



Research in Engineering Education Symposium (REES)
Regional Conference in Engineering Education (RCEE) &
Research in Higher Education (RHed)
September 29 – October 3, 2025
Johor, Malaysia



Rethinking Engineering Education for 2035: Progress Towards Closing Skill Deficiencies in Australian First-Year

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ABSTRACT

CONTEXT

Engineering education aims to produce graduates who are not only technically proficient but equipped with proficiency in professional and personal skills. These attributes are increasingly prioritised in graduate degree requirements such as the Engineers Australia Stage 1 Competency Standards and global calls for future-ready engineers, such as the Engineering 2035 Report. Given the timely and key recommendations from this report, identifying actionable changes for the curriculum is critical.

PURPOSE

This study examines the extent to which course learning outcomes in first-year engineering courses address the Engineers Australia stage 1 competencies. The goal is to identify patterns, discrepancies, and institutional factors that contribute to a possible imbalance between technical and professional skills and to provide actionable recommendations for aligning curriculum with future workforce needs. By highlighting these gaps, this research seeks to support the development of engineers equipped to meet the demands of industry.

METHODOLOGY

All first-year engineering programs from Australian universities were analysed for suitability for the study and the CLOs were categorised and mapped to the competencies. Quantitative analysis assessed the relative coverage of these skill types, while qualitative analysis explored institutional and contextual factors influencing CLO mapping. The analysis included 26 institutions, and more than 1400 individual CLOs. Comparisons were made between common first-year programs and major-specific programs, as well as between institutions categorised by type (Go8 vs. non-Go8) and delivery mode (online vs. on-campus).

OUTCOMES

There was very little difference between any of the institutions regarding the major, Go8 status, or delivery mode. Examining the three elements of the stage 1 competencies showed that there was a balance between all three. Exploring this further, it was revealed that there were two competencies (creativity & research skills) that were not mapped at least once across all programs on median, and there were several institutions that did not reach the Australian median. Furthermore, foundational scientific knowledge competencies are still being prioritised at a ratio of 2:1 to personal and professional skills. These gaps highlight a critical misalignment with the Engineering 2035 Report's emphasis on personal and professional attributes as essential to future engineering practice.

RECOMMENDATIONS

The findings emphasise the need for a more balanced approach to CLO design in first-year engineering education. To align with the 2035 Report, institutions must integrate personal skill development into CLOs, particularly in discipline-specific courses. Recommendations include revising CLOs and courses to include more authentic assessments to develop and begin the capacity building. Future research should explore the long-term impacts of this imbalance on graduate outcomes and the effectiveness of interventions to bridge the gap.

KEYWORDS

Professional Skills, Personal Skills, Learning Outcomes, Engineering 2035.

Introduction

The engineering profession is at a critical point as it prepares to meet the demands of 2035 requirement of engineers and beyond. The Engineering Futures 2035 report, commissioned by the Australian Council of Engineering Deans (ACED), highlights the urgent need to transform engineering education to produce graduates with a well-rounded skillset (Crosthwaite, 2021; Crosthwaite et al., 2018). This includes technical proficiency, professional attributes such as teamwork, communication, and ethical decision-making, as well as personal qualities like resilience, adaptability, and self-management (Beagon et al., 2019; Cajander et al., 2011; Litchfield et al., 2016; Munir, 2022; Quince et al., 2024; Shuman et al., 2005). These competencies are deemed essential for tackling challenges such as sustainable development, climate adaptation, and the integration of emerging technologies (Vanarla et al., 2024; Quince and Nikolic, 2025). To prepare for the future, the report stresses the necessity for engineers who can work in interdisciplinary settings, effectively collaborate across cultures, and manage complex systems (Engineers Australia, 2019; Picard et al., 2022; Simmons et al., 2021). The engineering challenges of the 21st century, including decarbonisation, digital transformation, and resource management, require not only technical skills but also strong ethical reasoning and the ability to solve problems adaptively. This demands a fundamental change in the design of engineering curriculum, especially in the foundational years.

First-year engineering education has a unique opportunity to fill these gaps and create a foundation for comprehensive skill development (Beagon et al., 2019; Litchfield et al., 2016; Nair et al., 2009; Rizzo et al., 2013). This stage introduces students to the field and establishes the groundwork for their academic and professional paths. Focusing on capacity building during this period promotes a solid understanding of engineering principles while supporting personal and professional attributes (Hills et al., 2023). Additionally, evaluations of one's self in the first year can yield insights into student learning and readiness, allowing for targeted interventions that support skill development, and foster professional identity development. Research has shown that when students engage in reflective practices, active learning, and scenario-based problem-solving early in their education, they are more equipped to adjust to the demands of their future careers (Fang, 2012; Nikolic et al., 2025; Picard et al., 2022; Popli & Singh, 2024). Missing key skills at this stage can create gaps in knowledge and competencies that are difficult to address in later years of education. Therefore, ensuring that learning outcomes (LOs) in the first year are comprehensive and balanced is imperative for producing well-rounded engineers who are ready to meet the challenges of the future. Learning outcomes are critical in higher education as they define the knowledge, skills, and attributes that students are expected to achieve by the end of a course or program. They provide a clear framework for both teaching and assessment, ensuring that educational goals are aligned with student needs and industry expectations. In the context of constructive alignment, LOs are central to the process (Allan, 1996; Hills et al., 2023; Maher, 2004; Meda & Swart, 2018).

Constructive alignment, is a concept introduced by Biggs (1996), ensures that the curriculum, teaching methods, and assessment tasks are all aligned with the intended learning outcomes. This creates a cohesive educational experience where every component supports student learning in a structured and meaningful way. Furthermore, LOs play a vital role in the accreditation process of engineering programs. Accreditation bodies, such as Engineers Australia, assess whether programs meet specific standards and criteria essential for preparing competent professionals. Thematic mapping of LOs against accreditation standards helps institutions identify areas of strength and areas needing improvement (Quince et al., 2023). This process ensures that programs are continuously updated to reflect current industry standards and emerging trends, ultimately enhancing the quality of engineering education. These gaps identified in the literature, led to the formation of the following research questions.

Research Questions

1. To what extent do current engineering programs emphasise technical competencies in first-year education?

2. What gaps exist between Engineering 2035 recommendations and current first-year engineering curricula?

Methods

Stage 1 Competencies

The EA stage 1 competencies (Engineers Australia, 2019) are divided into three (3) subsets: '*Knowledge and skill base*'; '*engineering application ability*'; and '*professional and personal attributes*'. To further compartmentalise, '*knowledge and skill base*' have six (6) areas of competency which then cover:

- (1.1). Comprehensive, theory-based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.
- (1.2). Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline
- (1.3). In-depth understanding of specialist bodies of knowledge within the engineering discipline.
- (1.4). Discernment of knowledge development and research directions within the engineering discipline
- (1.5). Knowledge of engineering design practice and contextual factors impacting the engineering discipline
- (1.6). Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline

'*Engineering application ability*' which can be further broken into the four (4) sub categories.

- (2.1). Application of established engineering methods to complex engineering problem solving.
- (2.2). Fluent application of engineering techniques, tools and resources.
- (2.3). Application of systematic engineering synthesis and design processes.
- (2.4). Application of systematic approaches to the conduct and management of engineering projects.

Finally, '*professional and personal attributes*' which cover the following.

- (3.1). Ethical conduct and professional accountability.
- (3.2). Effective oral and written communication in professional and lay domains.
- (3.3). Creative, innovative and pro-active demeanour.
- (3.4). Professional use and management of information.
- (3.5). Orderly management of self, and professional conduct.
- (3.6). Effective team membership and team leadership.

The Stage 1 competencies established by Engineers Australia (EA) were designed to align with the graduate attributes outlined by the Washington Accord (International Engineering Alliance, 2021).

Selected Universities

This research aimed to map the course learning outcomes (CLOs) of first-year engineering programs at Australian universities against the Engineers Australia (EA) Stage 1 competencies. In January 2024, a thorough examination of all Australian universities offering a four-year engineering degree was conducted by a web search, and CLOs were manually extracted from the enrolment plans. Programs lacking publicly available course information during this search were excluded from the study. CLOs represent the learning outcomes that students are expected to demonstrate understanding of by the completion of their assessment tasks. These outcomes are typically aligned with the assessment tasks and are made accessible to students as part of the course. Several institutions did not provide the CLOs on public-facing websites and were excluded from the study, marking a limitation of the research.

The remaining institutions underwent an investigation of several parameters before final inclusion in the study. The universities were categorised based on their status as Group of Eight (Go8) institutions, which denotes a select group of high-research-performing universities. Each university was also assessed for its delivery mode (online or in-person) and the majors offered. The study focused on the four most prevalent engineering majors in Australia: civil, mechanical, mechatronics, and electrical engineering. Furthermore, programs were analysed for their common versus non-common structures, reflecting the courses that students are required to take in their first year based on their selected major.

Ultimately, the study identified 26 universities that met all outlined criteria for review. These are: Central Queensland University, Southern Cross University, Charles Darwin University, James Cook University, University of Queensland, University of Sunshine Coast, Australian National University, University of Wollongong, Western Sydney University, Victoria University, Swinburne University, Federation University, Edith Cowan University, Flinders University, Charles Sturt University, La Trobe University, University of Tasmania, Griffith University, Queensland University of Technology, Macquarie University, University of Sydney, University of Technology Sydney, Royal Melbourne Institute of Technology, Deakin University, University of Western Australia, and University of Adelaide. Table 1 details the universities identified through this comprehensive search, alongside key program information.

Table 1: Comparison of first-year course offerings from selected universities

University	Majors offered	Common First Year	Online or in-person
Australian National University	MTR	Y	In-Person
Charles Darwin University	CE, EE, ME	Y	Online
Central Queensland University	CE, EE, ME, MTR	Y	Online
Charles Sturt University	CE	Y	In-Person
Deakin University	CE, EE, ME, MTR	N	In-Person
Edith Cowan University	CE	Y	In-Person
Federation University	CE, EE, ME	Y	In-Person
Flinders University	CE, EE, ME, MTR	Y	In-Person
Griffith University	CE, EE, ME, MTR	N	In-Person
James Cook University	CE, EE, ME	Y	In-Person
La Trobe University	CE	Y	In-Person
Macquarie University	CE, EE, ME, MTR	N	In-Person
Queensland University of Technology	CE, EE, ME, MTR	N	In-Person
Royal Melbourne Institute of Technology	CE, EE, ME, MTR	N	In-Person
Southern Cross University	CE, ME	Y	Online
Swinburne University	CE, EE, ME, MTR	Y	In-Person
University of Adelaide	CE, EE, ME	N	In-Person
University of Wollongong	CE, EE, ME, MTR	Y	In-Person
University of Queensland	CE, EE, ME, MTR	Y	In-Person
University of Sunshine Coast	CE, EE, ME, MTR	Y	In-Person
University of Sydney	CE, EE, ME, MTR	N	In-Person
University of Tasmania	CE, EE, ME	Y	In-Person

University of Technology Sydney	CE, EE, ME, MTR	N	In-Person
University of Western Australia	CE, EE, ME	N	In-Person
Victoria University	CE, EE, ME	Y	In-Person
Western Sydney University	CE, EE, ME, MTR	Y	In-Person

CE is civil engineering, EE is electrical engineering, ME is mechanical engineering & MTR is mechatronics engineering

There were no programs available that offered a non-common first year in an online format. More than 50% of the institutions provided all four examined majors, with only three focusing exclusively on civil engineering and one on mechatronic engineering. Of these, mechatronic engineering was the least commonly offered, while civil engineering was available at nearly all institutions, with just one exception. Additionally, over 50% of the institutions provided a common first year for their students. All program structures examined in this study assume that students meet the required level of mathematics proficiency and will not need to take bridging mathematics, which is a common assumption across engineering programs. The universities involved were randomised and assigned descriptors to ensure an unbiased reporting process.

Learning Outcome Mapping

To map the CLOs to skills that should be attained throughout the program each of the CLOs were manually compared against the EA stage 1 competencies. Whilst this manual mapping does present limitations to the mapping process, previous literature indicates that it is a suitable method to thematically align curriculum with professional attributes (Australia, 2019). There was a total of 250 courses that contained 1411 CLOs. To validate the mapping process, 5% of all CLOs were moderated by a second reviewer that demonstrated consistent alignment.

Each competency is accompanied by at least one indicator of attainment, usually more. These indicators facilitate self-assessment and peer review of the competencies. Due to the overlapping nature of some indicators, a single CLO that aligns with a specific competency will be recorded only once to maintain a concise representation. For example, if a units CLO mapped to multiple indicators of attainment within a single competency element, mapping would occur only once per CLO.

Among the 16 competencies, competencies 1.1, 1.2, and 1.3 contain key mathematical and science knowledge. While all competencies are relevant to technical issues and areas of study, these three are primarily focused on technical theories based in physics, mathematics, and the sciences. To explore the relationships among different institutions, modes of program delivery, and the mapped Stage 1 competencies, a series of critical comparisons were conducted. This analysis included comparisons between Go8 institutions and their non-Go8 counterparts, as well as distinctions between generic first-year programs and those that are major-specific or delivered online. The aim was to identify trends in the mapping of competencies 1.1, 1.2, and 1.3 relative to other competencies within the program. A comprehensive set of mapped programs accompanied by graphical data visualisations was produced to illustrate these insights.

Results and Discussion

Comparative Analysis

Analysis of the 16 competencies between institutions classified as Go8 and those that are not revealed minimal differences across the various competencies, shown in Figure 1. Go8 universities exhibited a small increase in competency 1.1, alongside a decrease in competency 1.6 when compared to their non-Go8 counterparts. This finding indicates that even within research-intensive institutions, there is no larger reported representation of technical content. For element 2, similar trends were observed, demonstrating an overall consistency. Additionally, there was an increase in the mapping of competency 3.4 for the Go8 institutions.

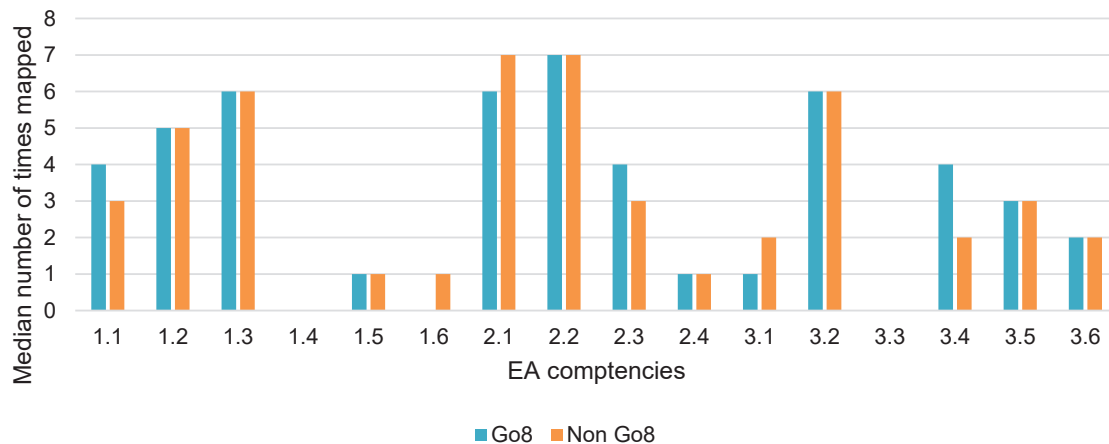


Figure 1: Competency mapping between Go8 status institutions and non Go8 status

A comparison of the 16 competencies for institutions offering online programs versus those with on-campus delivery revealed minimal differences across the competencies, as seen in Figure 2. Notably, competencies 2.1 and 2.2 were mapped an median of eight times across each program. Although the distinction between online and in-person delivery modes was minimal, all but one competency was mapped. Furthermore, there were no clear differences between the online delivery and the Go8 programs.

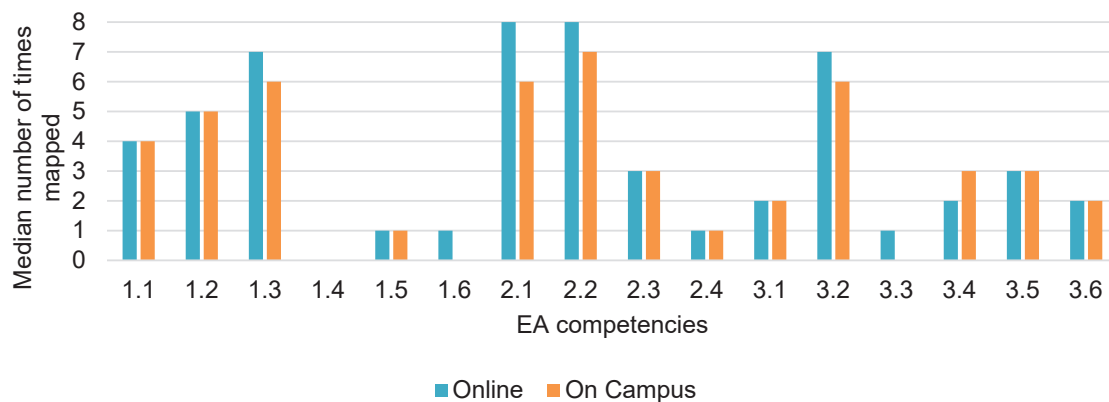


Figure 2: Competency mapping between online and on-campus delivery mode

In accordance with previous comparisons, there was minimal variation in competencies across each major, reflected in Figure 3. Specifically, for 9 out of the 16 competencies, there were no differences observed among the four majors. For the remaining 7 competencies, any differences noted were no greater than 1 between the majors. When comparing the majors to the common first-year programs, a slight decline was observed across several competencies; however, this change was consistent with the variations identified in earlier analyses.

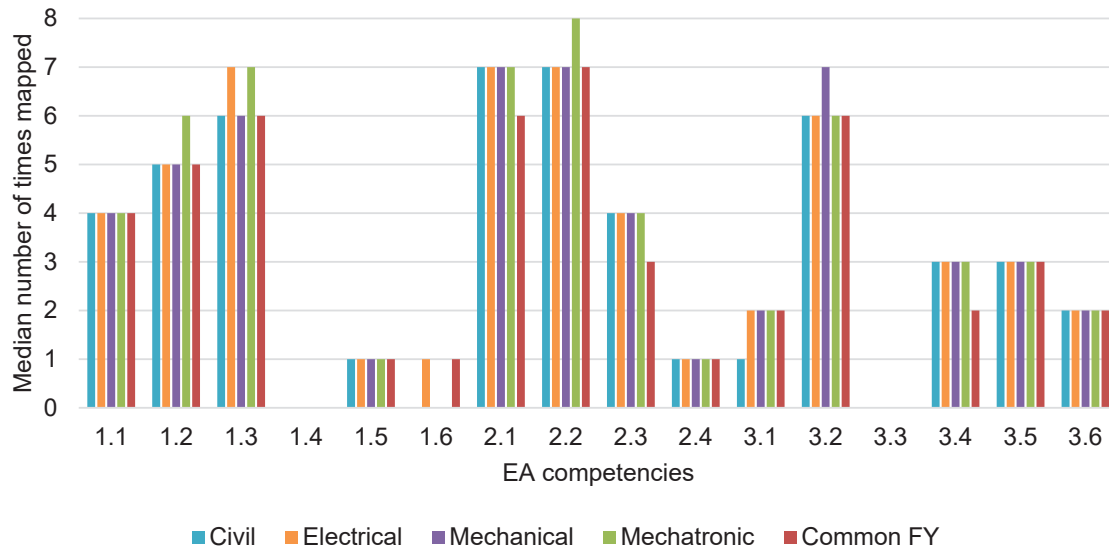


Figure 3: Competency mapping between major specific and common programs

Overall, the programs demonstrated minimal variance across different majors, Go8 status, and delivery modes. This suggests that, on median, all programs report comparable learning outcomes for first-year students, irrespective of the institution's type or the delivery method employed. Additionally, no significant variance was observed among the 16 competencies across majors. This is an important finding as it suggests a student's choice of major, or participation in a common first year, does not impede their ability to develop essential engineering skills. Furthermore, given the limited variation noted in the comparisons across various program offerings, the medians presented in this analysis can serve as a benchmark for current first-year curricula. Figure 4 illustrates the median mapping across all 26 universities.

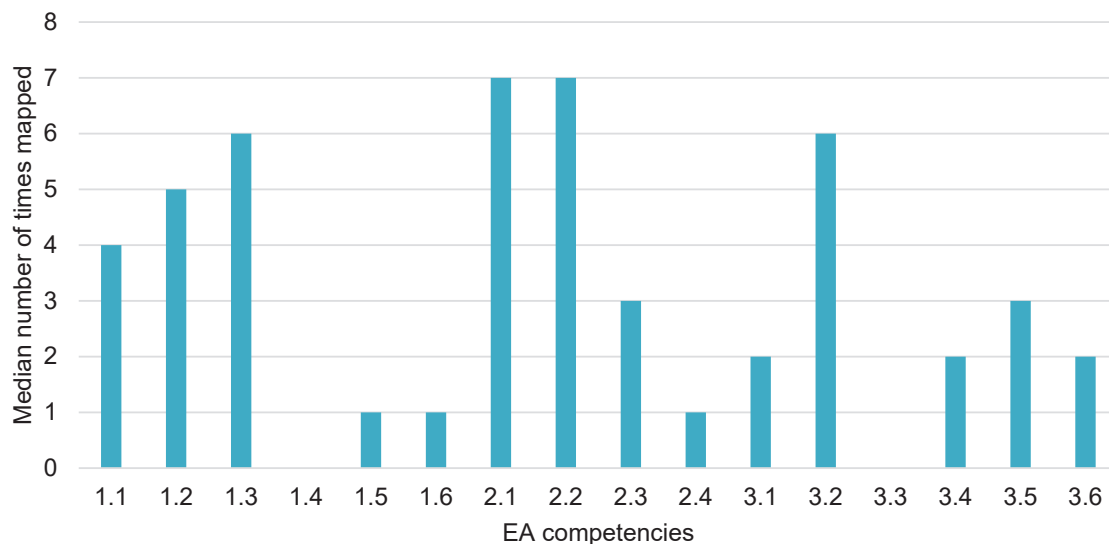


Figure 4: Competency mapping for all institutions as a population median

The analysis of the mapping of competencies reveals significant disparities that warrant attention. Out of the 16 competencies assessed, six were found to have mapping scores greater than the expected 6.25% distribution. These competencies include 1.1, 1.2, 1.3, 2.1,

2.2, and 3.2. While it is positive to see competencies 2.1, 2.2, and 3.2 showing an upward trend, likely due to project-based and application-oriented learning.

The findings also reveal that five competencies 1.4, 1.5, 1.6, 2.4, and 3.3 were mapped less than 2% on median. This stark contrast highlights a curriculum skewed towards technical competencies, with other essential competencies receiving inadequate attention. The observed deficiencies point to insufficient integration of critical areas such as discernment in knowledge development, understanding sustainable engineering practices, and fostering creativity and research skills. Notably, competencies 1.4 and 3.3 recorded mapping scores of less than 1 on median across programs. Embedding research and practice-based learning into first-year programs could effectively address these gaps and support students in developing a more comprehensive skill set essential for their future careers in engineering (McHenry and Krishnan, 2022; Vailasser et al., 2021).

Conclusions and Future Work

This study identifies significant gaps in the alignment of first-year engineering education in Australia with the vision presented in the Engineering 2035 Report for developing well-rounded engineering graduates. While the current curriculum effectively covers technical and some personal and professional skills, there are several that are underrepresented. Despite consistent trends among institutions in mapping technical and professional competencies, there remains an emphasis on technical skills. Competencies such as sustainable engineering practices, creativity, and knowledge discernment are often underrepresented in course learning outcomes. This imbalance not only misaligns with the Engineering 2035 vision but also jeopardises the readiness of graduates for the interdisciplinary, global, and rapidly evolving demands of the engineering profession.

Key limitations of this research include accessing CLOs, which were only available on publicly facing websites. Since this research focuses on the first year, it also excludes the development of the EA competencies in later years. Finally, the assumption is made that CLOs listed are accurate reflections of the courses being taught. Future research should assess the long-term impact of these curricular imbalances on graduate outcomes and investigate the effectiveness of interventions aimed at bridging these gaps. By addressing these disparities, Australian engineering education can produce engineers who are both technically proficient and resilient, ready to meet the challenges of 2035 and beyond.

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