineering degrees or associate degrees are built. For admission to a 4-year Bachelor of Engineering (Honours) degree, taken by most students, this level is at least that of the national curriculum subject *Mathematical Methods*[2]. How this is stated as a requirement for program entry differs between universities, as discussed later.

The proportion of school students taking the higher levels of mathematics in their secondary school certificate has not kept pace with the expansion of higher education provision over the past three decades. There is widespread concern that the number of school leavers with the higher levels of mathematics, particularly women, is trending down. The reduction of the 'pool' of domestic school leavers students academically prepared for higher education in quantitative degrees puts the country's future at risk.

The reasons for the declining take-up of the higher level mathematics subjects (*Mathematical Methods* and above) are complex and full discussion is beyond the scope of this paper. However, five matters have relevance here:

- a lack of female role models in the male-dominant occupations that are known to have high mathematical content, including engineering, IT and physical sciences, discourages many women from taking higher level of mathematics in senior secondary school;

- community belief that a higher ATAR (Australian Tertiary Admission Rank) may be gained by doing better at a lower level ('easier') subject. This may contribute to reducing numbers in higher level mathematics subjects, and increasing enrolments in *General Mathematics*;

- inadequate signalling by universities of the necessity to take higher level mathematics in order to gain admission to quantitative programs;

- the high level of out-of-field[3] teaching of mathematics (that is by teachers who do not have a full qualification to teach mathematics) to Years 7-10 students lessens the likelihood of students being inspired to take higher levels of mathematics in Years 11-12;

- a widespread societal perception that mathematics 'is hard' and 'for others' diminishes students' take-up of higher levels of mathematics and weakens Australia's potential in important areas of employment.

Admissions into engineering degrees

Enrolments by Australian students into Bachelor degrees in the field of education, 'Engineering and Related Technologies' ('Engineering' in this document) has declined as a proportion of Australian commencing enrolments, from 6.0% in 2013 to 5.2% in 2017. It is encouraging to report, nevertheless, that the proportion of women commencing engineering increased to 16.9% in 2017, after holding around 15% for many years.

The national need for engineers makes it desirable to increase the numbers of Australians entering and graduating from engineering degrees. ACED members will

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[1] Knowledge and skill in mathematics is one element of the graduate competencies for professional engineers, engineering technologists and engineering associates delivered by programs that have accreditation by Engineers Australia.

[2] The Australian national curriculum framework specifies four mathematics subjects at Year 12: *Essential Mathematics, General Mathematics, Mathematical Methods* and *Specialist Mathematics*. Each state and territory defines its own curriculum for these subjects. *Mathematical Methods* includes calculus, algebra and statistics at a suitable entry level for quantitative university programs. This subject is often described as 'intermediate mathematics' in analyses of student participation.

[3] G Prince & M O'Connor (2018), Crunching the numbers on out-of-field teaching. https://amsi.org.au/media/AMSI-Occasional-Paper-Out-of-Field-Maths-Teaching.pdf

aim to enrol as many domestic students as permitted (by their institution) who have a good likelihood of graduating.

Engineering enrols a high proportion of students directly from school on the basis of their ATAR. Engineering is consistently the field of education[4] with the **strongest ATAR profile**, with more than 70% of the students offered a place having an ATAR greater than 80. This is likely to be because they have taken a higher level of mathematics and have thereby met the specified program requirements.

Other commencing students will have had prior studies in the VET sector or in higher education, or have met other admissions criteria. Students in the latter categories must demonstrate equivalent mathematics attainment at the level of the programs into which they are admitted, or be directed to a suitable 'pathway' program.

Admission requirements in mathematics

All ACED members publish their entry requirements in mathematics on their admissions websites. The terminology of these requirements differs between institutions and states and territories. Five terms are used for the **minimum** requirement:

Prerequisite, Essential or Required: the subject that must be attained for entry; often at a specified minimum level.

Assumed knowledge: the subject level upon which the degree is built. This term is used most frequently by New South Wales institutions. The guidance[5] to Year 10 students states: "*If you do not have the assumed level of knowledge but have met the admission criteria you may still be selected for the course, but you may have some difficulty coping with your studies. Bridging courses may be recommended for some students who do not have the assumed level of knowledge*".

Recommended: students admitted without the specified subject will have additional support.

The number of ACED's 35 members currently using each of these designations is summarised in the following table.

mathematics subject	Prereq. Essential Required	Assumed knowl'e	Recomm-ended
Mathematical Methods (MM)	23*#	6	2
Specialist Mathematics (SM)	6#	3*	-

    * one institution uses both designations
    # four institutions state the prerequisite as '*MM* or *SM'.*
       Students commencing with *MM* only are required to take an
       additional mathematics subject equivalent to *SM* at the start
       of their degree program.

Some institutions also use '**Recommended**' or '**Desirable'** to specify a higher level of mathematics subject that "*will help you in your course but will not affect selection*"[4].

Mathematics readiness tests and pathways

Many engineering schools test students on entry, irrespective of their prior mathematics, and direct them to take additional mathematics subjects as necessary. This is

clearly consistent with the advice given to students attempting programs for which they do not have the assumed knowledge or recommended subjects. ACED members report that students on such pathways, which often have an additional summer semester subject, normally catch up during their second year of study. Such support programs ensure that the largest possible number of students will graduate to the required standards.

Commentary and Actions

ACED and its members value mathematics. All bachelors engineering degrees develop students' mathematical abilities through two or more specific subjects to facilitate analysis and logical thinking. Mathematics may be further extended within engineering topics, and exploited within software packages for problem solving and design.

Irrespective of their institutions' terminology for specifying entry-level mathematics requirements, ACED members have endorsed setting the minimum mathematics require-ment for commencing a BEng(Hons) degree at the level of the national curriculum *Mathematical Methods* subject.

ACED would not favour setting a higher mathematics requirement for BEng(Hons) programs, as this would severely reduce the number of school leavers eligible for engineering degrees, particularly women. Furthermore, Year 12 *Specialist Mathematics* is often not available in public schools outside metropolitan centres.

ACED recognises the potential value of a more uniform nomenclature for program requirements to assist prospective students. Nevertheless, the available evidence is that the 'assumed knowledge' terminology is well understood, particularly in NSW. The three large engineering schools in NSW that set their assumed knowledge at the *Specialist Mathematics* level have no problem in recruiting large numbers of students. Further work could be undertaken to ascertain whether the assumed knowledge designation is compromising the take-up of *Mathematical Methods* more generally.

Most engineering schools that enrol students without the specified prerequisite or assumed knowledge, or who do not demonstrate sufficient mathematical ability on commencement, already provide alternative pathways and support in mathematics to enable students to progress to graduate. These practices will continue, and should be provided wherever these needs are identified.

ACED and its members are keen to collaborate with others, including science and education faculties and schools, and employers, to support pre-service teacher education and teachers' professional development, to raise understanding of the opportunities that higher levels of school math-ematics, science and technology offer to school students.

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[4] Medical, Dental and Veterinary Studies are sub-fields of the 'Health' field with stronger ATAR profiles, but with much smaller enrolments than 'Engineering and Related Technologies'.
[5] University Admissions Centre (2018), *Steps to Uni for Year 10 students*. https://www.uac.edu.au/assets/documents/year-10/year-10-booklet-2021.pdf