Australian Council of Engineering Deans National Award for Engineering Education Excellence
2025 Nomination Statement, Dr. Andrew C. Brown, Mr. Hugh Morris, Mr. Con Lu

Turning Engineering Students into Engineers: The University of Auckland Civil Engineering Capstone Project

Introduction and Context

The **University of Auckland Civil Engineering Capstone Project** was introduced in 2017 in response to accreditation requirements. Our goal was to draw together the earlier learning of the degree and prepare final year engineering students to be effective engineering practitioners. For students, this involves a sometimes painful transition from detailed technical work within well-defined parameters, to conceptual design work involving a great deal of uncertainty. As Jonassen (2014) appropriately states: "**Engineering students think like students, not engineers**, challenging instructors to clarify and simplify the content they are distributing. If students are to learn to think like engineers, they must be challenged to solve authentic, complex problems."

Our role in the Capstone project has been developing and improving the course as coordinators and directors of the relatively large teaching team (2 coordinators and 12 to 14 technical specialist staff in a given year, teaching between 200 and 300 students each year). The course was initially developed by Mr. Hugh Morris, first running as a pilot course in 2017 before being fully implemented as a compulsory fourth-year course from 2018. Since 2018, the course has been coordinated by Mr. Hugh Morris (from 2017-2021), Dr. Andrew C. Brown (from 2018-present), and Mr. Con Lu (from 2022-present). The team of coordinators brings a diverse array of industry, academic, and practical experience to the course, allowing them to develop a truly authentic design experience for engineering students. This nomination statement focuses primarily on the implementation and impact of the Capstone Project, with the overarching goal of **turning engineering students into engineers**.

Capstone Concept, Course Delivery Model, Assessment and Evaluation

As described in Brown & Morris (2020), the University of Auckland Capstone project was developed with a focus on Washington Accord attributes, and is based on a Civil Engineering design office experience, which allows students to experience **authentic involvement with a real-world, open-ended project**. Students integrate their technical knowledge by working in teams to deliver an engineering design report and presentation that must achieve real, coordinated outcomes targeted for a non-specialist client. The Capstone design project is selected each year with the help of local engineering practitioners, with the goal of allowing students to work on a challenging civil engineering project. The ideal project is 1) Local (i.e. students can visit the site in person and observe the design problems first-hand), 2) Currently in progress (i.e. final details of the selected solution are not yet constructed), and 3) Interdisciplinary to a degree that requires substantial input from each specialisation within Civil Engineering (e.g. Construction, Environmental, Geotechnical, Transportation, Structural, and Water).

Students manage their own design teams of 7 to 10 individuals with a team structure similar to a small design consultancy, with some students performing as team leaders, others as specialisation or subgroup leaders, and others as team contributors. In recent years, student deliverables have consisted of an approximately 40-page pre-feasibility report and presentation/Q&A at the mid-semester mark, and an approximately 80-page concept-level design report and presentation/interview at the end of the semester. Individual student assessments include a presentation, a peer- and self-assessment, and final marks are scaled to account for each student's individual specialist and team contributions. With typical course enrolments of between about 220 and 270 students, there are about 25-30 student teams in a given semester.

Past Capstone Project Selections, Key Challenges, and Course Refinements

Because our course is based around a real-world, ongoing project with support from the real-life project team, one of the most important decisions each year is project selection (Table 1). The breadth and depth of our past projects have presented extensive problem-solving challenges not just for our students, but also for our course teaching staff and **industry engineers working on the real-life problem** itself. Rather than asking small student groups to work on contrived projects with limited scope, our emphasis on allowing larger, interdisciplinary student teams to tackle truly complex design challenges that have not yet been solved has provided immense opportunity for authentic learning.

Table 1. Past University of Auckland Capstone project selections by year, with key challenges highlighted.

Year	Project	Key Design Challenges
2017, 2018	Chapel Road Bridge Realignment	Active landslip, historic structures
2019	Ōrākei Basin Shared Path	Coastal environment, historic structures
2020	Puketutu Island Rehabilitation	Biosolids remediation project, unusual scope
2021	Auckland Harbour Cycle Crossing	Stakeholders, cost, existing structures
2022	Paerata Railway Station	Future population growth, lifetime carbon
2023	Chapel Road Bridge, Revisited	Additional scope for full road realignment
2024	Newmarket Campus Redevelopment	Stormwater controls, adjacent railway
2025	Herne Bay Collector Tunnel	Stakeholders, construction methodology

One of the most positive aspects of our course model is that it gives the students an opportunity to learn how experts approach a problem that the expert is also seeing for the first time. Year-on-year in the Capstone course, we have the opportunity to watch students work through difficult, open-ended design problems together with experts in the field. The true "light bulb" moment for students in this course is not in any technical learning, but in **learning how experts initially approach a complex problem**, applying simplifying assumptions to make important design decisions without going straight into advanced technical calculations.

Since full implementation of this course in 2018, we have continued to evolve the teaching approach to suit the unique needs of this course and student group. What we found in early iterations of the Capstone project was that detailed project briefs and prescriptive rubrics could sometimes stifle the design process in students, as they tried to reverse engineer their deliverables based on our rubric and project brief, rather than engaging in an authentic design process. In recent years, we have streamlined our course content, emphasised the importance of first principles and client focus, and most importantly have focused on the concept that **engineering design problems may have any number of correct solutions**. Our approach to evolving the Capstone course has been based on a combination of student observations, end-of-semester student evaluations and in-person team interviews, teaching peer review, and feedback from industry leaders who have employed our graduates. Our efforts have been disseminated in a UoA Faculty of Engineering SCOPE project entitled ***"Turning Engineering Students into Engineers".***

Course Components, Ongoing Challenges and Targeted Improvements in Course Delivery since 2018

The key logistical challenges associated with this course model, and the changes we have implemented over the years based on student and staff feedback, are summarised below.

Student Team Formation (Prior to the Semester): Student team formation occurs prior to the semester. Based on student feedback during end-of-semester team interviews, some students want to form their own teams, some students want to be placed on a team by staff, and each group feels strongly. Based on student feedback during 2022 team interviews, it became clear that there was not a one-size-fits-all solution for our student cohort. In 2023, we implemented a two-stage team formation process, where students who want to form their own teams are permitted to do so (with staff approval) and students who prefer to have staff formed teams are placed on teams according to their specialist capabilities and desired team leadership level. Student feedback during 2023 team interviews indicated they appreciated the change.

Lecture and Q&A Sessions (1 hour per week): Early iterations of the Capstone course included weekly lectures, with one lecture allocated to each core specialist area. What we found was that students sometimes felt they could not start on design aspects until they had been officially addressed during the corresponding specialist lecture, and there was limited time for discussion and Q&A during the lecture timeslots to address student queries. Since full course implementation in 2018, we have streamlined lecture content to focus more on core aspects of engineering design and the project context, without providing detailed technical guidance, which provides a worthwhile challenge. As student feedback from 2022 indicated, *"The fact that we were given a problem and not a whole heap of guidance was a little tricky at the beginning, but I definitely learnt so much by making my own decisions as an individual and group."* During lockdowns in 2020, we began holding parallel Zoom Q&A sessions during the lecture timeslot, where each group of specialist experts host a Zoom session for students to ask more detailed specialist-focused questions. Student feedback on this adaptation was overwhelmingly positive, and we have continued to hold parallel Zoom Q&A sessions each year since 2020.

Design Office Sessions (2 hours per week): Finding suitable teaching spaces that allow for a large number of student teams of 7-10 to work effectively, and are also near enough to one another that 12-14 technical specialist staff can comfortably circulate as mentors and advisors, is an ongoing challenge. Additionally, staff who are new to the course and/or do not have extensive industry experience sometimes have a learning curve with helping students address design challenges. Although there is no easy way around the timetabling challenges for the course (we typically hold design office sessions in flat-floor seminar rooms spread across multiple floors in a single building), we have addressed the challenge of upskilling new staff by maintaining a core group of specialist staff who have extensive industry and/or course experience, so that more experienced course staff can serve as mentors to newer staff members.

Deliverables and Assessment (Less is More): Allocating sufficient staff resources to marking and assessment for a design course of this size is a considerable challenge. Early versions of the Capstone course involved submission of a scope and proposal, a 40% design report, a preliminary report, and a final report, along with two presentations. Student and staff feedback from early years indicated that a smaller number of more substantial and targeted assessments may be a more effective mode of course delivery. In recent years, we have reduced the written deliverables to a mid-semester report/presentation and an end-of-semester report/presentation, which allows students to receive more in-depth feedback from course coordinators and from each specialist area (similar to what they would receive in engineering practice from a technical reviewer), and has been broadly appreciated by both staff and students.

Leadership and Impact of the Capstone Program, across the University and Beyond

As our Capstone program has become one of the most well-established Capstone programs at the University of Auckland (including a **University of Auckland Teaching Excellence Award** for Andrew Brown, a key member of teaching staff), we have been able to use this recognition to disseminate effective practice across the University and beyond, to mentor less-experienced staff who are developing similar courses in their own Faculties, and to disseminate our Capstone learning internationally. Our contributions have included publishing and presenting at **international conferences** (Brown & Morris, 2020), maintaining **external engagement with the profession** through Capstone development, and by contributing to workshops and events across the University focused on effective teaching practice. The impact of the Capstone program resulted in **collaborations with staff across the University of Auckland**, who were currently developing their own Capstone programs and keen to incorporate elements of our course and deliverable design. The **Capstone project is now serving as a model for similar courses throughout the University**. Internationally, Our Capstone course has also been featured as a case study in the book "***Experiential Learning in Engineering Education***" (Steele, 2023).

Industry Recognition, Student Feedback, and Accreditation Feedback

Excerpts from industry, student, and accreditation panel feedback are highlighted below:

"Many of our summer students and new graduates have communicated with me in regard to the value they have gained from this multidisciplinary project... Key attributes we look for in our potential graduates and employees are confidence, interpersonal skills and the ability to collaborate, which in the past has been very difficult to teach. This project has enabled students to interact on a professional level with lecturers and industry professionals and to develop these skills."

-Industry leader involved with early course development

"The Capstone Project was the highlight of my engineering degree… The teamwork, problem-solving, and approach to incorporating multiple stakeholder inputs I learned in this project gave me the confidence to pursue my chosen career. Within this career, I apply the leadership, teamwork, and communication skills I learned in the capstone project every day." -Former Capstone student (now working in industry)

"I have worked as one of the members of staff for the CIVIL 756 Capstone course.…Teaching design to engineering students is a considerable challenge. The challenge for the teaching staff is to provide the students with both effective mentoring support and technical support within an experiential learning environment to allow the students to take this leap from engineering analysis to design. The student comments at the final evaluation presentations at course end speak for themselves - that they considered the course both challenging and enjoyable and they appreciated the course's relevance to the careers they are now embarking on."

- Industry mentor and course teaching staff

"The model for, and mode of delivery of capstone projects taken by both structural and civil engineering students is exemplary and staff involved with it are to be commended."

-Engineering New Zealand, Accreditation Panel Feedback, 2025

Conclusion (portions adapted from Brown & Morris, 2020)

The Civil Engineering Capstone Project at the University of Auckland, New Zealand incorporates many of the features of an open-ended, industry-affiliated project as described in Dutson et al. (1997) and has implemented them for a large class size of approximately 220 to 270 (or more) students, with acclaimed results and positive feedback from students, staff, and industry. Through the incorporation of real-world, open-ended problems, student interaction with industry practitioners working on similar projects, and an emphasis on a higher level understanding of the project context and goals, the University of Auckland Capstone Project incorporates several of the aspects Naylor (2016) has identified as key to increasing the relevance of tertiary engineering studies in New Zealand. Although students are challenged by the course, their comments indicate that they appreciate and value the experience. Key pieces of student feedback are provided below:

- *"Although it was really difficult, throwing such a large scale project on the team really enabled me to think more critically and accommodated an environment for me to grow exponentially."*
- *"This was one of the most unique courses we took, and one of the most enjoyable. I feel it genuinely helped in preparing us for the professional world because it is exactly what we will be doing as engineers."*

The basic framework of the course has been demonstrated to provide a rewarding experience for the students, academic staff, and industry practitioners involved. Although challenges still exist (e.g. maintaining consistency across large numbers of students and staff, the need to select a new project each year, etc.) the course is well-positioned to build on its successes, helping to prepare engineering students for the realities of functioning as effective problem solvers in a rapidly changing world.

Acknowledgments (adapted from Brown & Morris, 2020)

The teaching team extends their sincere gratitude to the industry practitioners who have assisted with the development of the Capstone Project, and to the University of Auckland academic staff involved in the development and implementation of the Capstone Project. And finally, a very big "thank you!" is in order for the hundreds of students who have enthusiastically thrown themselves into this project, and who have provided invaluable feedback over the first few years of the course. Future students will have a better educational experience because of you. We wish you all the best.

References

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