Doing Design Differently: Hybrid Teaching in the age of Covid-19

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Somewhat uniquely, in our department, we teach a version of engineering design to each of 4 year groups registered for the M.Eng (masters in engineering) in chemical engineering. These design projects culminate with a final-year group design, but students are introduced to group design in their second week of their first year of study. The first-year design project deliverables are assessed, but equally the design project serves as an opportunity for students to get to know one another through organised group work and serves as an introduction to the concept of design in a chemical engineering context. The first-year design project has traditionally been taught face-to-face (F2F), with the design project taught in 2 cohorts of ~75 students to accommodate the students enrolled in the first year of the programme (approximately 150-160 in total). Lockdown restrictions last year due to the COVID-19 pandemic (COVID) meant that the design project was redesigned as a remote teaching model which was delivered very successfully using Microsoft TEAMS. This academic year, some restrictions have lifted and as a result of which a hybrid model for teaching the first-year design project has been adopted.

In this paper, this hybrid model of teaching is discussed along with the challenges faced in designing and delivering it. For example, one of the main challenges we faced was how to keep students and staff safe when they were on campus, which was not a concern pre-pandemic. Important decisions have been made about how to vary assessment measures [1] for example by having students give a pre-recorded, non-assessed group presentation, and to then use the constructive feedback to prepare a live, assessed, group presentation. Similarly, we were obliged to re-consider how best to support peer-to-peer collaboration [2] with students being set collective goals, and meeting face-to-face on a group rotational basis once a week with contribution and attendance being periodically monitored. Furthermore, students were encouraged to make use of sanitised study space in the department, and to actively converse through TEAMS as and when appropriate. Additionally, challenges arose with managing academic support effectively with most of the support offered face-to-face through team teaching in blocks. Other challenges faced included ensuring the available teaching space could be kept safe [3], and that time could be managed effectively. The disadvantages and benefits of adopting a hybrid model of teaching are explored from both staff and student viewpoints, by critically reflecting on student evaluations for the module and the perceptions of staff retrospectively.

Introduction

The design project

In our chemical engineering department at a research-intensive higher education institution (HEI) in the UK, we have been running a design project for our 1st year cohort since the early 1980s (with precursors established in the 1960s [4]). In its present manifestation, the Engineering Design course is part of a core 1st year module on Engineering Practice, with Chemical Engineering Laboratories and MATLAB contributing the other two components. Engineering Design is one of the very first courses that students engage with and acts as a useful means to introduce them to the actual work of a professional chemical engineer. The initial intention of the design project was to introduce students to engineering conventions and procedures that can be carried forward into subsequent design and later projects [5]. This
primary intention has not changed over the years with identifying and solving a chemical engineering design problem at the heart of the course (Ibid.). However, there have been certain shifts in terms of the course material, and in the design and delivery of the project itself. For example, in the earliest version students were introduced to the nature of problems (discerning the difference between those of description, calculation, explanation and invention). In the current version, there is greater focus on what specific questions need to fully understand and comprehend the scope and nature of an engineering problem. It is a common element of most high school science curriculums to focus the students on providing detailed solutions to a clearly defined problem. The critical skills of learning how to frame and comprehend a problem from primary sources such as end users, clients, society or management are not taught. Students need to make sense of the answers from such primary sources and establish how all this information together allows the problem to be defined, but more importantly they need to learn the right questions to ask. The notion of problem statements were introduced to students in both earlier course versions and in the current version with students working in groups of 5-6, and they are expected to demonstrate their creative flair in addition to solving the actual problem.

In the original version of the 1st year design project, students were addressing a design problem based on the unacceptably high radioactivity levels in part of a pressurised water nuclear reactor. In the entirely face-to-face (F2F) iteration of pre-pandemic years (2019 model), students would spend 2 weeks working on the course, and are presented with 2 group design problems:

- Determining the number of homes that can be heated from excess heat produced by a nuclear power plant – outcomes are assessed through a group presentation and design brief. Serves as a mock exercise from which students receive formative feedback.
- Redesign of a chemical process plant by replacing individual process coolers and heaters with heat exchangers to reduce running costs – solutions proposed are assessed through a website, group presentation and design brief. Outcomes are formally assessed.

During the F2F 2-week course (that consists of 8 afternoon sessions of 3 hours each), students are introduced to some important engineering ideas and concepts through lectures, including how to ask questions, the content and structure of a design brief, and the principles of heat exchangers. Students are then expected to work in their groups to solve the problems, produce the assessments by the deadline, and seek help from academic members of staff and graduate teaching assistant (GTA) facilitators, who effectively float around the room checking in on groups periodically. In the F2F model, students are expected to attend the taught sessions and contribute to the assessments. As the students are required to prepare 2 group presentations (one for the trial first exercise and a second for the assessed exercise) groups periodically look for quieter spaces e.g. seminar rooms in order to prepare these specific assignments.

Teaching in the age of COVID-19

The onset of COVID-19 accelerated a teaching and learning revolution, especially with respect to technology, with the higher education community developing a greater appreciation of how technology could be used to support student learning [6]. Students themselves are digital
natives who are more adapted to learning through technology than those teaching them. As such, they are acutely aware of what enhances their student learning experience. For example, a recent survey suggests that live lectures are more appreciated than pre-recorded ones, and students demonstrate a preference for eye contact and visual expressions from tutors (even though they themselves might be invisible) [7].

An exclusively remote model of teaching does not allow the important relationships students need to foster with one another and members of staff to develop in an exclusively online teaching environment [8]. Whether students actively engage with it or not, group work also reflects the real work-based scenarios that students, with good working relationships that foster good teamwork behaviours becoming an integral part of their professional working practices [9]. It is important to acknowledge that a by-product of COVID-19 is a reconsideration of professional working practices that might also be more hybrid in nature going forward [10] so this approach serves as a useful way of preparing students for a different working culture in the future.

**Alternative models of teaching design project**

Over the past couple of years, we have had to reconsider the delivery of our first-year engineering design project with particular care and attention, as is the case with other institutional engineering design projects [11][12]. Goldberg [11] reflects on how he tried to retain the educational aims of the project he was delivering, but that students had to be inventive with the resources they could use and readily be able to access them for the project during a lockdown period. Similarly, Jamieson [12] grappled with the creation and maintenance of an online community of learners and discussions on reworking assessment. Even though it was important for the teaching staff involved with our particular chemical engineering design course to retain the core philosophies and educational outcomes, due to the onset of COVID-19, several modifications were made to accommodate students learning experiences differently through a hybrid model of teaching.

Figure 1 highlights some of the changes between an entirely F2F model (2019), an entirely remote teaching model during a Government-imposed lockdown (2020), and a hybrid model that was in place for this academic year (2021). As expected, and as previous research has indicated, hybrid models of teaching require careful thought and planning in terms of both design and execution, with contingency plans in place. Unlike F2F teaching, which depends on resources (teaching staff and appropriate classrooms), and remote learning which depends on technological advances (good internet connections and digital platforms that enhance collaboration), the hybrid model required us to focus on all of these aspects and more in specific ways to facilitate students’ learning. For example, Figure 1 shows that digital platforms were still a necessity post lockdown and as part of a hybrid model, as students periodically had to self-isolate if they had either tested positive for the SARS-CoV-2 virus, or come into close contact with others who had, or if they were unable to physically be in the UK. Similarly, feedback was delivered both remotely and F2F in the hybrid model, and this was facilitated with the use of proforma-type assessment documents so we could work to similar standards irrespective of the delivery medium. Students expect that similar levels of detail are maintained and care given when it comes to formative feedback [7].
Some challenges arose with the hybrid model. For example, the premises had to be kept as safe as possible at all times, which is a growing concern post-pandemic [13]. Fortunately we have a dedicated design room which would ordinarily accommodate between 70-80 individuals (F2F and pre-pandemic). The layout of this room had to be redesigned, with fewer tables, fewer chairs around the tables (6 rather than 10) and for them to be appropriately distanced from one another. Our department applied a rigorous safety risk analysis to the teaching environment for all courses which were being taught F2F. It started with an reconfiguration of the room layout, providing safe working distances for all in the classroom. The department had a compulsory face-mask policy, so all students and teaching staff wore facemasks throughout each of the 3 hour teaching sessions. A small number of students, 1 or 2 in each class, had face mask exemptions, and were issued with “I am facemask exempt” badges to wear. In practise, compliance with the wearing of facemasks was very high, always above 90%. Occasionally, a few students in a cohort of 160 required continual reminders. In addition, we provided free facemasks and handwash in the classroom at all times. No member of the teaching staff, 4 academics and 6 GTA reported being COVID-19 positive during the period the course ran. The teaching itself was also intense at times as each session was taught thrice a week – a demanding undertaking of the core teaching team, especially the course convenor. In addition, during the course, some students were unable to attend physically due to mandatory isolation because of COVID-19 illness or visa restrictions, so in the F2F element of the hybrid teaching, some groups had members who were working with them using TEAMS remotely.

The research question and methodology

In this paper we are exploring how different modalities of teaching affect student learning of design by comparing and contrasting the 3 modalities we utilised to teach the design project: F2F (2019), remote (2020) and hybrid (2021). In terms of the methodology, students completed surveys and brief interviews were held with members of staff and supporting staff to establish how conducive each modality was to learning and teaching. As part of a wider discussion, we are presenting some of the key choices made with respect to design and delivery of the taught content as the situation changed during the COVID-19 pandemic.

Evidence and analysis on the hybrid modality

Feedback from academic staff and GTAs

Data was obtained from academic staff and supporting staff, on how they found and adjusted to the hybrid model of teaching. The 1st year design course was the first exposure that any of our undergraduate 1st year students had to hybrid teaching with respect to practical coursework, so it was important to appreciate whether it was still a useful learning experience. Comments from GTAs were mostly positive:

I thought that the module itself was taught in quite an engaging manner … I found that students were instantly stimulated as groups. Being open-ended it really pushed them to start thinking about problems in a different, more "real world" manner - an important part of becoming an engineer. I thought that the students were generally better at engaging with one another in F2F format, though saying that I think that applies to myself also. I found teaching far more engaging, and practical for that
matter, when interacting F2F; the ability to share information is heavily improved, for instance, being able to draw on a schematic to help them understand a PFD (something which I imagine could be done online, but not without some hassle - perhaps some space for improvement with teams). However, I understand the necessity for the hybrid format - given the difficulty of being able to fit all students in a room whilst social distancing, the way the course was set out was the best of both worlds. Teaching was streamlined by not having to repeat the same core information over and over, but the students and staff all got to engage in F2F activities which I felt was very important for the success of the module.

GTA 1

My experience as a teaching assistant for the First-year design course in the 2021/22 academic year has been a largely positive one. The hybrid teaching format consisted of weekly in person sessions for group discussion and occasional Teams meetings constituting lectures and breakout rooms for the full cohort. As Group work is a daunting prospect for many, and something that many incoming undergraduates will not have interacted with before, I think the in-person parts of the course allowed the students to communicate more comfortably with each other. They were particularly useful for quieter students to be involved fully in the group work. I also believe it helped teaching assistants and staff to appear more approachable for help than is sometimes the case with remote learning. The remote teaching elements of the course functioned well, with some initial confusion over breakout rooms allocations unavoidable. Importantly, helping to deliver the course felt like a minimal COVID risk due to the splitting of the first-year cohort into three groups and the use of a large hall for sessions.

GTA 2

Both GTAs have reflected on the importance of student peer-to-peer interaction, and how much that seemed to benefit students and enhance their learning experience. From the perspective of these GTAs, students were able to engage in a way that was comfortable for them. Additionally, comments are made about safety and COVID-19 risks, with both appreciating the measures that were in place.

One member of staff had the following to say about the experience:

Personally, I found it hugely challenging. I spent an hour on the tube [London-wide transport system], 3 hours teaching and back on the tube – masked up the whole time. Most days I would go to bed with a splitting headache, especially as I came in 3 days a week. As a learning experience for our students though, I felt it was really, really positive. They could meet and talk to their peers, work through the problems together. They finally experienced university life as it should be experienced. We went to great lengths to create a relaxed environment – it was as much about social interactions as it was about learning. Not everything was F2F, and I think it was useful that all-group lectures for example were delivered remotely. Even going forward this might be a good practice – we should do more with technology. It felt safe in the department. We had so many procedures in place if anyone got sick, bottles of hand sanitiser at every table and boxes of face masks appeared regularly.

Academic staff 1

The experience of the member of academic staff recognised the physical difficulty of teaching during the pandemic, but that student-to-student engagement was important for student
learning (as mentioned by the GTAs). An interesting comment is made about how hybrid teaching could be a useful model going forward.

**Feedback from students**

Periodically, students have been invited to complete a departmental survey that has served as a ‘stop-check’ tool for staff throughout the pandemic in a bid to monitor how students are getting on. Different and varied questions are asked of all students in all year groups. Information has been isolated that pertains to 1st year design project and students’ experiences of it during 2020 (remote modality) and 2021 (hybrid modality). We were not able to capture data for 2019 as the monitoring surveys were not in use at that time. For the year 2020, 70 students completed the survey and for the year 2021, 46 students completed the survey. As there is disparity between the numbers, the survey responses to 3 statements (1. I am able to follow the project 2. I am comfortable asking for support for project work 3. I feel the project is being delivered in a way that supports my learning, given restrictions) have been presented as percentages in Figures 2, 3 and 4 respectively. Students were invited to provide additional open-text comments anonymously as part of the survey design. Some of these are included in this section.

![Figure 2: Student responses by percentages (Likert scale) for the statement ‘I am able to follow the project’](image)

Open text comments for remote-learning model:

- The time slot is quite late for me. Other things are fine as it is well explained and structured.
- It could be better if the objective of the course could be made clearer. Our group was more focused on the calculations rather than the layout of the presentation etc. It would be a lot better for me personally, if it were emphasised that getting the correct numbers was not the main objective.
➢ The module was a bit tiring. Having a three hour session while sat in a chair isn’t the best.
➢ Slightly more guidance on which direction we should look to reach the expected solution would be nice. Sometimes the task seemed too vague and it was unclear what was required to be included as part of our final solution.
➢ I am aware that this year was a special case due to COVID-19, but this module was particularly hard for us students in the far east, as lectures/group work would often end very late (2am). I know no one is to blame for this but, for future situations (not that pandemics happen very often), maybe take into further account students from other time zones.

Open-text comments for hybrid-learning model:
➢ We had to turn up to all the lectures, someone was taking a register initially (like you were at school). I missed a few as I was isolating, but I connected with my team through my laptop. If you missed things, your team could fill you in.
➢ Too abstract. It was very confusing to begin with. Not everyone understood what was going on.

![I feel comfortable asking for support for project work](image)

Figure 3: Student responses by percentages (Likert scale) for the statement ‘I feel comfortable asking for support for project work’

Open text comments for remote-learning model:
➢ GTAs for each group worked very well and they were very responsive and helpful. The only negative was WIX didn't work very well for collaborative work but the teachers are aware of that.
➢ GTAs provide great help and it is really good to allocate people with about the same
time zone in a group in this year's condition.
➢ Group work was particularly hard to organise over TEAMS.
➢ Regarding the circumstances, and the hours associated to the design project, it was
really tough to meet up as a group and discuss/work on the project. Therefore we mostly
spent our Wednesday afternoon's to work on the project because there were no other
hours assigned for it. Overall, if there could be more time assigned to work on it 'freely'
as a group (without really the necessity of a GTA) that would relief pressure
encountered at some times during the hours spent for the design project!

Open-text comments for hybrid-learning model:

➢ Our GTA was really helpful. They seemed to be able to tell when we were stuck and
when we needed help from them without us having to say very much to them. I think
all GTAs were nice and friendly.
➢ The feedback on the mock we did was helpful for the design brief and the presentation
as you could make changes and have another go. The GTAs were always more
encouraging than the lecturers.
➢ There should have been more access to the lecturers and GTAs. One afternoon a week
is not enough for a project like this one. It was a lot of work.

![I feel the project is being delivered in a way that supports my learning, given restrictions](image)

Figure 4: Student responses by percentages (Likert scale) for the statement ‘I feel the project is being
delivered in a way that supports my learning, given restrictions’

Open-text comments for remote-learning model:

➢ While I highly enjoyed this course, the way information is provided to us could be
clearer and easier to follow, because I was not sure if my group has all the information
needed for the problem, and sometimes the TA-s weren't sure either.
➢ There should have been more emphasis on how we are graded and the importance of different features. It is also unfair to mark students upon uses of different technology such as which software to use to record as this was not specified, and things like microphones as these are not provided and students aren't at fault for the quality of those.

➢ Given current restrictions, the module was delivered as best as could have been.

Open-text comments for hybrid-learning model:

➢ I would have preferred to be in the design rooms more than we were as it was a good space for being able to discuss things and get help. We only had one session a week there, which meant the project dragged on for 6 or 7 weeks.

➢ It was intense, especially at the end. I liked working on different bits of the project at different times though – doing the presentation, putting the website together. I was told by my friend in the second year that they had to do this project online, which would have been difficult.

Interestingly, all 3 graphs indicate broad similarity between student experiences in terms of the percentage response regarding satisfaction. A few key differences worthy of note however, is that there is some discrepancy between agree and somewhat agree for the first statement ‘I was able to follow the project’, with the agree response being higher for the hybrid-learning model and the somewhat agree response being greater for the remote-learning model. Similarly, when students were asked about how comfortable they felt asking for support, the hybrid-learning model has a greater percentage response for moderately comfortable and the remote-learning model a larger percentage response for slightly comfortable. More significant is the difference in percentage margins for the third statement ‘I feel the project is being delivered in a way that supports my learning, given restrictions’ where the hybrid-learning model scores relatively well in the strongly agree response, whereas the remote-learning model scores well in the somewhat agree response. The additional open-text comments provided by students also indicate levels of similarity between the remote-learning and hybrid-learning models, although equally there are some important differences. For example, the support offered by the GTAs was appreciated in both modalities with GTAs agreeing to be easily accessible to students when the teaching was entirely remote (2020). However, students in East Asia felt they were hindered by time differences in the remote-learning model and the request that they access live lectures which were scheduled at 14:00 Greenwich Mean Time (GMT). We did not analyse the frequency with which students accessed the pre-recorded material, although this may have been a useful exercise.

It is worth noting from personal observation, that attendance rates were best for the F2F modality (approximately 95%), and were fairly good for the hybrid modality (approximately 85-90%). It was difficult to determine how regularly students met as a group (outside of scheduled time slots) for the remote modality, although attendance was high (approximately 90%) for live lectures during this period. Equally, students’ grade averages were broadly comparable with some expected differences as a response to the quantity and quality of support students were able to access. The modal average for the F2F modality was a mid-range ‘A grade’, for the remote modality it was a high ‘B grade’ and for the hybrid modality it was a low ‘A grade’.
Discussion and concluding remark

Our experiences of switching from F2F to remote learning to hybrid learning in the space of 3 years, suggests that HEIs are more equipped than we might have thought possible of teaching in different modalities. In the early stages of the pandemic, it was not feasible to make informed choices, and decisions had to be made quickly which was the case for many in the higher education sector [14]. Students by and large responded positively towards the design project and their learning experience with some of their responses and associated comments not being out of place among former cohorts in pre-pandemic years. With respect to the hybrid-learning approach in particular, even though this was introduced as part of a stop-gap protocol, arguments can be made for hybrid teaching on a more permanent basis. Research suggests that the amount of time, resources and costs that have gone into hybrid teaching has made it expensive [15]. Therefore it would be useful to develop and build on hybrid approaches to extend their viability, especially if the after-effects of the pandemic remain with us for a few years. As an accelerator of digitalisation, hybrid learning allows for flexibility and introduces students to multimodal learning that potentially serves them better [16]. International students are still able to access their education, although serious concerns are raised about the quality of the access (mentioned later). From observation, students seemed to benefit from being able to access the lectures and collaborate with their peers if they were away from the physical classroom due to testing positive for the SARS-coV-2 virus or visa restrictions. A secondary advantage of social distancing meant that in comparison to our regular F2F practice (2019), student numbers were smaller when students were F2F in the hybrid model (from approximately 75 to 50), and received more attention and help from staff and facilitators. It was interesting that one of the students in their open-text comments pointed out that their GTA facilitator could effectively ‘read the room’ and from the students’ expressions and body language determine whether they needed help or not. This more immediate appreciation of students’ moods is missed in remote teaching scenarios, but could equally be missed in large classes.

It is important that a careful balancing act takes place when considering a hybrid-learning model. For example, our student cohort is mostly made up of students from Europe (principally Great Britain) and students from East Asia (principally China), and students’ comments imply that those taught the design project remotely experienced inequality. Students either had to stay up late to access lectures or watch the pre-recorded version, so did not directly communicate with staff – with the lack of engagement being unhelpful for learning [17]. An effective hybrid model would mean that levels of engagement between staff and student ought to be equal for all students. As it was, we were able to maintain peer-to-peer interaction for each of the 3 modalities, although students struggled with an entirely remote setup (not able to organise themselves on TEAMS) and with the hybrid mode (limited by number of group sessions in the classroom). Another example of the importance of maintaining the right balance, is in considering greater flexibility in the scheduling of contact hours for lectures and taught sessions. A student commented that they had to sit in a chair for 3 hours when the project was taught remotely. The 3-hour long sessions were a feature of the F2F model and the hybrid model, but are they necessarily the best practice especially if students are working remotely at least some of the time? Recent literature suggests that educators ought to ‘prepare for flexible timing for student assessment; discontinue traditional three-hour lectures’ [18]. This may
mean breaking up taught sessions with scheduled breaks to allow students to get some fresh air etc. or setting time aside to engage with students in different time zones.

Other considerations of note include 1. The adoption of a netiquette (remote and hybrid models) 2. Utility of novel modes of assessment. Even though it is not directly commented upon, a netiquette was introduced to help students navigate the teaching-learning culture when working on the design project. As the design project was one of the first courses students undertook, it was important for them to appreciate how to work with staff and their peers remotely and effectively [19]. The netiquette serves as a useful tool as students and as a gentle reminder to staff that the transition from secondary education to higher education (irrespective of the pandemic) is still unfamiliar territory – the netiquette may be useful going forward. Students were provided with the document, but probably ought to have been encouraged to add to and amend it producing a negotiate version, so that we could equally familiarise ourselves with students’ expectations and ways of working. With respect to the utility of assessment, for the F2F modality, students final assessment was a poster on a piece of A1 card. As it was not possible to have students work together on this during the remote-learning scenario, the assessment was changed from a poster to a company website using WIX as the website-generator app. Students were introduced to something entirely new through this assessment and developed different skills (e.g. graphics and layout, selling the product, presenting the company, branding) through the implementation of the website as a mode of assessment [1].

An open-text comment was made by one of the students (remote learning mode) on WIX not allowing students to collaborate, although this situation has now been rectified by the app provider and students were able to edit the website simultaneously during the hybrid-learning scenario. Students experienced some frustrations with modes of assessment and when delivered in different modalities, but such frustrations are not unusual, students adapted, and their summative marks were broadly similar for the 3 modalities (as stated previously). These two examples show that the onset of COVID-19 has accelerated some changes and resulted in some cognitive shifts regarding effective learning for our particular situation.

Finally, we offer a few thoughts on health and safety and coping in a pandemic. Admittedly, teaching the course was not easy with the academic member of staff commenting on how difficult it was to remain masked-up throughout their journey into and from work and while teaching. For the hybrid mode of teaching, strict protocols were followed, but through observation it was noted that students became increasingly weary of wearing masks and social distancing. Some students had to be constantly reminded of their responsibility to one another to protect each other and themselves as best they could, but they experienced fatigue and were frustrated by the situation occasionally. Others came across as a little withdrawn and disengaged. Academic staff and GTA facilitators had to be as aware and responsive to students’ ability to cope with the situation (being away from home, unfamiliar culture, pandemic-related stress, possible illness etc.) as they were with their progress with the academic tasks. Students in higher education reported higher levels of depression, anxiety and suicidal thoughts during the pandemic [20]. Some feelings of anxiety were reflected among our own student cohort, and probably ought to have been addressed during the design project. Even though we have a departmental student wellbeing advisor in post, it would have been beneficial to further reassure students or create space for them to talk about their concerns with adjusting to their new situation and how they were coping.
In conclusion, we would attest to some of the difficulties mentioned earlier of teaching engineering design throughout a global pandemic. However, considered and deft responses have enabled us to renegotiate what is done (changing some of the assessment), how it can be done effectively (following social-distancing protocols and re-formatting taught sessions), and most importantly the rationale for informing our choices (understanding what students might be comfortable with). In this paper, we have discussed some of the necessary and important changes made (e.g. having students attend a limited number of taught sessions F2F during 2021, connecting students in similar time zones when access was remote), and how first-year design might be different going forward.

References


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Face-to-face 2019

- Groups of 6-8
- Half the entire first-year cohort works on project exclusively for 2 weeks and then rotates
- Assessment consists of design brief (verbal feedback provided by course lead and provisional grade given), group presentation and an A3 poster (delivered F2F to small panel of staff/GTAs)
- GTAs supporting individual groups (monitoring them by circling the room) and usually assigned 2 groups each
- F2F lectures held to present main ideas to students
- Group tours of pilot plant for students to appreciate how plants operate/understand how things work
- Project 1 is a mock exercise and opportunity for students to use feedback for Project 2. Poster prepared for Project 2 only which academic staff and GTA students assess following on from presentation.

Remote 2020

- Groups of 6-9 (additional criteria of location used to determine group make-up) set up as a channel for collaboration on MS TEAMS
- Group make-up determined by time zones with broadly European students together in groups and Asian students together
- GTA accessibility differed depending on student group affiliated to e.g. GTAs available from 09:00 (GMT) for Asian students and available from 14:00 (GMT) for European students. Lecturers did not offer support in this way
- Assessment consists of design brief, website (both uploaded), group presentation (pre-recorded)
- All lectures delivered via MS TEAMS and recorded for students to access at leisure
- Support offered by staff and GTAs periodically assessing a group channel or being asked to join the group channel
- Tour of pilot plant pre-recorded using webcam for students to access at leisure
- Project 1 – mock exercise with design brief and presentation deliverables (with formative feedback delivered remotely by small panel).
- Project 2 – same deliverables as Project 1, with additional deliverable of website.
- Netiquette introduced for remote learning

Hybrid 2021

- Groups of 6 (maximum)
- Cohort of approx. 150 split into 3 groups of approx. 50 with each group physically attending sessions once a week for 6 weeks
- Lectures informing students of plan for the day, the next tasks etc. delivered F2F, and also recorded via TEAMS at the same time. Generic lectures [main principles of design] delivered via TEAMS to the entire cohort on one occasion (and recorded)
- For the group presentations (part of assessment) - students pre-recorded presentation for Project 1 and gave a F2F presentation to a small panel for Project 2
- Design briefs uploaded and assessed for both projects (Project 1 – formative, oral feedback; Project 2 – oral feedback and provisional grade). Additionally website required for Project 2.
- Support offered by staff and GTAs F2F (circling the room and periodically sitting among groups)
- Group tours of pilot plant as per F2F model
- Students required to keep social distances, wear face masks (exempts exempt) and use hand sanitiser
- Required to self-isolate if showing symptoms of SARS-CoV-2 virus and access group meetings via TEAMS if well enough to do so
- Netiquette introduced for hybrid learning

Figure 1: Diagram of comparative representation of main features of F2F teaching (2019), remote teaching (2020) and hybrid teaching (2021)