COLLABORATIVE ENGINEERING EDUCATION IN THE DIGITAL AGE

Case Study

Engineering Challenges

PUC, Chile

Distinctive feature of case study

Undergraduate teaching assistants co-creating the course's transition online

Student cohort: **830**
Location: **100% online**
Duration: **1 semester (≈15 weeks)**
Date delivered: **March 2020**
Activity type: **Core 1st year course**
New/existing: **Existing activity**
Hands-on element: **At home prototyping**
Cross time-zones: **No**
Case study approved: **Dec 2020**

Activity overview

Engineering Challenges is a first-year design course at the Pontifical Catholic University of Chile (PUC) that challenges multidisciplinary teams of engineering students to develop technology-based solutions to major societal challenges facing Chile.

Independent review

Engineering Challenges caters to a large student cohort and combines a wide range of pedagogies and learning outcomes. Moving the course online was therefore a major undertaking. The success of this online pivot was underpinned by the inclusive and flexible approach taken to co-design by the teaching team, in which undergraduate teaching assistants were empowered to develop and roll out incremental improvements to the course in real time, in response to the students' experiences and feedback.

Institutional setting

With academic rigour at its heart, three characteristics set apart the PUC Engineering undergraduate education: (i) the integration of inter-disciplinary learning; (ii) the concept of 'care', to both support student wellbeing and the application of their learning to drive positive world change; and (iii) a focus on entrepreneurship, innovation and design.

Activity details

Engineering Challenges is a semester-long course – bringing together all incoming engineering students – that moved online for 2020. The course is structured around the user-centred design process with a particular focus on building empathy with a team's chosen user group. The course also introduces students to the broad principles and applications of engineering, and supports the development of their prototyping, modelling and presentation skills.

1. Activity overview

Engineering Challenges is a 'cornerstone' course that provides incoming students – from across the school – with both an introduction to the field of engineering and a framework for their learning over the rest of the five-and-a-half-year undergraduate program. While the course brings together a significant number of components, pedagogies and learning outcomes, its backbone is a user-centred design project that focuses, each year, on a different societal challenge facing the country. In 2020, the theme for the design project was 'Lockdown'. Over 800 newly-enrolled engineering students – none of whom had met in person before starting – were tasked with developing a technology-based solution that addressed challenges facing the Chilean population living under tight COVID-19 restrictions.

To support the development of their team-based project, the course takes a highly structured approach to guiding students through the user-centred design process, scaffolding their progress and learning throughout the semester. This training and development includes scheduled classes in topics such as data analysis and materials selection, workshops to develop modelling and prototyping skills, and sessions dedicated to peer learning and self-reflection. Building empathy and understanding with each team's chosen user group is also a prominent theme; teams must work independently to reach outside their own communities to engage with and listen to members of their user group, as well as work with them to test ideas and prototypes. The course learning outcomes also focus on students' mindsets and skills – including their confidence, collaboration, engagement, ethical decision-making, problem-solving, creativity, prototyping – within a team-based environment.

The introduction of COVID-19 restrictions in Chile – which took all teaching at the university online with immediate effect in March 2020 – coincided with the scheduled start of both the academic year and the Engineering Challenges course. Due to the size and complexity of Engineering Challenges, a number of different approaches were employed to pivot the course online. One major adaptation was to the requirement for teams to produce functional prototypes of their solutions: in the 2020 course, teams were asked instead to develop and test their prototype using 3D modelling, as well as create a 'mockup' of their design using materials found at home.

2. Independent review

2.1. Distinctive features

Before the 2020 online pivot, Engineering Challenges stood apart from peer engineering project-based courses in two key respects. Firstly, the course supports a deep societal connection, with a new theme each year that responds directly to a key challenge facing Chilean society, such as the need for low-cost emergency housing following devastating fires in the country. Secondly, the course has required students to travel off-campus to connect independently and directly with their chosen user groups; in

the example above, students connected with groups such as firefighters and families displaced by the fires.

While these features set Engineering Challenges apart during its pre-COVID, face-to-face delivery, interview feedback pointed to one overriding feature that distinguished the course's transition to online delivery: **co-creation by undergraduate teaching assistants (UGTAs)**. UGTAs have long played an important role in the course's design and delivery, including offering mentorship to the teams and delivering workshops to develop students' prototyping, testing and presentation skills. Interview feedback suggested that the engagement of the UGTAs was also integral to the success of the online pivot of Engineering Challenges and its ability to respond quickly and effectively to student feedback.

In March 2020, the teaching team had less than two weeks' notice to redesign Engineering Challenges for online delivery. The UGTAs' engagement both helped to shape the immediate approach to this online pivot, and to ensure the iterative improvements and changes made to the course throughout the semester. So, for example, prior to the course launch, UGTAs proposed that they deliver a second week of skill-development workshops during the course, to consolidate and apply students' learning. Drawing on their own experience as undergraduates adapting to an online learning environment, the team of 55 UGTAs were also well-placed to listen to and empathise with the challenges and opportunities faced by students during the delivery of the Engineering Challenges course. Acting as a bridge between undergraduate participants and the course teaching team, these issues were quickly identified and acted upon through weekly meetings between the lead UGTA and course director. While many of the ongoing , incremental changes made were minor, they were reported to have played a major role in building student motivation and engagement. Changes informed by UGTA feedback included: (i) when and how course materials and feedback were delivered, such that students were better able to plan and structure their time; and (ii) the online messaging tools used for communication between teams and mentors, which facilitated quicker responses that could also be accessed by students across the cohort.

2.2. Success factors

In addition to the co-creation with UGTAs (as outlined in the 'Distinctive features' section above), interviewee feedback pointed to two further inter-related factors that underpinned the success of the online pivot of Engineering Challenges:

- **high levels of student engagement.** Interview feedback suggested that the levels of student engagement in the online iteration of Engineering Challenges were consistently higher than those apparent in previous years. Described by many as a "*love it or hate it course*", Engineering Challenges had long divided opinion amongst participating students. Some viewed the course as excessively time-consuming for its 10-credit load, squeezing the time they could otherwise devote to the fundamental engineering science courses that populate the rest of the first-year curriculum. Others clearly drew considerable inspiration and engagement from tackling

authentic societal challenges in a competitive team-based environment. These differences in student opinion were still apparent amongst participants in the 2020 online iteration of Engineering Challenges: however, feedback from course leaders and UGTAs pointed to a marked reduction in student dissatisfaction as compared to previous years. Most attributed this to two factors. The first was the opportunity for meaningful interaction and connectivity that the course offered the newly enrolled student cohort, at a time when they were isolated within their homes and studying a curriculum that was otherwise largely delivered in a lecture format. The second factor was that the online delivery appeared to significantly reduce the time burden imposed by Engineering Challenges: the use of Zoom for classes, team interactions and for students' interaction with user groups eliminated the need for students to travel to and from campus across the city which, for many, could consume many hours of their week.

- **flexibility in the course design:** The structure, focus and design of Engineering Challenges have been under continuous redesign and development since its establishment in 2002, as informed by student feedback and review by the teaching team. Interview feedback suggested that this flexibility of the teaching team – not being wedded to a fixed idea of what the course must look like – played a crucial role in its 2020 online pivot. So, for example, when some elements of the course proved problematic to deliver in a remote online setting (such as students' engagement with external user groups or the development of functional prototypes), the teaching team were able to place emphasis on other course elements that were supported by the online delivery (such as students' presentation skills and 3D modelling of prototypes). The course director has played a pivotal role in establishing this flexible and responsive approach: in canvassing feedback, reviewing the issues emerging and driving iterative ongoing improvements to the course, both prior to and during the period of 'emergency teaching'.

2.3. Challenges faced

Engineering Challenges brings together a range of components, pedagogies, and learning outcomes, all delivered to a large and diverse student cohort. As such, the online pivot for the course was a major undertaking. When discussing the challenges associated with the online delivery of the course, interviewee feedback fell into two distinct categories – one focused on the logistics of course delivery and one focused on particular course elements – as outlined below.

Course leaders, school leaders and UGTAs spoke about difficulties associated with the logistics of online course delivery at a time of great uncertainty. These included:

- the instability of faculty and students' internet connections, which presented a particular challenge as the vast majority of the course was delivered synchronously;
- the inability of the teaching team to provide students with a confirmed timetable and set of deliverables for the course, due to changes and uncertainty in the semester schedule;
- the lack of insight into the engagement levels of many student participants, as a high proportion kept webcams turned off during section-wide activities;

- the difficulty of ensuring that students across the 10 discrete course sections each experienced the same quality of learning when teaching teams were unable to interact face-to-face and share their approaches.

Interviewees also pointed to particular course elements of Engineering Challenges that were especially problematic to deliver remotely and online. Three repeatedly highlighted were:

- **supporting informal connectivity across and between teams.** Engineering Challenges is one of five courses that students study on entry to the engineering school, and is the only one that relates specifically to engineering or that integrates team- and peer-based learning. As such, it offers the major curricular mechanism for engineering students to connect and build friendships and networks. While students were able to work and interact within their teams of seven in the 2020 course, interviewees pointed to particular difficulties faced in allowing students to 'mingle' informally and make new connections across different teams. This happened organically in previous years by virtue of students sharing the same physical spaces. As the 2020 course progressed, the teaching team therefore created new activities to support student interaction outside their own teams. For example, students were randomly paired to practice their interviewing technique with another student from the course. In addition, teams were divided in half, and half-teams were randomly paired together to listen to and provide feedback on early iterations of each team's challenge solution and final 'pitch'.
- **establishing meaningful engagements with user groups.** A fundamental characteristic of Engineering Challenges is the requirement for teams to identify and build empathy with their chosen user group. Prior to 2020, teams were asked to travel off campus to meet with and interview user group members at specific points in the design process, to better understand their needs, experiences and perspectives. These interactions were designed to challenge assumptions and preconceptions that students might have held about users from demographic groups different to their own; it had been a clear stipulation of the course that these users should not have been previously known or connected to any members of the team. Without the ability to travel outside their homes in the 2020 online course delivery, teams struggled to identify and broker such new external connections. The teaching team therefore amended its guidance to allow teams to draw upon the network of the school's student and alumni networks to forge virtual connections with user groups, and also to allow them to speak with individuals with insight into the user group rather than the group themselves (so, for example, speaking to school teachers rather than children).
- **creating an interactive and engaging closing exhibition**. Engineering Challenges closes with what is described as a 'technological fair': a major exhibition, open to the public, where students showcase their ideas and interact with visitors and judges from industry and the regional community. UGTAs, in particular, spoke about the importance of this exhibition as a culmination to the course during previous years, and the pride and excitement of students as they exhibited their projects. In the words of one UGTA, "*it is a formal thing, we put on our suits and everyone comes to see what we have done. It is a closure for what we have achieved*". While the technological exhibition was delivered at the close of the 2020 course, many interviewees noted

that its online delivery (using Zoom) did not offer students an equivalent to the face-to-face experience in terms of the "*atmosphere of excitement*" or the ability to network with individuals from across and beyond the university.

2.4. Advantages of online delivery

Despite the challenges faced, teaching team members pointed to three respects in which the online delivery of the 2020 Engineering Challenges offered advantages over the face-to-face approach used in previous years:

- **flipped classroom approach.** Engineering Challenges dedicates three hour-long 'classes' per week to introduce students to fundamental engineering concepts and the key stages of the user-centred design process. In previous years, this class time was devoted to a mixture of lectures and peer-learning activities in topics such as data analysis, estimation, and materials selection. In the 2020 course delivery, all theoretical content was delivered in the form of short videos made available in advance, with the synchronous 'class' time dedicated wholly to discussion and activities. Teaching team members consistently noted the advantages of this approach, which allowed much more flexibility during class time for students to apply their learning to their team projects.
- **greater focus on modelling and presentation of ideas.** The 2020 course delivery removed the workshop training component as well as the requirement for teams to build a functional prototype. Instead, teams were asked to develop 3D models as well as create at-home mockups of their solutions. Despite the loss of important hands-on learning components, teaching teams pointed to the benefits that teams derived from having additional time to devote to iterating their ideas and presenting their final solutions. In previous years, the prototype build was often time-consuming and a task that teams therefore started at a relatively early stage in their solution development. Teaching team members noted that the development of online 3D models allowed teams to dedicate more time to iteration and testing of their ideas, which resulted in more appropriate and well-considered solutions. The quality of final presentations was also noted to have improved, with teams dedicating more time to developing their pitching and design skills.
- **greater efficiency in team working and evidence gathering.** Students and teaching team members noted that the use of videoconferencing and other online interaction tools adopted for the 2020 course played an important role in increasing the efficiency of many team tasks and activities. Most prominent was the reduction in time spent in travelling to and from the PUC campus – which is based in a suburb of Santiago – to connect face-to-face with other team members or user groups. Messaging platforms – such as Discord – were seen to improve communication between groups and with UGTAs, providing rapid answers to questions that could be shared across the student cohort. Other technologies were employed within teams to

improve decision making, such as a system by which team members could vote anonymously for their preferred idea from the selection of those proposed during the ideation process.

Plans are in place to incorporate each of the above components into Engineering Challenges after the COVID-19 restrictions are lifted. The teaching team is also considering taking some of these ideas further in next year's course. One example is to connect teams remotely with the Challenge 'judges' – the group of 80 engineers, designer and experts in the Challenge topic who assess teams' solution at the end of the semester – at an earlier stage in the course, such that teams can benefit from their feedback during the design process.

Source of evidence: the independent review of the Engineering Challenges drew upon one-to-one interviews with 12 individuals: two school leaders, two course leaders, four UGTAs and four undergraduate course participants. More information about the case study research methodology is provided at the project website: http://www.ceeda.org/about/selection-development-process.

3. Institutional setting

3.1. What are the defining features of the school's educational approach?

Like engineering schools across Chile, PUC Engineering has historically delivered long (seven-year) undergraduate engineering programs that were dedicated almost exclusively to mathematical and scientific fundamentals. The past decade, however, has seen a radical shift in the school's educational approach.

A shorter, five-and-a-half-year undergraduate curriculum, has been developed. While academic rigour remains at its core, three major new themes have emerged. Firstly, there is a stronger focus on interdisciplinary learning, with the introduction of new interdisciplinary programs, activities and majors in areas such as sustainability and AI. Secondly, there is a greater emphasis on what is termed 'care', built both within the student and faculty communities (via a suite of support and mentorship programs) and through connectivity with the regional and national community (with many curricular and non-curricular activities linked to external communities to address challenges and innovations in Chilean society and industry). Thirdly, greater prominence is given to design, entrepreneurship and innovation, whose prominence has grown significantly in the past five years. For example, the school has established a suite of opportunities to develop students' capabilities in technology-based entrepreneurship both within and outside the curriculum, including a 'sister' course to Engineering Challenges in the third year of study, where multidisciplinary student teams from across the engineering school work with regional entrepreneurs to develop and launch technology-based start-ups.

3.2. What is the school's approach and vision in educational technology?

Educational technology has not played a prominent role within the PUC Engineering undergraduate curriculum. However, since 2015, the school has offered subsidies for faculty to create Spanish-language massive open online courses (MOOCs) across a range of topics to support engineering learning across Latin America. Since the transition to 'emergency' online learning in November 2019, the school's priorities for MOOCs' development have shifted: funding is now directed at MOOCs and associated online material that can be utilized within the PUC Engineering undergraduate programs.

3.3. What has been the approach to COVID-19 'emergency teaching'?

Due to social unrest across the country, the university first pivoted online in November 2019. Shortly after these emergency teaching measures were eased, they were reinstated due to the COVID-19 restrictions from mid-March 2020. The imposition of COVID-19 restrictions coincided with the start of the academic year and the start of the Engineering Challenges course, which, like all other courses in PUC Engineering, was taught 100% online.

The school took a decentralised approach to the online pivot. Faculty and teaching teams were asked to develop an online/remote version of their courses in whatever way worked best for their subject, students and areas of expertise. The only stipulation set by the Dean was that the approach must not disadvantage any student group, particularly those without access to fast/reliable internet or other equipment. So, for example, the Electrical Engineering department posted circuit components to their students, but did not penalise those unwilling to use the kit due to concerns of infection risk. Some interviewees noted that the online pivot at PUC Engineering benefitted from the MOOCs that many of the school's faculty had previously prepared; although never intended for delivery to undergraduates in the school, much of this material could be easily adapted to curricular courses and activities.

Interview feedback pointed to a number of benefits to student learning of this online pivot. Levels of student engagement with the online courses and materials were reported to be higher than pre-2020, with many students reviewing online materials multiple times in advance of synchronous classes. A "*closer relationship between professors and students*" was also reported, with a wider range of students willing to ask questions and post ideas through anonymous 'chat' functions than would have been willing to do so in person within a lecture theatre.

Feedback also pointed to two major challenges faced by the school in its online pivot. The **first challenge** was in student evaluation: the practicalities of administering mid- and end-of-semester synchronous tests and examinations, particularly where many students experienced intermittent or slow internet access. In response, the school moved away from large-scale exams at the mid-point and end of semester and instead instigated continuous assessments through, for example, weekly testing of students. The **second challenge** was around students' mental health: both their exhaustion from dedicating long days working onscreen and their anxiety in coping with the uncertainty and impact of both the national social unrest and the COVID-19 pandemic. The Dean of the school instituted weekly

meetings – open to the full undergraduate community – to allow students to raise and discuss the problems they were facing. Mid-semester student surveys of a number of courses – including Engineering Challenges – captured feedback on students' wellbeing and ability to work. As a result of the feedback received, a series of changes and adjustments were made to alleviate these difficulties. These included the introduction of a 'recess week' in the middle of the fall 2020 semester, where no additional work was set, and the appointment of additional psychologists to the school to offer students one-to-one mental health support.

3.4. What is the impact of 'emergency teaching' on future educational strategy?

The school's experience during its two periods of emergency online teaching – due to the social unrest in late 2019 and early 2020, as well as due to COVID-19 – is likely to have a considerable impact on its educational approach once face-to-face learning again becomes possible. As outlined below, three sets of changes are currently under discussion:

- **pedagogical approach.** Following the lifting of the COVID-19 restrictions, it is envisioned that many of the online delivery modes and associated pedagogical approaches will be maintained. For example, many courses will retain a flipped classroom approach, where online material will be delivered in advance in the form of short videos, and synchronous in-class time is dedicated to group-based or peer-to-peer learning. Courses involving hands-on learning will also retain a strong emphasis on 3D modelling and testing, as mechanisms to allow students to refine and iterate ideas further before embarking on the physical production of a functional prototype. In addition, much greater use will be made of videoconferencing when asking students to connect and interact with external stakeholders.
- **connectivity with society.** The school is looking at ways in which it can position itself even more explicitly – in both its research and educational activities – as an engine for positive societal and economic change in Chile. PUC Engineering is looking at ways to further build its external connectivity and take students' learning into the community.
- **'care' for students.** Since 2018, PUC Engineering has placed an increasing focus on 'care' for students – through offering personal support and establishing an 'emotionally safe' environment for learning – with a line item of the school's budget dedicated to these activities. The school's Engineering Education Unit is also conducting research into the 'care' practices currently delivered by the school and how these might be developed in the future. The experience of COVID-19 and emergency teaching has brought the issues of students' mental health into sharp focus and interviewee feedback suggested that the issue of 'care' for students would only become a more prominent component of the school's approach in the future.
- **graduate attributes.** The school is considering a reform to its stated graduate attributes, with a new and explicit focus on building students' resilience and ability to navigate uncertainty and change in both their personal and working lives.

4. Activity details

4.1. Participants

All incoming students to PUC Engineering take the Engineering Challenges; in 2020 the cohort size was 830. This full-year cohort is randomly divided into 10 sections of 80–85 students, with each section overseen by one engineering faculty member. The sections are divided into 12 teams, each of around seven students. The composition of the teams is based on an algorithm that ensures at least two women in each team, with members taken from a range of backgrounds, engineering disciplines, modes of entry to the university and geographic locations pre-university entry.

Students enter the course from high school, with almost no background in either engineering or design. The cohort participating in the online version of Engineering Challenges in March 2020 were all new to the university and very few had connected in person prior to the course.

4.2. Structure of the course

Engineering Challenges[1] is a course delivered in the first semester to all first-year students entering the engineering school. As a 10-credit course from a total 50-credit load in the first semester, students are expected to dedicate 10 hours per week to Engineering Challenges, which includes three hours of scheduled 'class time' with most of the remaining time dedicated to team-based project work. It should be noted that the course usually runs for 15 weeks, but this was reduced to 12 weeks for 2020 to accommodate the rapid shift online as well as the introduction of an additional 'reccess week'.

Outlined below are the major components included in the 2020 online delivery of the course.

Kick-off session	In the opening week, video footage and guest speakers were used to introduce the challenge context to student participants. A video was also shown featuring members of the previous year's winning team, who offered reflections and advice for the new student cohort.
Team projects	The spine of the course was the team-based project, which was structured around the user-centred design process. The four main phases of the project development were: 1. **Context assessment:** teams identified a user group within the challenge context and developed empathy with and understanding of the group's experiences, needs and aspirations through conducting at least 30 interviews. Teams also selected their chosen problem and identified a range of existing solutions. 2. **Design opportunity:** teams selected one design opportunity, identified a range of existing solutions and ideated three possible novel solutions. 3. **Idea development:** teams developed, modelled and created one mockup prototype of their chosen idea.

[1] Engineering Challenges online course information: http://ing1004.ing.uc.cl.

	4. **Analysis and testing:** teams tested their solution (both using 3D modelling as well as gathering feedback on the concept from user and expert groups), and prepared their five-minute 'pitch' for the closing exhibition. At the close of each phase, teams presented their progress/ideas to their 'section' of the course, which comprised 12 teams.
Structured 'classes' and development	Throughout the semester, three hour-long classes per week were used to deliver theory and build skill development (in topics such as mathematical modelling and interview techniques) to support and inform students' progress at each stage of the design process. In the 2020 course, these classes took a 'flipped classroom' approach, with the 'theory' delivered in advance in the form of short videos, and synchronous class time dedicated to discussion around the topics or application of the ideas within teams.
One-week workshops	During two separate weeks of the course, UGTAs delivered workshops to build the skills students needed to design, research, test, validate and present their solution online. Each team member was expected to attend a different workshop and relay their learning back to the rest of the team. While pre-2020 workshops covered skills such as CNC machining and laser cutting, the 2020 workshops focused on skills that students could develop and apply at home. Five core workshops were offered to students in all sections (Arduino, Illustrator, physical 'at home' prototyping, digital prototyping, and 3D modelling). Additional workshops were also designed to respond to the particular projects under development in each section and the particular skills that members would need to prototype and present them. The second week of workshops was introduced for the 2020 course, to provide additional and dedicated support for students to apply these particular skills to their team's project.
Technology exhibition	The culmination of the semester-long course was a closing exhibition, where teams pitched their ideas to a judging panel of engineers, designers and subject-matter experts. The exhibition was open to all members of the academic and regional communities.

4.3. The challenge

The challenge theme for the course changes each year, and is a closely-guarded secret before it is announced to the full student community during the first week of the semester. The challenge theme for Engineering Challenges 2020 was 'Lockdown': the confinement of the national population during the COVID-19 pandemic. Teams were able to consider this theme from the individual or systems perspective. Within this broad theme, the solutions[2] developed by teams addressed a wide range of problems, including how garbage build-up can be reduced in tenement buildings, how to provide exercise for dogs who were unable to be walked outside, and how to offer daily structure for autistic children who were dislocated from familiar routines outside of the home.

[2] The deliverables produced by each team in the 2020 Engineering Challenges are available online: http://ing1004.ing.uc.cl/?page_id=2719.

4.4. Deliverables and assessment

Similar to the previous face-to-face delivery of Engineering Challenges, the 2020 course incorporated deliverables both for each team and for each individual student. These team and individual deliverables are outlined below.

Team deliverables: teams were asked to deliver presentations at the conclusion of each of the four major phases of the course. Each 'section' of 80–85 students came together for these presentations, which each took place over one week. Structured around the user-centred design process, the four presentations focused on:

1. context assessment: identification of, and evidence gathered from, the team's chosen user group;
2. design opportunity: presentation of design requirements and three potential solutions;
3. development of idea: development and prototyping of the team's chosen idea;
4. analysis and testing: presentation of the team's chosen solution, including background research.

The final presentations were delivered via Zoom at an online 'technological fair' to two panels of judges, each comprising one engineer, one designer and one expert relevant to the team's solution. In this final five-minute 'pitch', teams were required to bring together key elements of their previous three presentations. For each of these four presentations, students provided peer-assessment on the contribution of their team-mates to the progress and working environment of the group.

Top-rated teams from each section were taken forward to a competition final at the close of the fair.

Individual deliverables: students were asked to submit ongoing assignments related to the weekly 'classes', which were typically evaluated by peers or UGTAs. In the pre-2020 iteration of Engineering Challenges, students also took a mid-term test and a final exam that explored their individual contribution to the group project. Both of these assessments were removed for the 2020 online delivery of the course. Feedback from teaching team members suggests that these components will not be reintroduced into the course in the future, as their removal appeared to have limited impact on student learning and progress.

4.5. The teaching team

The teaching team supporting Engineering Challenges is outlined below:

- **10 engineering faculty members**, including one course director. Each faculty member oversaw one section of 85 students, delivered the weekly classes to this group (to a common template, consistent across all sections) and acted as a mentor to students teams (offering weekly technical support and feedback). The selection of faculty members changes each year depending on the blend of expertise that students will need to draw upon to tackle that year's

challenge. The course director coodinated all participating faculty and UGTAs, who were taken from across and beyond PUC Engineering.

- **55 UGTAs**, including one lead UGTA. One team of five UGTAs was assigned to each section of 80–85 students, of which four were senior engineering undergraduates (who had themselves participated in Engineering Challenges during their first year of study) and one was a senior design undergraduate. UGTAs designed and delivered the workshops (which sought to build students' prototyping, modelling and presentation skills) and provided mentorship and advice directly to teams in their section. The lead UGTA's role was to gather feedback and suggestions from UGTAs across all sections, and to liaise with the course director.
- **80 judges**, working in groups of three: one engineer, one designer and one expert in the challenge context. The 'expert' judges were selected after the second team presentations – where the teams' ideas are showcased – to ensure that judges' background and experience were aligned with the types of problems and projects that teams were working on. For example, for the 2020 course, a significant number of teams focused on health (maintaining mental and physical health while under confinement) and sports (undertaking physical training while under confinement), so the expert judges selected included psychologists, clinicians, personal trainers and sports scientists.

Although not part of the teaching team, an undergraduate mentor is also assigned to each team of seven students on the Engineering Challenges course, to support their social development and integration into the engineering school throughout their first academic year of study.

4.6. Technology used

The following technology was used to support the online delivery of Engineering Challenges:

- Canvas was used to establish the learning map for the course, and provide students with all major materials such as readings, tasks, videos and content. Within Canvas, SpeedGrader was used to provide student feedback;
- Zoom and Google Meet were used to host all classes, team-working sessions, workshops and mentorship sessions;
- other platforms and chat functions were used by teams and UGTAs to share ideas, ask questions and interact, including Discord and Milanote.