University of Southern Queensland

1 June 2022

Past Excellence, New Success in Engineering Education | PENS-E2

Briefing Report

CRICOS: QLD 00244B, NSW 02225M | TEQSA: PRV12081

PENS-E2 Project is an exciting initiative that will reform how engineering is taught at UniSQ.

As identified by the Australian Council of Engineering Deans (ACED) in their 2035 report, the use of artificial intelligence, big data, the internet of things, advances in a range of technologies, increasing globalisation, changes in work, changing societal expectations, and evolving human needs are impacting on the nature of engineering. Professional engineering graduates entering the workforce will therefore require a different set of skills compared to those who graduated in the past.

Although Australia's engineering education system has served the country well in the past, it must change if it is to meet future expectations and needs.

UniSQ's PENS-E2 project aims to make the changes required to the way engineering is taught to ensure UniSQ engineering graduates have the anticipated knowledge, skills and attributes that will be expected of professional engineering graduates entering the future workforce.

This report gives and an overview of:

1. the background and drivers for wanting to make this change, including our existing engineering cohort, external accreditation drivers, and stakeholder opinions,
2. the proposed program design, including the project-based leaning approach,
3. the expected outcomes, including expected benefits for students and staff.

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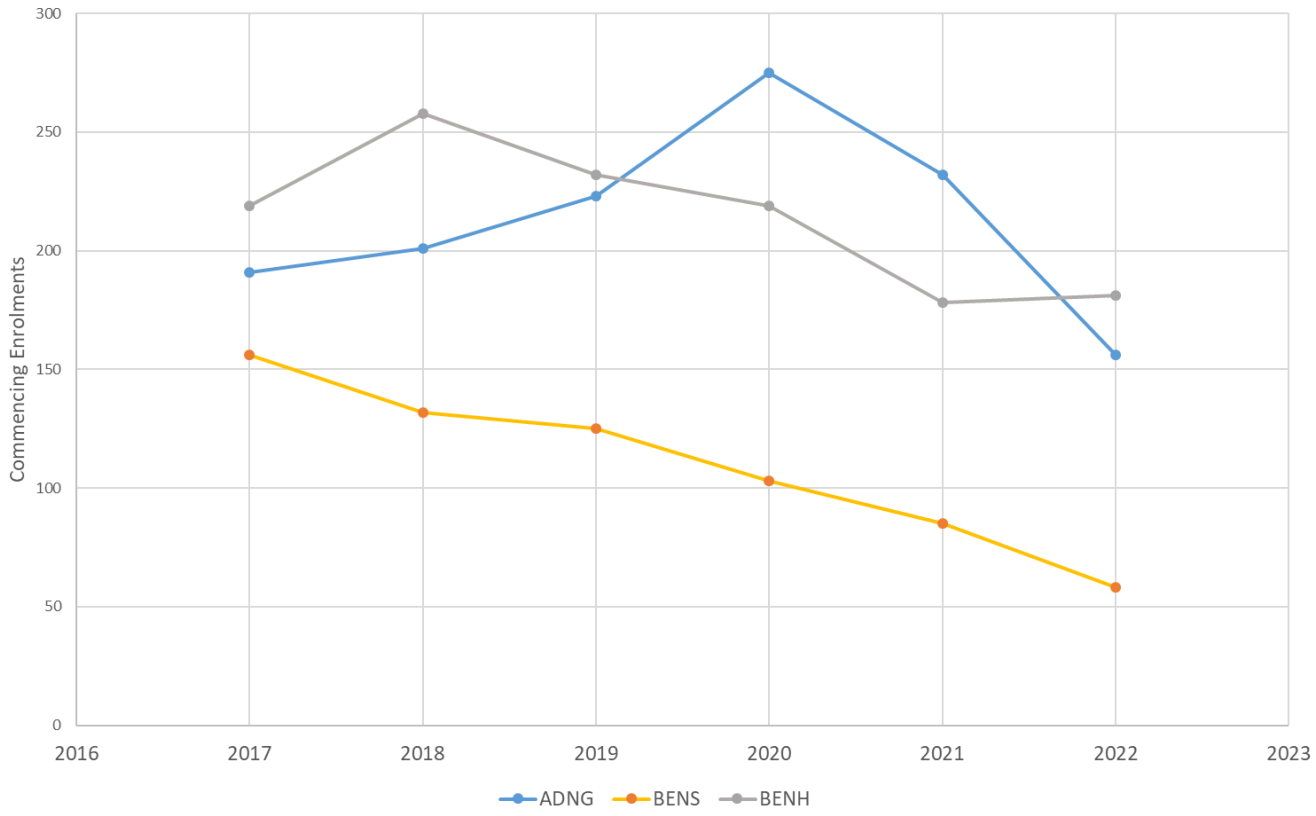
Background and Drivers for Change

Numbers in Engineering have been declining at UniSQ over the last few years (see Figure 1), and many other Australian universities are moving online, reducing our longstanding competitive advantage. With our Springfield campus, we have a presence in one of the fastest grown areas in Australia. To remain viable and relevant, we need a value proposition that makes our Engineering programs distinctive, requiring an ambitious systematic reform.

Figure 1: UniSQ Undergraduate Engineering Programs, Commencing Enrolments (2016-2023)



There is a strategic imperative to increase on-campus student numbers, especially in Springfield. This requires engaging on-campus experiences. Academics have reported difficulties in resolving the ambiguity of prioritising engaging on-campus experiences and focusing on online students. We require an equitable delivery model with enough inbuilt flexibility to support student needs independent of their background and situation to address these challenges. At the same time, the strong industry focus and practical nature of the program will enable a unique on-campus experience. Ongoing project work facilitated sessions, makerspace areas, and a strong staff presence will make our on-campus experience at both Springfield and Toowoomba an interesting, exciting, and inviting place to be.

While numbers in the UniSQ engineering programs are currently in decline, the programs still retain considerable goodwill and reputation externally. This proposal represents a unique opportunity to reinvent ourselves and position ourselves ahead of the curve with a curriculum that addresses the emerging issues of 21st century and draws upon emerging global best practice while still retaining the core character and strengths of our existing offerings.

Existing Cohort

Students in Built Environment and Engineering have a broad background and come to UniSQ with various skills and abilities. Depending on where students fit, their needs are very different. While we have been

aware of the differences, we have not addressed the needs of all groups. Overall, our programs focus on students already working in the industry and completing most subjects externally with a load of one or two subjects per semester. In addressing the different needs, we have tried to offer equal experiences. This has led to this current situation where all groups feel like second class students. External students feel like we are offering more to on-campus students through tutorials. On-campus students feel like our teaching approach with recorded videos is geared towards external students. This has also been highlighted by an external review of our Bachelor of Engineering Honours (BENH) program.

There is a very strong mindset that the majority of 'our students' are studying while concurrently employed in an engineering-related role. While there are substantial numbers of students who meet this description, they are a plurality rather than a majority. The development of the engineering identity is largely outsourced to the workplace of these students; the unfortunate corollary of this is, for students not currently employed in industry, this identity development is instead just abrogated. The proposed program design needs to address these current shortcomings in the program.

An analysis was undertaken of the factors contributing to attrition in our current cohort of students. For the BENH cohort commencing from 2015 to 2019, the findings included:

- Attrition is approximately 20%, concentrated in the first year. Cohorts that have been studying longer don't have much higher attrition rates, suggesting that it is the first year when people leave.
- Attendance Mode and Enrolment Load are strongly predictive of attrition with part time more likely to attrite than full time and attrition greater in on-campus students than externals.
- ATAR is strongly predictive of attrition.
- There is no evident relationship between attrition and the demographic factors of school leaver/non-school leaver, first in family, socioeconomic status (SES); however, the demographics factors of first in family, low SES, and gender (male) are all predictors of whether students will be more likely to leave without re-entering elsewhere in another program.

Transition to study and first year experience for different cohorts needs to be central to the design of the program to reduce attrition of commencing students.

Program Code: ADNG

Associate Degree of Engineering (2 years)

2015-2020

Sample size: 1,314

1.1%
International

30.8%
School Leaver

68.0%
Non-School Leaver

39.7%
1st in Family

59.1%
Not 1st in Family

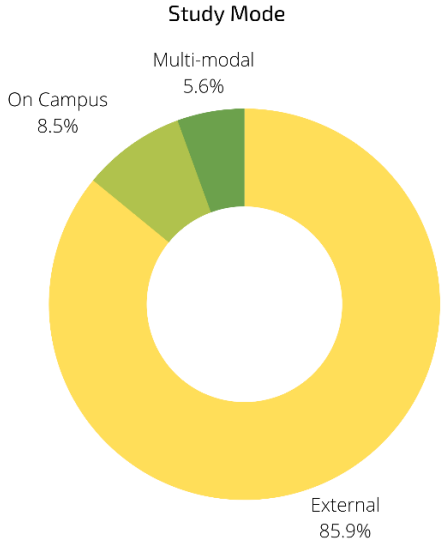
51.9%
Urban

46.7%
Regional / Remote

11.7% Female

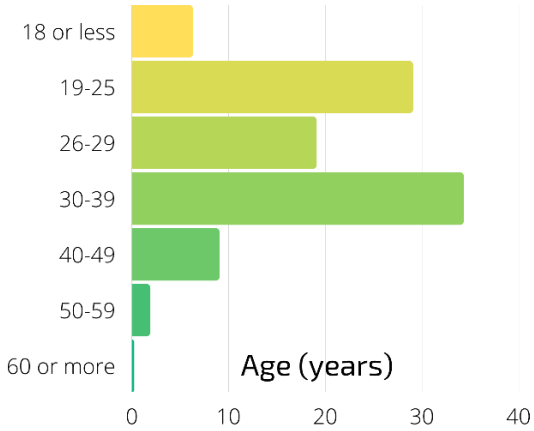
88.3% Male

1.75% of students are First Nations People



92.1%
Part-time

8.0%
Full-time



53.7% of all students are male, non-school leavers and studying externally, part-time.

Note: Contains rounding error and null results have been removed

UniSQ

Program Code: BENS

Bachelor of Engineering Science (3 years)

2015-2020

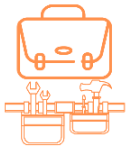
Sample size: 748

12.70%

International

20.05%

School Leaver



67.25%

Non-School Leaver

36.6%

1st in Family

50.7%

Not 1st in Family

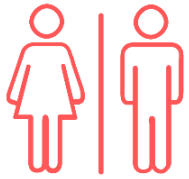
49.2%

Urban

36.9%

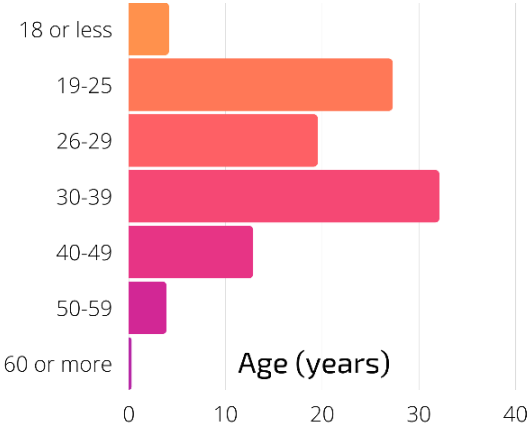
Regional / Remote

11.4% Female

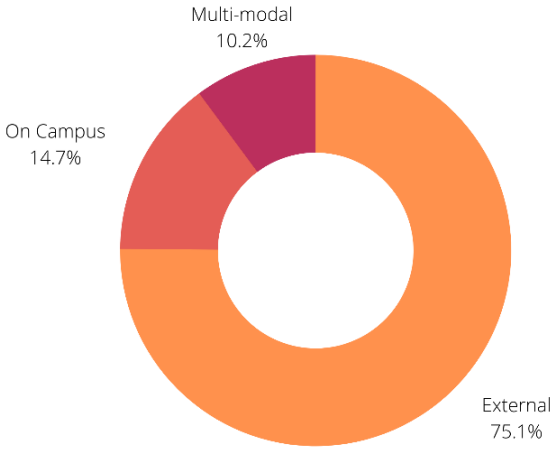


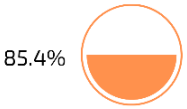
88.6% Male

1.9% of students are First Nations People



Study Mode





85.4%

Part-time

14.6%

Full-time

54.95% of all students are male, non-school leavers and studying externally, part-time.

Note: Contains rounding error and null results have been removed

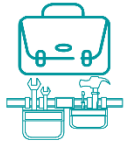
UniSQ

Program Code: BENH

Bachelor of Engineering (Honours)
(4 years)
2015-2020
Sample size: 1,574

9.85%
International

32.6%
School Leaver



57.6%
Non-School Leaver

35.7%
1st in Family

54.45%
Not 1st in Family

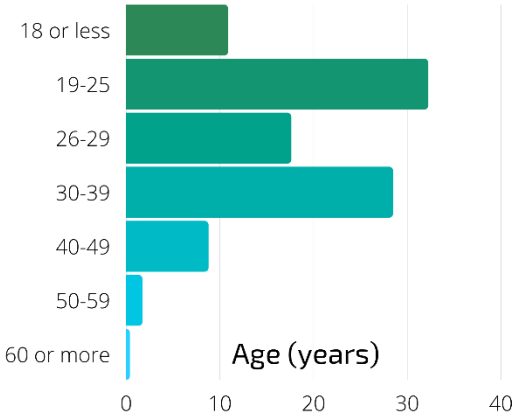
45.1%
Urban

43.9%
Regional / Remote

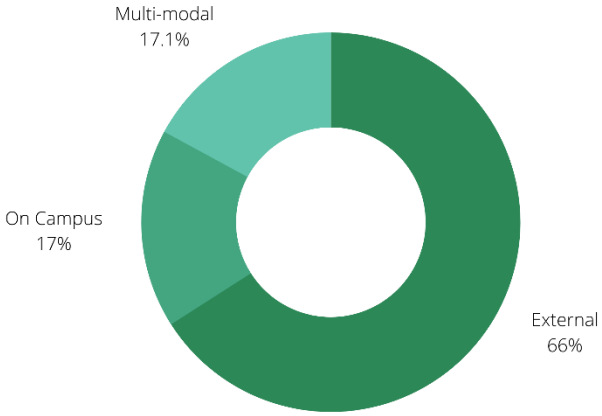
Note: Contains rounding error and null results have been removed

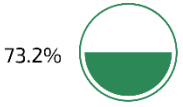
11.8% Female
88.2% Male

1.5% of students are First Nations People



Study Mode





73.2%
Part-time

26.8%
Full-time

41.3% of all students are male, non-school leavers and studying externally, part-time.

UniSQ

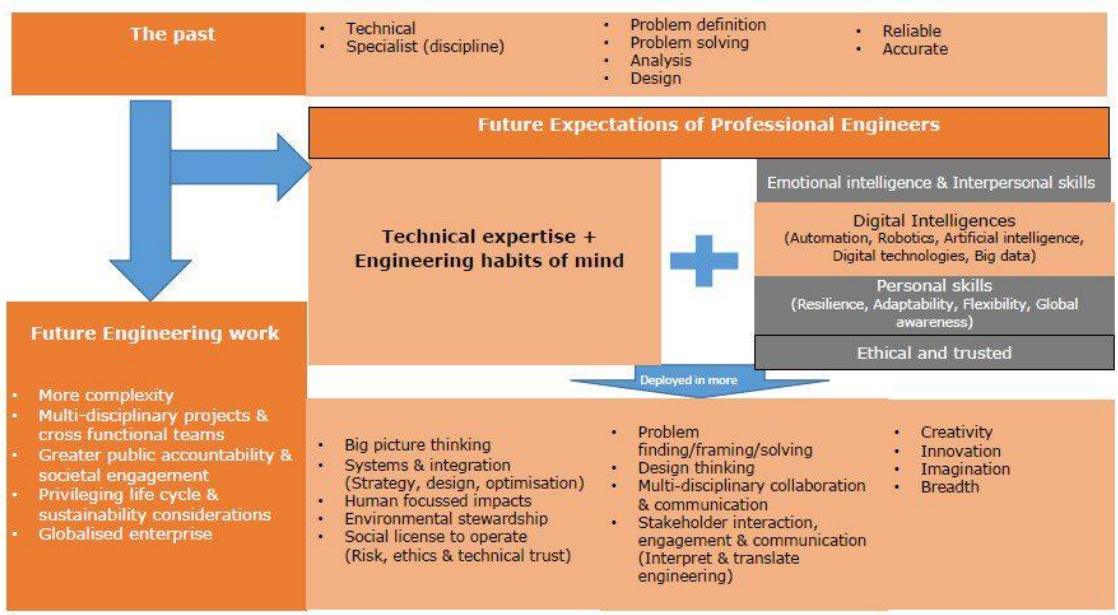
External Accreditation Drivers

The current UniSQ graduate capabilities and elements for the undergraduate engineering programs (UniSQ Submission to Engineers Australia, 2019) are aligned with Engineers Australia's Stage 1 Competency Standard for Professional Engineers, Technologists and Associates, last updated and approved in 2013. It is expected that Engineers Australia's Stage 1 competencies will be updated shortly, particularly with the release of the International Engineering Alliance (IEA) Graduate Attributes and Professional Competencies (Sept 2021). Mapping against the IEA Graduate Attributes has identified gaps in our current programs in the areas of:

- impacts of design, net carbon zero outcomes;
- sustainable outcomes as represented by the 17 UN Sustainable Development Goals (UN-SDG);
- meeting cultural requirements in all engineering activities;
- understanding economic decision-making and application to one's own work.

Another key driver is the scoping study commissioned by the Australian Council of Engineering Deans (ACED) exploring *"the knowledge, skills and attributes of professional engineers required to meet anticipated changes in the nature of engineering work in Australia in the year 2035."* The scoping study identified that a step change in engineering education is required to deliver graduates needed and valued by the industry. The study emphasises a move from "I" shaped graduates with a strong technical focus to "T" shaped graduates with the technical competencies complimented with skills and expertise (amongst others) in:

- Systems approaches
- Privileging lifecycle and societal considerations
- social license to operate will increase
- problem finding
- collaboration
- creativity
- literacy in the use of digital tools



Source: Engineering Futures 2035: A Scoping Study (Australian Council of Engineering Deans, April 2019)

Final year student, graduates, and industry employer surveys

Analyses have been conducted on a number of historical surveys undertaken by the university's engineering schools to examine the university's engineering degrees and resulting graduates. In 2019, 63% of final year students were generally satisfied with their level of engagement; however, would like to interact more with their peers during the studies. In relation to graduate skills, there was significant overlap between employer and graduate responses about the skills to be improved. Overall, the employers surveyed rated UniSQ engineering graduates positively in skills and preparedness for work and nearly 95% would be likely or very likely to consider hiring another UniSQ engineering graduate in the future. The list of skills to be improved that overlap with graduate responses include:

- Business capabilities (management, financial, cost/benefit, WH&S, risk analysis abilities)
- Leadership capabilities (organisational, develop teams, manage projects)
- Ability to develop innovative ideas
- Verbal communication skills
- Ability to identify new opportunities

UniSQ engineering graduates rated their skill development positively and 82% rated their preparedness for work as 'well prepared' or 'very well prepared'. In addition to the above listed skills for further development, graduates also indicated that working well in a team, getting on with others in the workplace, and ability to use technology effectively were skills to be improved. Graduates were also asked 'What are the main ways that your UniSQ degree could have better prepared you for your employment in your organisation?'. The top three responses included real world application, industry exposure, and improved teaching.

Overall, from the analysis conducted of final year students, graduates, and employers, four key themes emerged.

On-Demand Engagement: Engagement is to be provided on-demand, meaning students can tailor their experience to suit their situation. Different approaches with different levels of interaction will be required for online, on-campus, and hybrid approach students. Flexible learning options must continue to be prioritised and supported by state-of-the-art online collaboration tools, making it easy to engage with teaching staff and other students as needed. To continue to improve and maintain high quality teaching, UniSQ staff must build their digital engagement and delivery skills.

For Real: The Engineering programs need to build greater connections and partnerships with industry to ensure students build industry-relevant skills, are exposed to real world applications, and are shown how engineers can make a difference and contribute to society. These should include (but are not limited to): big world issues, such as climate change and poverty; technological advancements, such as in machine learning, big data and advanced manufacturing; and, major and local projects, such as Inland Rail and the Wellcamp Airport precinct. These partnerships should flourish into: industry-led/involved coursework; work experience opportunities for students; educational site visits; and real world problem solving.

Setting Them Up: The programs must support students with the transition into university life and create an engaging first year experience that will retain students for the length of their study. UniSQ must continue to give students strong technical skills, foundational knowledge, practical skills through the residential school and an Engineers Australia accredited degree. The university should supplement this with broader skills in collaboration, leadership, and communication, while also supporting students as required with employment assistance and work experience.

Eyes on the Future: An engineering degree from UniSQ should be future-focused and offer skills in business, a multidisciplinary approach, digital literacy, and innovative thinking. UniSQ should give students greater choice in options, and help students to evolve and adapt as times change. Students should also be able to transition easily out of university and into employment and continue to thrive into the future.

Project Goals

The PENS-E2 project (Past Excellence, New Success in Engineering Education) was developed to improve and progress the refresh of the undergraduate engineering programs. The working goals of the project are:

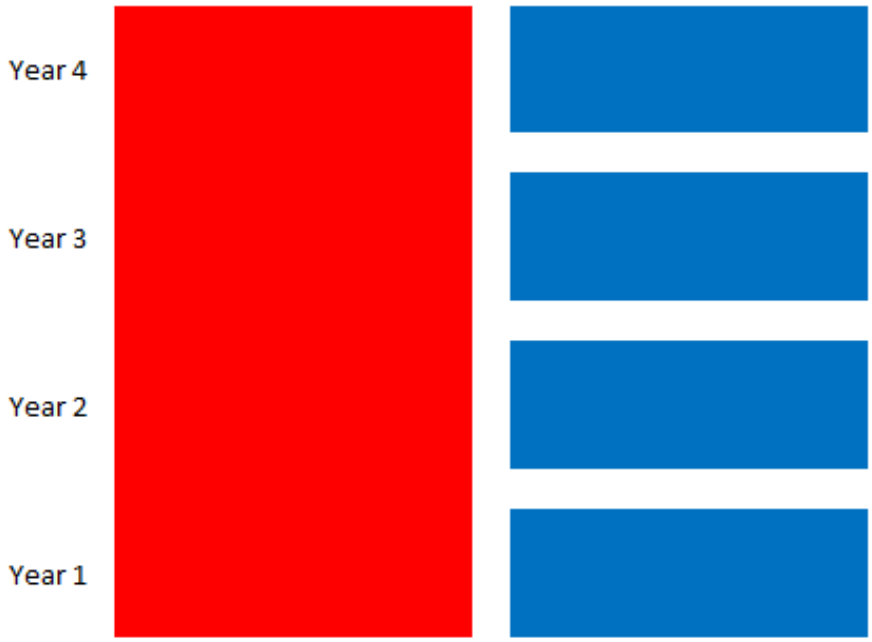
- Offer programs that are attractive to the market using a program design that is both scalable and efficient in its delivery,
- Quality assurance for program level competencies
- Produce T-shaped graduates through a greater emphasis on developing skills and knowledge that are focused on: human-centered, big picture, systems thinking; problem finding, framing, and solving; creativity and innovation; digital intelligence; collaboration and communication; adaptability, flexibility and resilience; employability, ethical professional practice; and emotional intelligence,
- Develop multiple pathways with personalisation to allow students to fast track as well as to address gaps/weaknesses,
- Develop different approaches for different cohorts (school leavers, change of career, working in industry),
- Include all in the journey to ensure the Engineering School has staff that are competent, engaged, and invested in delivering a state-of-the-art engineering education.

Project Goal	Program Design Element / Project Activity
Programs that are attractive to the market	**Attractiveness:** Embedded awards – increased employment prospects partway through program, complimented by early Work Integrated Learning, no competitors in this space. Program design proactive in maintain UniSQ's reputation as delivering most employable graduates / highest starting graduate pay Contemporary delivery, no traditional high stakes written exams, authentic project-based learning On-demand underpinning fine grained curriculum component Supported RPL process – "bring your learning with you" **Efficiency & Scalable:** Consolidated major offers. Consistency of program structure across majors Smart delivery – on-demand (maximising flexibility offered by academic calendar); study hall approach; project-based learning topics across disciplines and year levels
Quality Assurance for program level competencies	Competency approach for underpinning fine grained curriculum: pass/fail, high level of achievement, multiple (but limited) attempts within single enrolment. Explicit mapping from assessments to program outcomes and demonstration in ePortfolio; tracking of assessment towards program level competencies.

	Repeat opportunities for benchmarking/self-assessment against program level competencies.
Multiple pathways with personalisation to allow students to fast track as well as to address gaps /weaknesses	Orientation – skills assessment and supported RPL applications Fine grained curriculum – facilitate RPL Assessment approaches – pre-assessment and self-assessment to address gaps
Different approaches for different cohorts (school leavers, change of career, working in industry)	Multiple entry and exit points Greater focus on employability for students not currently working in the industry (school leavers, change of career) including portfolio development from Day 1 and formal WIL early in program (S3) Greater recognition and structured approaches for RPL and RCL for students working in industry Structure that facilitates customised pathway options
Staff who are competent, engaged and invested in delivering a state-of-the-art engineering education.	Staff involvement has been a key aspect of the program design with staff engaged early at the conceptualisation stage and throughout the refinement of the program model.

Proposed Program Design

The new model is structured on the basis of progress and competence, rather than by content. It will be comprised of two components: a professional component, in which student engineers engage in a sequence of authentic, actual projects; and an underpinning component, in which the underpinning technical and professional content is delivered online and on demand at a fine-grained resolution.



The model will cascade to serve the suite of three engineering degrees programs:

BENH: An AQF8 Bachelor of Engineering (Honours), accredited as a Professional Engineer

BENS: An AQF7 Bachelor of Engineering Science, accredited as an Engineering Technologist

ANDG: An AQF6 Associate Degree in Engineering, accredited as an Engineering Associate

A fully embedded model has been developed where all students enrolled in either the BENS or BENH will be awarded the ADNG. Similarly, full credit (16 units) will be provided for students entering the BENS and BENH with an equivalent AQF 6 program in cognate major.

The model is standardised and independent of major; all students undertake the same structure.

Project Based Learning Component

Developing rich authentic scenarios to offer as projects is time and resource intensive. To ensure that this investment is maximised, the projects will be conceptually decoupled from courses. It is intended that the same project be able to service multiple courses simultaneously, and for these courses to be interoperable. This will allow for a range of heterogeneous options:

- Teams from different courses working on the same project at the same time, e.g., some teams completing P3 at the same time as other teams are completing P5, but on the same virtual project.
- Students from different courses working in the same team on the same project at the same time, e.g., two P3 students and two P5 students in the same team. This approach offers real possibilities to exploring the authentic nature of the engineering team, which is comprised of Associates, Technologists and Professional Engineers.
- Students from the same course working on different projects offered within the schools.

This paradigm is already implemented in co-curricular contexts, such as the Formula SAE team.

Fine grained underpinning content

Structuring the degrees based on progress allows for the underpinning content to be organised in more fine-grained ways; it is no longer essential that content be grouped into 120-hour, 1 credit point courses.

Content will be a (nominally) 10-hour module with 3 modules combines into a 0.25 unit for enrolment and reporting purposes.

The underpinning content will be delivered online on demand through a Learning Management System. This approach will extend the UniSQ policy requiring the phasing out of lectures, providing asynchronous access to the underpinning content to students regardless of their location. The online delivery will be supported by synchronous tutorial sessions that could be potentially delivered on campus and online.

A mastery paradigm approach will be adopted for the fine-grained underpinning content:

- Competency based (Pass/Fail),
- Multiple but limited attempts of assessments within a single enrolment,
- On-demand content and assessments,
- Re-useable assessments to facilitate efficient delivery,

The flexibility in the academic calendar will be levered to offer the underpinning half of the program over multiple teaching periods to allow students to increase their load density and minimise the impact/delays following any unsuccessful attempts.

Student tutorial support will be offered through a “Study Hall” mechanism across the underpinning half of the program to provide frequent and timely support. To facilitate this, this requires:

- Delivery by a teaching team that can load share rather than a traditional single examiner model,
- Delivery across year levels and topics within an engineering strand,
- An appropriate medium in the LMS.

Pre-requisites and hold points

The model is designed to have very few hard pre-requisites, instead favouring an approach of recommending pathways and assuming knowledge. Hard pre-requisites place constraints upon patterns of progression, forcing students into a lockstep progress model where potentially a single failed course can necessitate a significant delay in further progress.

Each project course will be a pre-requisite for the subsequent project course.

Fine grained underpinning components, project-based learning components and completion of the e-portfolio should be progressing in parallel (over multiple teaching periods) without one component proceeding significantly ahead of the other components. Appropriate hold points will be introduced to limit any component significantly falling out of step in a student’s progression in the program.

Project courses will have clearly mapped assumed knowledge aligned with the fine-grained underpinning content half of the program with progression supported through opportunities to complete and reattempt fine grained curriculum components regularly.

Professional Identity & Portfolio Component

a. On entry to their program, students complete a compulsory course for credit which includes an assessment of the student’s prior study and experience (potentially for some RPL) and begins to establish their identity as a ‘student engineer’, setting their path to developing their professional identity. This will be a 1-week, on-campus residential school.

b. Students record/track their progress towards achieving the expected Graduate Capabilities (and Engineers Australia competencies) within their e-Portfolio, which includes capturing artefacts and reflective writing entries. Student progress is assessed by a regular review of the student's e-Portfolio and as a capstone assessment of the student's capabilities close to program completion.

Articulation

a. Provides an exit point for the ADNG after 2 years of the BENS or BENH programs. Capstone ADNG project requirements are embedded within the BENS and BENH programs.

b. Provides an exit point for the BENS after 3 years of the BENH program. Capstone BENS project requirements need to be met and will be additional to courses included in the BENH.

c. Re-entry to higher level programs will grant full credit for the previously completed program. For example, a student who completes an ADNG will receive 16 credits when returning to continue study in a BENH.

Expected outcomes & change management

Anticipated benefits for students

a. Allows students to commence study when they want, take on study load in smaller increments to suit their capacity for load.

b. Allows students to progress at their own pace (potentially at an accelerated pace)

c. Allows for students to utilise existing experience (possibly for RPL in early years)

d. Fully nested programs allow for seamless graduation points and restart points with full credit at ADNG level.

Anticipated benefits for academics

a. Fewer assessments to prepare, potentially based on parts of larger school- or discipline- wide projects

b. Fewer assessments to mark. Assessment of foundational knowledge and base discipline knowledge to be re-useable and where possible, automated.

c. Less academic integrity issues are expected for assessments which require students to demonstrate knowledge and skills, rather than every student answering that same 'question'

d. Student submissions should be more varied and more interesting to mark

e. Shorter 'teaching' periods focused on key topics, enable team teaching and increased staff load flexibility for underpinning find grained curriculum component.

f. Increased industry engagement due to the collaboration in developing project topics, with potential opportunities to develop research projects and consultations

Work required, change management and cost

a. Development of resources presenting finer grained content, organised into blocks/topics, accompanied by short, pre-recorded lectures and practice exercises with suitable automated formative and summative assessment.

b. Development of workshops, practical work, consulting arrangements etc which teach students how to approach problems, breakdown larger complex, multi-discipline, multi-level industry projects; how to identify the relevant knowledge and skills needed and how of create and present suitable solutions to elements of multi-faceted projects.

c. Team teaching development.

d. Forging stronger industry connections and collaborations on the development of those larger projects.

e. Development of assessments at a course level based on aspects drawn from those larger projects.

f. Development and deployment of new delivery models tailored for online and on-campus cohorts.

g. Training/upskilling of staff ahead of the new delivery model.

h. There is an expectation that academics will become involved in different aspects of the program redevelopment – e.g., project preparation, facilitation, enabling/technical content preparation, etc.

An extensive consultation process is underway with engineering staff in the School of Engineering and the School of Agriculture and Environmental Science, leading to staff buy-in. The model that is proposed is a qualitative change to the way our curriculum is delivered, but it is a change that has logically emerged from the requirements identified through staff consultation. It is a strength of this proposal that the emergent priorities from staff reconcile with best practice advice from external experts. Staff understand why and can see the evolution of the what; the challenge will be to support them on the how.

Glossary

ADNG	Associate Degree of Engineering
BENH	Bachelor of Engineering (Honours)
BENS	Bachelor of Engineering Science
Course	A course is a subject of study within a program. Full-time students usually study 4 courses per semester, whereas part-time students usually study 2.
ePortfolio	The online medium used to document and track competencies
Formula SAE	A motor vehicle development project for undergraduate engineers and other disciplines areas
Hold point	A point in the program where a student cannot progress unless they have completed specified courses. Hold points are defined by the pre-requisites in a course.
Modules	The principal unit to organise content
RPL	Recognition of Prior Learning
Unit	A unit is a measure of a student's workload. The majority of courses are worth one unit, however there are some that are worth more and some that are zero unit. Zero unit courses require completion for graduation, but have no financial cost attached to them.

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