Chemical Engineering Stream (CEICAH)

School of Chemical Engineering

Introduction

The CEICAH Chemical Engineering stream in the 3707 Bachelor of Engineering (Honours) program at UNSW trains graduate engineers with specialist discipline knowledge and who have developed the Engineers Australia Stage 1 Competencies.

In this integrated graduate specification, we describe the aims of the stream, what sets chemical engineering apart from other engineering streams, the stream learning outcomes, and the overall curriculum. Detailed mappings between courses, stream learning outcomes and EA Stage 1 Competencies are included.

Aims of the stream

Chemical Engineering involves researching, developing and improving properties of products we use every day through the selection of raw materials, the design of chemical processes, and improving the conditions for production. It's about taking projects from inception as a research proposal, through product development and on to commercialisation and manufacture. At UNSW, Chemical Engineers learn how to apply advanced knowledge in chemical engineering and chemistry to optimise complex chemical processes in environmental management, general industry and services like water delivery. Chemical Engineers master the entire process, extrapolating small scale, laboratory chemistry into large, industrial scale production. To get work ready, graduates apply these skills through 60 days of approved industry training.

Our Chemical Engineering alumni work in a broad range of industries, covering everything from the traditional petrochemical industry through to the emerging hydrogen economy, and from food manufacture to mineral processing. The defining characteristic of a successful chemical engineering graduate is the ability to apply knowledge from a broad foundational of chemistry, mathematics, physics and computing to this wide range of contexts; moreover, the chemical engineer much include safety, the environment, people, and economics within their work.

The Chemical Engineering stream in the BE(Hons) aims to ensure a rigorous foundation of chemical engineering theory is developed and that graduates are able to apply this theory to a range of design and operation scenarios. As an Honours level stream (AQF level 8), the curriculum contains advanced disciplinary knowledge, enquiry based learning, and an introduction to research. Graduates are able to use their advanced skills to analyse critically, evaluate and transform knowledge into chemical engineering designs and solutions. Moreover, they are able to develop and communicate solutions to complex problems with autonomy and professional judgement.

The stream is composed of individual courses that are articulated into four thematic areas: process design, thermodynamics, fluids & materials, lifelong learning. It is important that both staff and students understand the connections between the courses that together produce a graduate engineer. As part of our curriculum development and review cycle, these thematic areas have been summarised in the following diagrams, that help explain to our students and staff how the individual courses are designed to fit with each other, developing a graduate engineer at the successful conclusion of the studies.

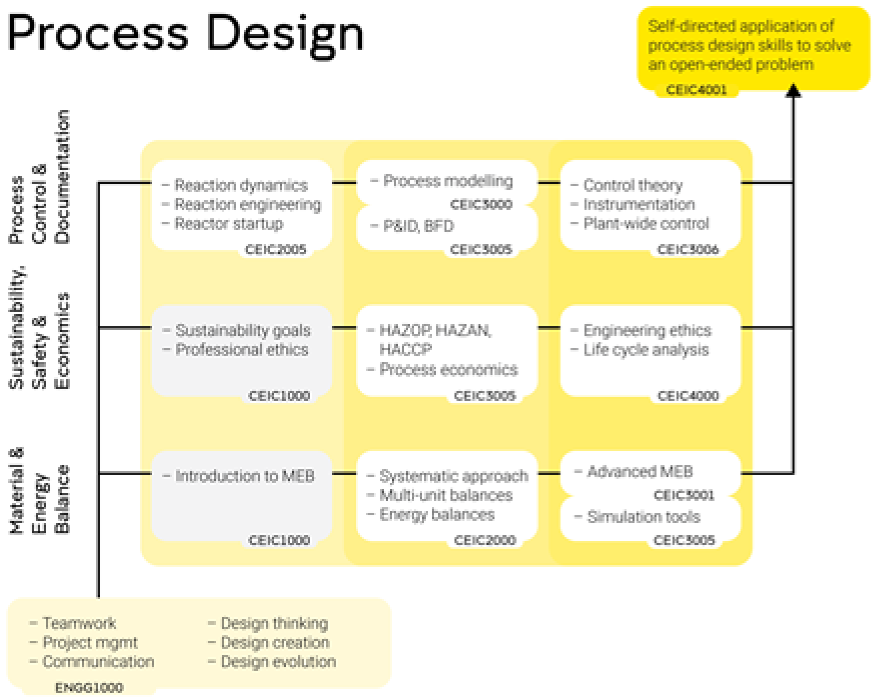

Figure 1: Chemical Engineering specification for the Process Design Theme

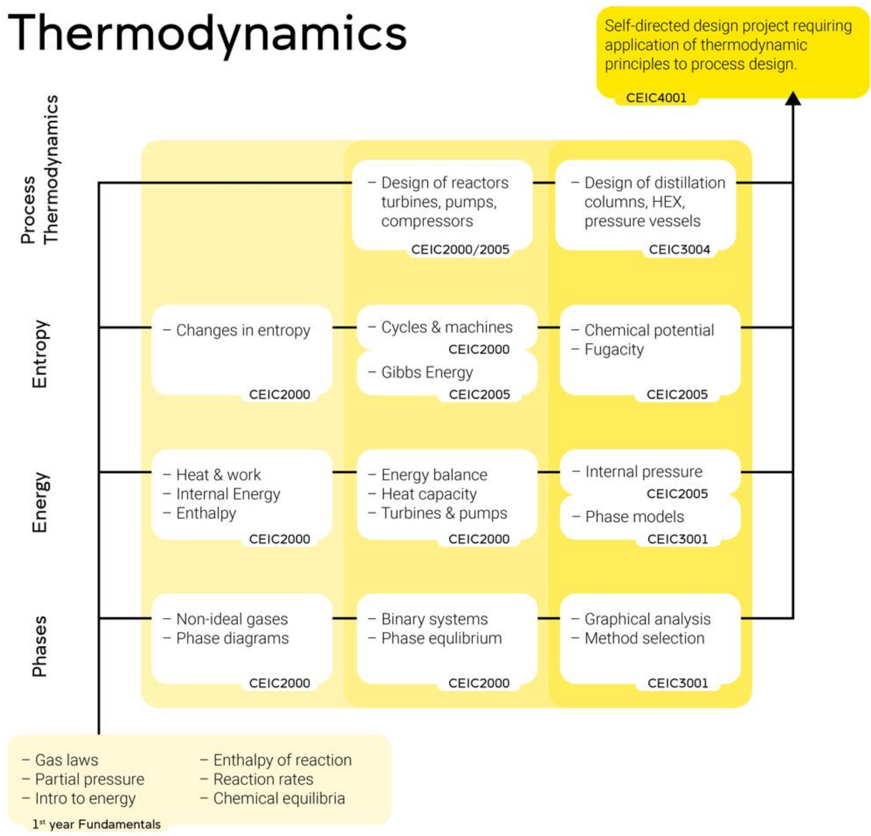

Figure 2: Chemical Engineering specification for the Thermodynamics theme

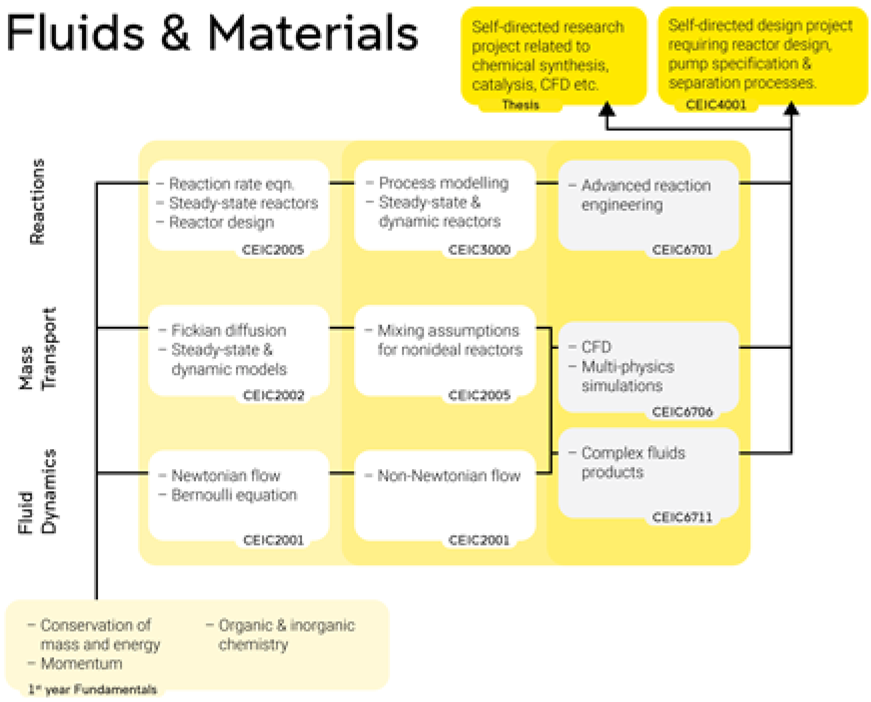

Figure 3: Chemical Engineering specification for the Fluids & Materials theme

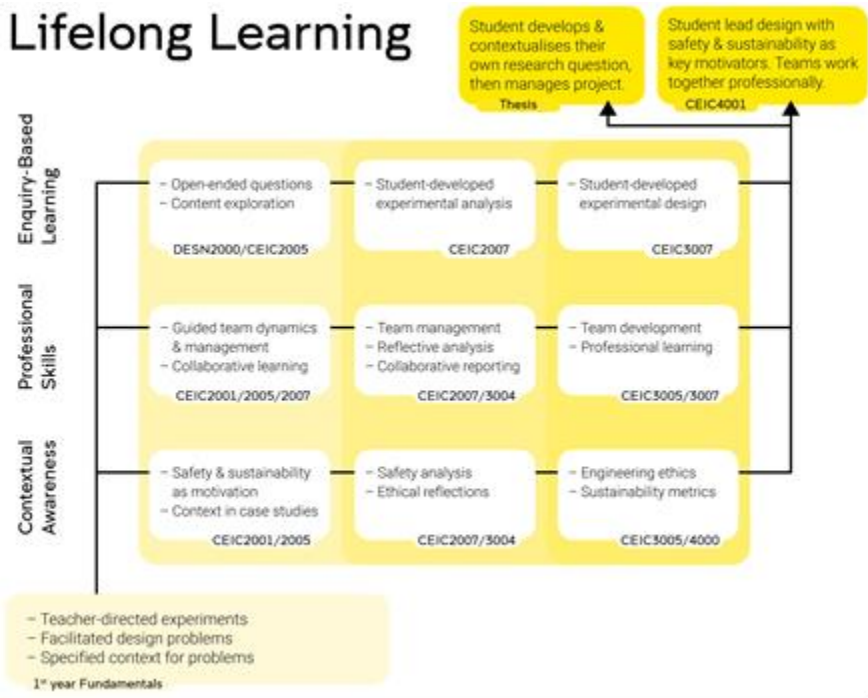

Figure 4: Chemical Engineering specification for the Lifelong Learning theme

Stream Plan

The standard plan is shown below for the Chemical Engineering stream. It is noted that students may approach the stream in different sequences for a range of reasons, including: Co-op Scholarship placements, international exchange, enrolment in a double degree, part-time study, commencing the degree in Term 2 or Term 3, or failing an individual course. To complement the study plan shown below, the School has developed recommended study plans for other common eventualities and these are published on the Faculty website; our Academic Advisors also work with individual students to develop study plans tailored to their circumstances.

https://www.unsw.edu.au/engineering/student-life/student-resources/enrolment-sequences

Table 1: Normal enrolment sequence for the Chemical Engineering stream

Year 1			
	Term 1	DESN1000	Introduction to engineering design and innovation
		CHEM1811	Engineering Chemistry 1A
		MATH1131	Mathematics 1A
	Term 2	ENGG1811	Computing for Engineers
		CHEM1821	Engineering Chemistry 1B
		MATH1231	Mathematics 1B
	Term 3	CEIC1000	Sustainable product engineering and design
		PHYS1121	Physics 1A
		MATH2018	Engineering Mathematics 2D
Year 2			
	Term 1	CEIC2000	Materials and energy systems
		CEIC2001	Fluid and particle mechanics
		MATH2089	Numerical methods and statistics
	Term 2	CEIC2002	Heat and mass transfer
		CEIC2005	Chemical reaction engineering
		Gen Ed	General education elective
	Term 3	CEIC2007	Chemical engineering lab A
		DESN2000	Engineering design and professional practice
		CEIC3001	Advanced thermodynamics and separation
Year 3			
	Term 1	CEIC3000	Process modelling and analysis
		CEIC3004	Process equipment design
		CEIC3005	Process plant design
	Term 2	CEIC3006	Process dynamics and control
		CEIC3007	Chemical engineering lab B
		CEIC4000	Environment and sustainability
	Term 3	ENGG4999	Industrial training
Year 4			
	Term 1	CEIC4001	Process design project
		CEIC4951	Research thesis A
	Term 2	CEIC4952	Research thesis B
		Elective	Discipline elective
		Elective	Discipline elective
	Term 3	CEIC4953	Research thesis C
		Elective	Discipline elective
		Gen Ed	General education elective

Stream Learning Outcomes

On successful completion of this stream, graduates will be able to:

1. Demonstrate knowledge and expertise in the use of the methods, tools and ideas from chemistry, mathematics, physics, and computing that underpin chemical engineering.
2. Solve chemical engineering problems by competent application of technical knowledge in material and energy balances, thermodynamics, fluid mechanics, particulate flow, chemical reaction engineering, transport phenomena, separation technologies, process equipment selection, process modelling, process simulation, process control, economic analysis, and safety analysis.

3. Demonstrate expertise in the design of chemical engineering systems, using established methods to create and document solutions that are technically feasible, appropriate, safe, sustainable, economically viable, socially acceptable, and standards-compliant.
4. Use systems thinking to guide engineering practice, including articulating financial and technical constraints on process design, analysing competitor processes to identify opportunities in market and technologies, developing process improvement plans, and liaising with product engineers to select appropriate process designs.
5. Make responsible engineering decisions in the face of uncertainty, complexity, and incomplete information in consultation with stakeholders, via critical reflection, and through the planning, collection, and analysis of data from research, experimentation and simulations.
6. Effectively manage process engineering projects and multidisciplinary teams with robust project planning and project management approaches that are adaptable, responsive, and appropriate in benefiting from the capabilities of diverse teams.
7. Communicate complex ideas effectively and professionally through a range of media to diverse audiences within and outside of chemical engineering, effectively incorporating feedback and being responsive to others.
8. Conduct themselves professionally, ethically, respectfully and with integrity, being accountable as an individual, as members of teams, and as a leader of teams, while recognising the social and environmental obligations of chemical engineers.

Development of Stream Learning Outcomes

To develop an initial draft of the SLOs, a working group was formed that included members of the school with relevant industry experience, specialists in education and curriculum design, and the stream coordinators of each stream. The group was selected to ensure diversity in professional background, industry experience, cultural background, and gender, gathering a representative set of views. Over the course of six weeks, the group progressed through a sequence of divergent then convergent phases of identifying important topics to be included in the SLOs, finding suitable wording for the SLOs, combining the work, and the refining the draft.

The draft SLOs were widely circulated for comment, critique, and suggestions around the entire academic staff of the School, the Faculty Accreditation Working Group, and the School's Industry Advisory Board. The final versions of the SLOs were endorsed by the School's Education Committee, and the industry and student members of the School's Industry Advisory Board.

Curriculum Mapping

The following data shows the mapping from:

- stream learning outcomes (SLOs) to Engineers Australia Stage 1 Competencies
- courses to SLOs
- courses to Engineers Australia Stage 1 Competencies (derived from the above two mappings)

The weightings displayed in the latter two mappings are derived from a cognitive scale that takes each assessment weighting and the assessment to CLO mapping for each course to derive an overall contribution to the course and stream.

The recommended first year elective of CEIC1000 Sustainable Product Engineering and Design is included in the mappings. A representative set of three 4th year discipline electives are also included;

these courses were chosen as they represent a popular cross-section of the courses taken by recent cohorts: CHEN6701 Advanced Reaction Engineering, CEIC8204 Entrepreneurship and the Innovation Cycle, CEIC8341 Membrane Processes.

Table 2: Mapping of the stream learning outcomes to the Engineers Australia Stage 1 Competencies

SLO → GC Mapping	Engineers Australia Stage 1 Competencies															
Learning Outcomes (LO)	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	3.5	3.6
SLO1 Demonstrate knowledge ...	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SLO2 Solve chemical enginee...	-	-	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-
SLO3 Demonstrate expertise ...	-	-	-	✓	-	-	✓	✓	✓	✓	-	-	-	-	-	-
SLO4 Use systems thinking t...	-	-	-	-	-	-	✓	✓	✓	✓	-	-	-	-	-	-
SLO5 Make responsible engin...	-	-	-	-	-	-	-	-	✓	✓	-	✓	-	✓	-	-
SLO6 Effectively manage pro...	-	-	-	-	-	-	-	-	-	-	✓	-	-	✓	✓	✓
SLO7 Communicate complex id...	-	-	-	-	-	-	-	-	-	-	-	✓	-	✓	-	✓
SLO8 Conduct themselves pro...	-	-	-	-	-	✓	-	-	-	-	-	-	✓	-	✓	-

Table 3: mapping of courses to the stream learning outcomes

CO → SLO Mapping	Stream Learning Outcomes (SLOs)							
Courses (CO)	SLO1	SLO2	SLO3	SLO4	SLO5	SLO6	SLO7	SLO8
CEIC1000	12.5	20.2	9.2	0.0	16.0	13.0	16.0	13.0
CHEM1811	70.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0
CHEM1821	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
DESN1000	0.0	18.3	16.9	8.5	0.0	30.6	17.1	8.5
ENGG1811	91.2	8.8	0.0	0.0	0.0	0.0	0.0	0.0
MATH1131	89.2	0.0	0.0	0.0	0.0	0.0	10.8	0.0
MATH1231	89.2	0.0	0.0	0.0	0.0	0.0	10.8	0.0
PHYS1121	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CEIC2000	24.0	61.3	13.3	1.3	0.0	0.0	0.0	0.0
CEIC2001	0.0	37.5	37.5	0.0	25.0	0.0	0.0	0.0
CEIC2002	0.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0
CEIC2005	7.9	44.2	20.8	27.1	0.0	0.0	0.0	0.0
CEIC2007	0.0	22.2	0.0	8.3	13.9	27.8	13.9	13.9
DESN2000	0.0	5.0	17.7	12.7	7.7	27.0	20.0	10.0
MATH2018	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
MATH2089	27.4	60.6	0.0	0.0	0.0	0.0	12.0	0.0
CEIC3000	0.0	50.0	0.0	0.0	33.3	0.0	16.7	0.0
CEIC3001	0.0	37.5	25.0	12.5	25.0	0.0	0.0	0.0
CEIC3004	0.0	8.3	30.6	30.6	30.6	0.0	0.0	0.0
CEIC3005	0.0	16.7	33.3	16.7	16.7	0.0	8.3	8.3
CEIC3006	0.0	50.0	20.8	20.8	8.3	0.0	0.0	0.0
CEIC3007	0.0	19.2	18.1	3.9	7.2	8.3	30.0	13.3
CEIC4000	0.0	0.0	10.8	5.3	16.1	0.0	35.8	31.9
CEIC4001	0.0	0.0	25.0	33.3	8.3	8.3	12.5	12.5
CEIC4951	0.0	6.7	10.0	6.7	33.3	13.3	20.0	10.0
CEIC4952	0.0	0.3	3.0	0.3	6.7	0.7	1.0	3.0
CEIC4953	0.0	6.7	10.0	6.7	33.3	13.3	20.0	10.0
CHEN6701	0.0	27.5	12.0	22.5	23.0	0.0	15.0	0.0
CEIC8204	0.0	8.1	5.6	44.3	15.8	16.2	0.0	10.0
CEIC8341	0.0	25.0	40.0	10.0	25.0	0.0	0.0	0.0

Table 4: mapping of courses to Engineers Australia Stage 1 Competencies

Curriculum Mapping	Engineers Australia Stage 1 Competencies															
Courses (CO)	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	3.5	3.6
CEIC1000	6.2	6.2	4.0	5.9	4.0	8.4	5.9	1.9	5.8	5.8	3.2	9.3	4.3	12.6	7.6	8.6
CHEM1811	35.0	35.0	6.0	6.0	6.0	6.0	6.0	-	-	-	-	-	-	-	-	-
CHEM1821	25.0	25.0	10.0	10.0	10.0	10.0	10.0	-	-	-	-	-	-	-	-	-
DESN1000	-	-	3.7	7.0	3.7	6.5	9.2	5.5	5.5	5.5	7.7	5.7	2.8	13.4	10.5	13.4
ENGG1811	45.6	45.6	1.8	1.8	1.8	1.8	1.8	-	-	-	-	-	-	-	-	-
MATH1131	44.6	44.6	-	-	-	-	-	-	-	-	-	3.6	-	3.6	-	3.6
MATH1231	44.6	44.6	-	-	-	-	-	-	-	-	-	3.6	-	3.6	-	3.6
PHYS1121	50.0	50.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CEIC2000	12.0	12.0	12.3	14.9	12.3	12.3	15.3	3.0	3.0	3.0	-	-	-	-	-	-
CEIC2001	-	-	7.5	15.0	7.5	7.5	15.0	7.5	13.8	13.8	-	6.2	-	6.2	-	-
CEIC2002	-	-	10.0	20.0	10.0	10.0	20.0	10.0	10.0	10.0	-	-	-	-	-	-
CEIC2005	4.0	4.0	8.8	13.0	8.8	8.8	19.8	10.9	10.9	10.9	-	-	-	-	-	-
CEIC2007	-	-	4.4	4.4	4.4	9.1	6.5	2.1	5.6	5.6	6.9	8.1	4.6	15.0	11.6	11.6
DESN2000	-	-	1.0	4.5	1.0	4.3	7.7	6.7	8.6	8.6	6.8	8.6	3.3	15.3	10.1	13.4
MATH2018	25.0	25.0	10.0	10.0	10.0	10.0	10.0	-	-	-	-	-	-	-	-	-
MATH2089	13.7	13.7	12.1	12.1	12.1	12.1	12.1	-	-	-	-	4.0	-	4.0	-	4.0
CEIC3000	-	-	10.0	10.0	10.0	10.0	10.0	-	8.3	8.3	-	13.9	-	13.9	-	5.6
CEIC3001	-	-	7.5	12.5	7.5	7.5	15.6	8.1	14.4	14.4	-	6.2	-	6.2	-	-
CEIC3004	-	-	1.7	7.8	1.7	1.7	15.4	13.7	21.4	21.4	-	7.6	-	7.6	-	-
CEIC3005	-	-	3.3	10.0	3.3	6.1	14.2	10.8	15.0	15.0	-	6.9	2.8	6.9	2.8	2.8
CEIC3006	-	-	10.0	14.2	10.0	10.0	19.4	9.4	11.5	11.5	-	2.1	-	2.1	-	-
CEIC3007	-	-	3.8	7.4	3.8	8.3	8.4	4.6	6.4	6.4	2.1	11.8	4.4	13.9	6.5	12.1
CEIC4000	-	-	-	2.2	-	10.6	3.5	3.5	7.5	7.5	-	16.0	10.6	16.0	10.6	11.9
CEIC4001	-	-	-	5.0	-	4.2	13.3	13.3	15.4	15.4	2.1	6.2	4.2	8.3	6.2	6.2
CEIC4951	-	-	1.3	3.3	1.3	4.7	5.0	3.7	12.0	12.0	3.3	15.0	3.3	18.3	6.7	10.0
CEIC4952	-	-	0.6	1.4	0.6	2.0	2.1	1.6	7.1	7.1	1.4	24.9	1.4	26.3	2.8	20.7
CEIC4953	-	-	1.3	3.3	1.3	4.7	5.0	3.7	12.0	12.0	3.3	15.0	3.3	18.3	6.7	10.0
CHEN6701	-	-	5.5	7.9	5.5	5.5	13.5	8.0	13.8	13.8	-	10.8	-	10.8	-	5.0
CEIC8204	-	-	1.6	2.7	1.6	5.0	13.8	12.2	16.1	16.1	4.1	3.9	3.3	8.0	7.4	4.1
CEIC8341	-	-	5.0	13.0	5.0	5.0	15.5	10.5	16.8	16.8	-	6.2	-	6.2	-	-
Cognitive Scale	16.7	16.7	3.4	5.0	3.4	4.3	6.6	4.3	6.6	6.6	2.5	5.4	2.4	6.5	4.5	5.2

Reflection on Strengths, Weaknesses, and Future Action

Reflection on curriculum strengths

The curriculum map shows a structured development of knowledge within the stream: foundational knowledge is developed in Year 1, engineering discipline knowledge is built in Year 2, applications of this knowledge in design developed through Years 2 and 3, culminating in advanced disciplinary learning and design in Year 4. This structure builds applications on top of separately assessed foundational learning to ensure that all graduates have sufficient discipline knowledge.

The curriculum map also demonstrates the close integration that we maintain between theory and practice. Our courses bring together engineering knowledge with applications to chemical engineering problems and design; this is expressed in the curriculum map by the inclusion of many PLOs within each course.

Reflection on curriculum weaknesses

The nature of undertaking the mapping via the Cognitive Scale based around Course Learning Outcomes is that competencies that are assessed but not explicitly listed in a CLO might appear to be missing from a course. It might be tempting to use the above heatmap to conclude that there was insufficient treatment of some competencies, while the reality is that simply writing an additional CLO for a selected 2nd and 3rd year course and mapping an assessment to that CLO would smooth out the heatmap further.

Reflection on assessments

The mixture of assessment types used within the stream is shown below.

As is typical of many streams, early courses are content-driven and the assessments reflect a desire to see demonstration of individual learning in tests or examinations. Students commonly have opportunities for longer form formative or summative assignment activities. In later years, the assessment mix tends to pivot towards project work, often in teams.

It is noted that Assignment, Essay, Report, and Project as used quite interchangeably in many courses, as are Exam vs Test, and Presentation vs Performance; a presentation that is about a project might be classified as a project or as a presentation. Laboratory work (which might include wet labs or computer labs) may also be assessed via reports, interviews, or presentations, and so not appear with a “Laboratory” designation.

Table 5: map of assessment types used within the stream.

CO → AT Mapping	Assessment Types (AT)										
Courses (CO)	Assi	Essa	Exam	Lab	Othe	Perf	Port	Pres	Proj	Repo	Test	Tut
CEIC1000	-	-	-	-	-	15	-	-	55	-	15	-
CHEM1811	-	-	40	20	-	-	-	-	-	-	40	-
CHEM1821	-	-	40	20	-	-	-	-	-	-	40	-
DESN1000	-	5	-	-	20	-	15	15	-	45	-	-
ENGG1811	20	-	70	10	-	-	-	-	-	-	-	-
MATH1131	10	-	50	-	40	-	-	-	-	-	-	-
MATH1231	10	-	50	-	40	-	-	-	-	-	-	-
PHYS1121	-	-	50	20	30	-	-	-	-	-	-	-
CEIC2000	-	-	60	-	20	-	-	-	-	-	20	-
CEIC2001	-	-	100	-	-	-	-	-	-	-	-	-
CEIC2002	-	-	80	-	-	-	-	-	-	-	20	-
CEIC2005	20	-	50	-	-	-	-	-	20	-	10	-
CEIC2007	58	-	-	-	-	42	-	-	-	-	-	-
DESN2000	25	-	-	-	60	-	-	15	-	-	-	-
MATH2018	-	-	60	-	10	-	-	-	-	-	30	-
MATH2089	-	-	60	-	20	-	-	-	-	-	20	-
CEIC3000	30	-	70	-	-	-	-	-	-	-	-	-
CEIC3001	-	-	25	-	-	-	-	-	-	50	25	-
CEIC3004	30	-	-	-	-	-	50	-	-	-	20	-
CEIC3005	35	-	45	-	-	-	-	-	-	-	20	-
CEIC3006	30	-	50	-	-	-	-	-	-	-	20	-
CEIC3007	-	-	-	-	5	-	-	30	-	65	-	-
CEIC4000	60	-	-	-	40	-	-	-	-	-	-	-
CEIC4001	-	-	-	-	-	-	-	45	-	55	-	-
CEIC4951	-	-	-	-	-	-	-	-	100	-	-	-
CEIC4952	-	-	-	-	33	-	-	34	33	-	-	-
CEIC4953	-	-	-	-	-	-	-	-	100	-	-	-
CHEN6701	-	-	30	-	-	-	-	20	-	40	10	-
CEIC8204	65	-	-	-	-	-	-	-	35	-	-	-
CEIC8341	30	-	50	-	-	-	-	-	-	-	20	-

Even with the limitations of classification, it is seen that a broad range of assessment types are employed in the stream, offering many opportunities for students to demonstrate their learning, and different formats used to develop a variety of communications skills.

The School has a range of measures in place for assessment quality and academic integrity:

- All final exam papers are peer reviewed by the School Exam Review meeting. At this meeting, papers are checked for their academic level, correctness, and clarity. Marking rubrics are also reviewed along with the measures proposed by the exam setter to check for academic integrity.

- Reports are normally submitted via Turn-It-In where appropriate. Final year theses may also be checked via Turn-It-In if there are any concerns from either marker.
- Worked solutions with detailed marking guides or marking rubrics are created for all assessment items and used by markers.
- Final year theses are double marked to ensure consistency; if the markers are not in reasonable agreement on the final mark, a third marker is appointed.

As exams have moved online due to COVID-19, the following standard practices have been adopted as part of the exam setting and marking procedures:

- Fixed times for the start and end of the examination are maintained to prevent groups working in sequence.
- Long duration exams (for example 24 h exams) are discouraged as it makes it too easy for groups to work together; short duration examinations remain normal (2 h).
- Randomisation of questions is undertaken either using technologies like STACK (with random numbers included in the questions for each student) or by creating multiple variants of questions.
- Web searches are conducted before and after the exam is held, initially to see if there are sites that would give the answers to the students easily, and then after the exam to see if students have received assistance on “homework help” sites.
- The combination of question randomisation, question watermarking, and answer similarity checking permits many forms of exam misconduct to be trivially identified.

It is reasonable to assume that assessment practices will continue to evolve, with arguments unresolved about the best approaches to assess student learning, the impact of high stakes assessments on student welfare, and the efficacy of various assessment practices in maintaining academic integrity.

Summary

The Chemical Engineering stream in the BE(Hons) has strengths in its staged development of discipline knowledge across the 4 years, and the integration of content learning with application of knowledge. Chemical engineering as a profession has changed markedly over recent years and will continue to do so; the School will need to continue to track on-going trends regarding decarbonisation of industry, greater emphasis on sustainability and circular economy, and digitalisation. Revision of CLOs to more explicitly highlight the professional skills learning that is already within those courses will be undertaken. Changes to assessment types to ensure that both team work and individual competence are thoroughly captured by the assessment scheme are likely.