CASE STUDY

3

TITLE

Diversity of teaching and assessment modes in Environmental Engineering

Case Study 3

Dr Sarah Cotterill — Diversity of teaching and assessment modes in Environmental Engineering

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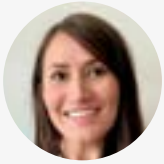


Dr Sarah Cotterill is an Assistant Professor in Civil Engineering and Stage 3 Year Head. Prior to joining UCD, she completed an Engineering Doctorate at Newcastle University, a Fulbright fellowship at The Pennsylvania State University and postdoctoral research at Durham University. She coordinates four modules at UCD including 'Creativity in Design' and 'Introduction to Water Resources Engineering'. In 2019, she received funding for a Learning Enhancement Project to create digital resources to improve student access to practical applications of environmental engineering. Her research interests include water conservation, nature-based solutions for stormwater management and resource recovery from wastewater.

Outline

Title	**Diversity of teaching and assessment modes in Environmental Engineering**
Abstract	This case study sought to expand the opportunities for student learning in a stage two engineering module through the inclusion of collaborative group work and practical-based applications of calculations. The cohort is a diverse mix of students from civil, structural and mechanical engineering. As such, the intention was to create a wider variety of learning modes, beyond lectures, to maximise engagement and opportunities for transdisciplinary knowledge exchange.
Module Name	CVEN20030 Environmental Engineering Fundamentals
Discipline	Civil Engineering
Level	Stage 2, 5 credits
Student numbers	56-62

Introduction and Context

Environmental Engineering Fundamentals is a core stage 2 module in Civil Engineering, and an elective module for Structural Engineering with Architecture, the Global Engagement Masters Pathway and the ME in Energy Systems Engineering. The module aims to lay a foundation for more intensive modules in later stages by introducing concepts about environmental ethics, engineering calculations, and the fundamental biological, chemical and physical processes used in environmental engineering.

There is a diverse cohort spanning two different stages and four degree programmes. In 2019/2020, 68% of the students were male; 42% of the students were international (either on a study abroad programme, such as Erasmus or a non-EU exchange, or on the Global Engagement pathway); and 3% of students were registered with UCD Access & Lifelong Learning as having a disability.

A change in coordination for this module in 2019/2020 coincided with the outset of this Inclusive Teaching Pilot Study. The intention was to increase opportunities for student engagement, to move away from 'chalk and talk' style lectures and expand the variety of assessment types and diversity of learning modes. This was thought to be needed from the student perspective based on initial feedback, from the 2019/2020 post-it note survey, which suggested there was a desire to see more group and practical work included and a greater diversity of learning modes such as laboratory experiments and worked tutorials to provide "more practice" and "more time to understand the examples".

Design and Implementation Description

In 2019/20 the course was taught as 30 hours of face-to-face lectures. In addition to this, there were two in-class tests in week 4 and week 8, and a revision/recap session in week 12 ahead of the exam. In 2020/21, the course was delivered entirely online due to COVID-19 restrictions. Initial plans for the Autumn 2020 trimester involved a blended delivery in which small group teaching could take place on campus, provided there were fewer than 50 people at a distance of 2m, present in a room at any given time. For all other situations, students were advised not to attend campus, and to work from home. The number of students registered on this module exceeded the maximum room capacity, and therefore no face-to-face activity was planned. Over the course of one online trimester, the intention was to create opportunities for variation in learning mode – i.e. learning from the lecturer, learning independently, learning from one another – and flexibility in communication style. The three, one-hour timetabled lectures per week were delivered in one of three delivery modes: (1) live Zoom lectures, (2) shorter pre-recorded videos and (3) 'offline' workbooks.

(1) Zoom lectures

Lectures were delivered live over Zoom once or twice a week. The lectures were recorded for those unable to attend or those who wished to re-watch later. Lectures involved a mixture of theory and discussion: the former was delivered, as it would be on campus, through the use of 'chalk and talk' PowerPoint slides, and the latter was facilitated through Zoom features including polls, whiteboard and breakout rooms. Polls (Figure 1) were used to gauge understanding, begin discussion and/or obtain feedback on an activity. The feature allows you to create single or multiple choice questions ahead of a Zoom meeting to gather responses from the students attending.

Figure 1. Two examples of a Zoom poll: to open discussion (left) and to obtain feedback (right).

The whiteboard feature enabled the lecturer and students to annotate a shared whiteboard screen by typing text, drawing lines and arrows or inserting pre-defined icons (such as a tick or a star). This was used as an ice-breaker or gateway to smaller group discussions in breakout rooms. Breakout rooms enabled groups of 4-5 students to discuss a topic in more depth before reporting back to the class in the main room.

(2) Pre-recorded videos

The nature of the blended cohort – comprised of several degree programmes – meant that some of the students (e.g. Stage 2 civil engineers, approx. 30 students) may have had small group campus activities prior to, or immediately after, this module's lecture(s). Therefore, there was an added challenge when scheduling live Zoom lectures that students may be travelling between campus and home, and might be unable to log in during the timetabled slot. To counter this, a proportion of the classes were uploaded as pre-recorded videos to Brightspace to allow greater flexibility for the students to access the content. A selection of shorter videos (e.g. 10-15 minute videos) were uploaded instead of one hour-long lecture.

(3) Workbooks

Finally, a number of workbooks were created which included a variety of guided tasks, reading, virtual labs, questions and calculations to support topics covered in lectures (Figure 2). This was intended to provide a break from the large volumes of videos and PowerPoint presentations the students were expected to be consuming (due to the online format of learning), and to encourage them to read more widely around the lecture content. Some of the workbooks were created around a particular theme, such as the sustainable development goals and resource use. Others functioned as remote laboratory classes, with links to animations or filmed footage of practical experiments, and simulated data sets aligning with the footage to use in calculations and data interpretation.

Biochemical Oxygen Demand (BOD)

Watch BOD Animation on Brightspace

You have three samples and want to measure and calculate the BOD (in mg/L) of each. First, you need to dilute each of the samples, as follows, in a 2 litre volumetric flask:

- [A] Raw Wastewater - 1/100 dilution
- [B] Settled Wastewater - 1/50 dilution
- [C] Final Effluent - 1/5 dilution

Then, you transfer each diluted sample into 4 * 300 mL BOD glass bottles, and prepare 4* bottles of dilution water (i.e. a blank) using 300 mL BOD glass bottles.

Measure the initial (day zero) dissolved oxygen (DO) in one of the sample bottles and one of the blanks using a DO probe and record it in the tables below.

Then, incubate the remaining 6 bottles for 5 days ± 1 hour at 20°C.

After 5 days, you measure the DO in all of the bottles using a DO probe and record the values in the table below.

Calculate the mean value (average) from each of the samples' triplicate bottles using the data in the tables below.

Figure 2. Excerpt from one of the virtual lab books. It referred to videos and animations of laboratory procedures (which were filmed and posted to Brightspace) with calculations and other questions.

Module content was assessed through a series of timed multiple choice question (MCQ) tests, a group poster and a take-home exam-style assignment. MCQs were delivered using Brightspace Quiz to evaluate numerical skills and the students' grasp of fundamental principles. Brightspace Quiz enables the creation of a question library from which a random selection of questions, generated to be of a comparable level of difficulty, can be selected for each student. The questions were designed to: (i) align with key learning outcomes relating to the fundamental ethical considerations environmental engineers face, and (ii) test their ability to perform basic environmental engineering calculations.

An academic poster was the required output for the group task. Students were assigned to groups by the module coordinator to ensure a mix of degree programmes, stages (years) and experience to promote and encourage cross-disciplinary knowledge exchange. They were each asked to pick a topic from one of the UCD Green Campus priorities, such as waste reduction or water conservation (Figure 3). They were asked to provide an introduction and context to the problem, to critically evaluate the progress UCD has made in addressing this topic, and to outline one or more suggestions for how UCD could improve further in this area. Suggestion(s) could include the implementation of new technologies, behavioural change and/or changes to policy or legislation.

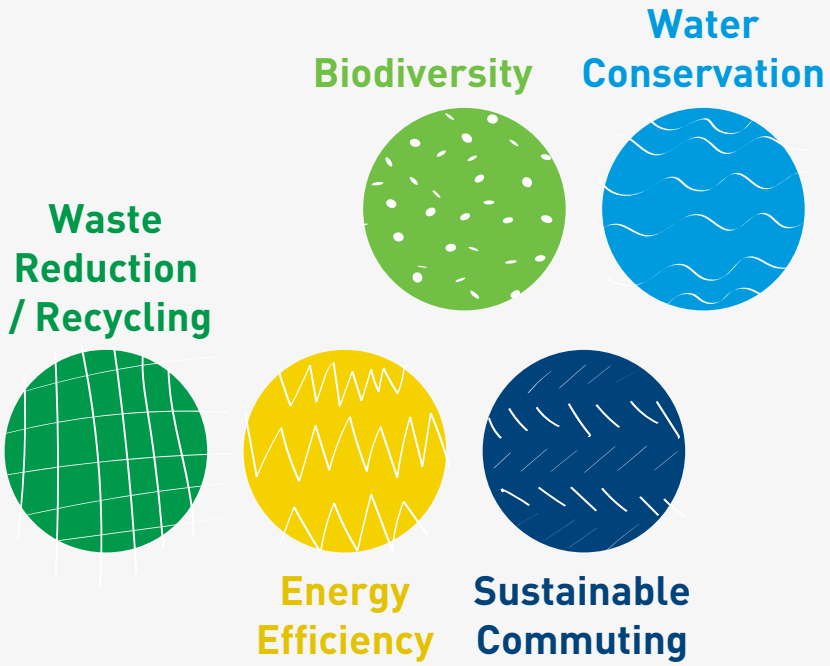


Figure 3. Five priority areas for sustainability for UCD Green Campus.

The poster was graded using a rubric, which was developed in partnership with the students. This was achieved in a single Zoom session, through the use of Zoom breakout rooms and MIRO – an online collaborative whiteboard platform – to identify what the poster should include and the relative importance of the component parts of the task. Students were allocated into breakout rooms and asked to discuss what they thought was essential for the poster. Ideas were relayed back to the entire class and mapped out collectively using MIRO (Figure 4).

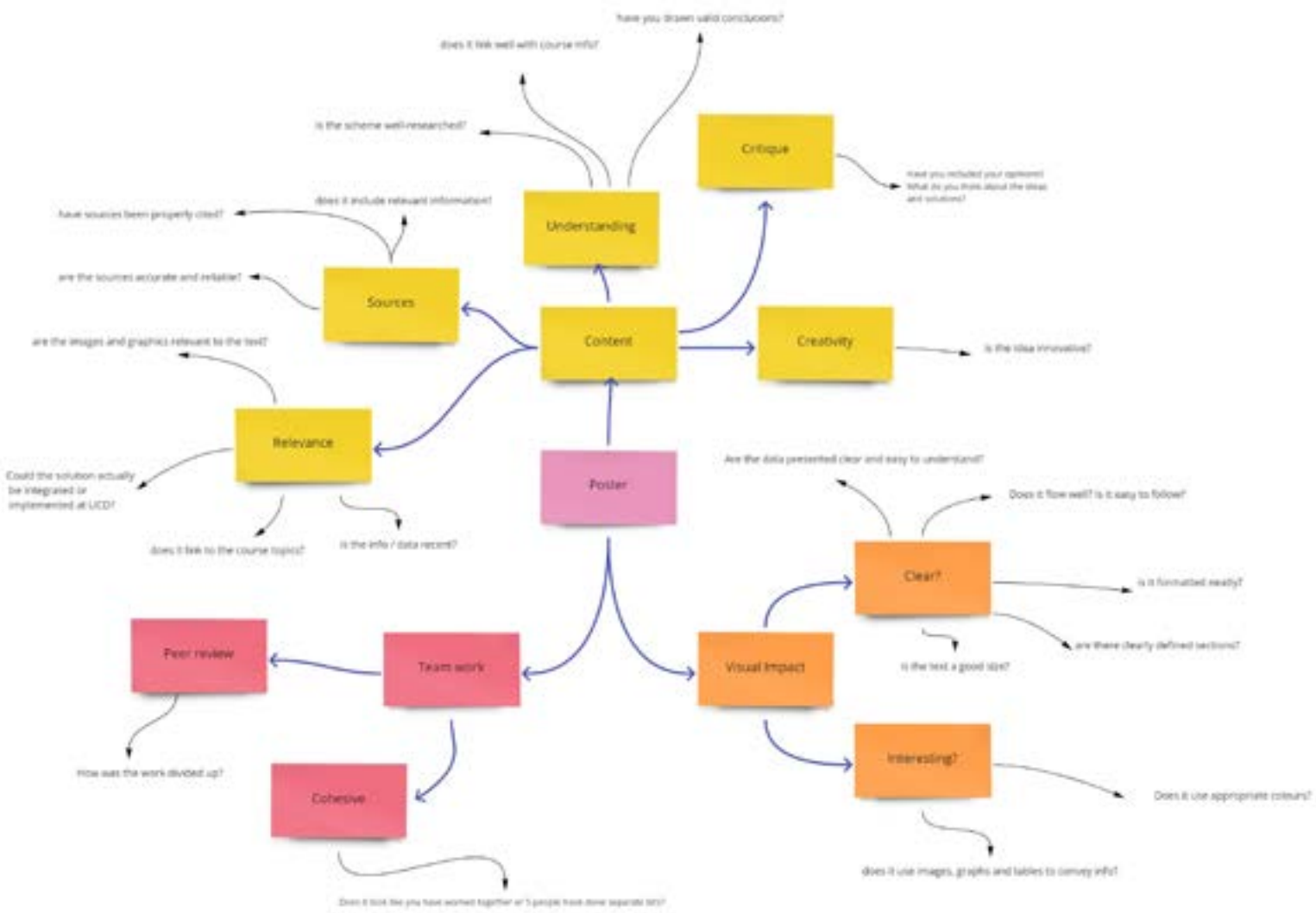


Figure 4: MIRO output summarising student comments on what the poster should include.

After this, students returned to their breakout rooms to discuss how they would allocate or weight the graded parts. At the end of the one hour Zoom call, students uploaded their suggestions (from each breakout room) to Brightspace. This was converted into a grading matrix (Figure 5) aligning the feedback and input from the students with the standard grading scales used at UCD.

	A+	A	B	C	D	E	F
	90-100%	**70 – 89.9%**	**60 – 69.9%**	**50 – 59.9%**	**40 – 49.9%**	**30 – 39.9%**	**20 – 29.9%**
Understanding: - **Context** - **Links with course material** - **Use and interpretation of references**	Exceptional understanding. Supported by wide ranging and credible references. Demonstrates clear understanding of the wider relevance. Seamlessly linked with the course material.	Excellent grasp of underlying issues. Clear evidence of thorough research, drawing on a wide variety of sources. Strong ability to connect concepts to context. Appropriately linked with the course material.	Sound grasp of issues. Some ability to connect concepts to context but little analysis of wider relevance. Limited references to support context. Attempted to link to course material.	General grasp of main issues, but some evidence of gaps in understanding. Limited attempts at linking with topics covered in the module.	General awareness of the context underlying the challenge selected. Some shortfalls are apparent (i.e. lack of understanding). Poor links with module content.	Superficial grasp of broad ideas and concepts. Major shortfalls are apparent in some key areas. No attempts to link with topics covered in the module.	Little or no grasp of broad ideas and concepts. Major shortfalls in most key areas or section missing entirely.
Analysis of Progress Made at UCD: - **Use and interpretation of references** - **Critique** - **Evaluation** - **Inclusion of appropriate data**	Summary of progress is concise, well presented and shows a high level of understanding. Exceptional interpretation of data collected from relevant and appropriate sources. Demonstrates ability to review, reflect and critique information. Substantial evidence of original thought including creation of own figures and/or tables.	Very good range of supporting evidence. Good evidence of critical analysis around the success of interventions. Some evidence of analysing multiple sources of data through creation of original figures/ tables.	Good use of a limited range of sources to present a clear summary of progress. Data included is appropriate and relevant. Some evidence of critical evaluation.	Summary of progress is hindered by a limited selection of sources and data. The summary is adequate, but provides limited critique. The images selected are primarily photos, rather than graphs or tables, and are not as impactful as they could be.	Limited references collected, and poor links provided between interventions, progress and context. Understanding is basic, but sound. Little evidence of critique or original thought. Lack of data included as figures or tables.	Very basic analysis and a poor summary of progress made at UCD with some substantial shortfalls in understanding and/or inaccuracies in places. No evidence of critique or original thought. Visual representation of data (figures and tables) missing.	No discussion of progress made at UCD – section missing entirely.
Discussion of Ideas for Future Solution: - **Innovation** - **Creativity** - **Relevance**	Exceptional suggestions highlighting original thought, creativity, and/or an outstanding review of the literature. Ideas are highly relevant to the topic and suitable for implementation on a university campus, such as UCD.	Very good discussion of ideas, with some original thought and creativity, or inventive suggestions taken from a thorough review of the literature. Ideas are relevant and realistic for an application on a university campus.	Good discussion of ideas, but limited evidence of original thought, with most ideas taken solely from the literature or other campuses. Suggestions are relevant for a university campus.	Some suggestion of ideas that are somewhat relevant and realistic. Suggestions lack original thought, creativity and innovation.	Limited discussion of ideas, OR suggestions which are somewhat irrelevant and unrealistic for application on a university campus	Ideas presented are irrelevant and unrealistic for implementation on a university campus. There is little to no discussion of these ideas.	No discussion of ideas or suggestions for future work to address this challenge.
Poster layout: - **Visuals** - **Structure** - **Cohesive** - **Referencing**	A visually outstanding poster, with a very clear structure, combining each of the team's contributions cohesively. Figures and images are excellent and referencing is of publication standard.	A very well-structured poster with good use of images and/or tables. Some of the figures are original (created by the group). The content is well written and flows logically between the different sections. There are no formatting issues (e.g. typos) and good referencing.	A well-structured poster, with some thought to the visual aspects, but without the creation of original figures. Concisely written with good grammar, but some (limited) formatting issues. Appropriate use of references.	A satisfactorily presented poster. Some issues with formatting (e.g. typos, large blocks of text, or lack of cohesion between different sections etc). Some references, but not entirely appropriate format. Visual design OK, including some figures, but could be improved.	Poor style of writing, with some parts difficult to follow. Visual design either lacks figures or tables or includes irrelevant ones. Layout is difficult to follow and is not cohesive. References provided in an inappropriate format.	Difficult to read and lacks a logical train of argument. Individual sections do not combine into a single piece of cohesive work. Very poor organisation and presentation with no, or poor quality, images included. References either not included, or not cited appropriately.	Little more than a set of notes. Poster lacks any real structure with no care given to the visual design. Arguments completely unclear. No references included.

Figure 5: Rubric created after student discussion identifying the key elements of the poster and the weighting they should have in the grading process.

A peer review template (Figure 6) was submitted by each student individually upon completion of the group poster (Figure 7) to assess how they worked within a team. The group assignment intended to stretch their ability to conduct independent research, synthesise information, collaborate with their peers and present information in a concise and engaging way.

Complete the Team Member Participation Evaluation Table below in respect of your evaluation of the quality of each team member's participation in the group task (including your own). The Partitcipation Evaluation Scale Table below should be used to assign a score for each criteria.

Where appropiate provide commentary in the box titled 'Steps Taken to Address Unequal Participation'.

Participation Evaluation Scale Table

Very good	Good	Satisfactory	Marginal	Unsatisfactory
5	4	3	2	1

Team Member Participation Evaluation Table

Group number: _____

*please also include yourself in the table

	Names				
Criteria	1.	2.	3.	4.	5.
Contribution to workload					
Engagement with group					
Meeting attendance					
Total					

Steps Taken to Address Unequal Participation:

Figure 6: Example of peer review template used to assess group contribution.

Finally, a take-home exam was chosen as an alternative to an end-of-trimester exam, due to the online circumstances and challenges with conducting timed closed-book exams. This assignment involved five open book style questions, testing their ability to connect fundamental concepts and integrate further reading. Students were informed that higher grades would be awarded for those using a wide range of sources (i.e., more than one text book, article or research paper) and the original presentation of the answers (e.g. using tables, diagrams, figures they had created themselves) – to discourage students drawing solely from their lecture notes.

Water Efficiency: Do UCD Care?

Introduction

Water efficiency is vital as our society, Water availability is dependent on the water cycle, Society are removing water from the cycle quicker than it can be replaced. Thus, water is a finite resource [1]

Water is essential for survival of our ecosystems. Fresh drinkable water only makes up 1% of the earth's water. It a scarce and essential resource [2]. Freshwater species, like some that depend on landfill resort and estuaries, are some of the most endangered in the world. [3]

It is crucial for businesses and institutions, such as UCD, to be super-aware of their water consumption. They should be working towards better water efficiency and sustainable water use.

To access efficient water consumption, we must only use the water that is necessary for each purpose and manage our machinaries. Doing so we can ensure that we safeguard our water resources for the future.

UCD: A Review

UCD's focus on water efficiency has led to a reduction in total water usage despite growth in population and number of buildings. This is a result of strategic management and organisation with regards to core water efficiency measures [4].

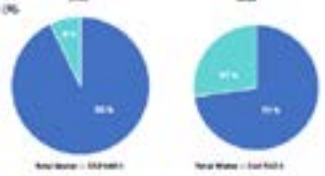
Management

The most impactful university sustainability progress are supported by an ongoing consultation. To achieve maximum water efficiency, a complex water approach must be taken [5]. UCD's water management team do this by working in conjunction with grounds management, technical services, and capital projects teams [6].

This effective management style was acknowledged in 2015 when UCD received ISO 50001 accreditation for water (and energy management) [4].

Efficiency Measures

To increase water efficiency, water metering is reduced. Leakages across water to be tracked. Building Management Systems (BMS) improve leakage detection, resulting in improved water efficiency [6]. UCD's BMS now account for water leakages.



Potable Water Consumption
Non-Potable Water Consumption

Groundwater water consumption cannot be reduced, non-potable water cannot then be prevented. UCD has reduced potable water usage by 4.5%, despite the growing campus population and GFA. [4].

There are some holes in UCD's water efficiency plan.

Lacking Information

Direct interaction on UCD existing strategy is limited. The Environmental Review highlights complex water quantities. Building and college specific consumption and efficiency measures being implemented in some fields are limited [4].

Behavioural Change

UCD so far has focused on improving efficiency without student/population engagement [4]. But marginal efficiency improvements per capital investment are higher this way. However, the next steps in water usage reduction needs to focus on the individual.

14%

Suggestions for Improved Efficiency

Smart Water Network

UCD Environmental Baseline Review says that there is a future ongoing initiative to incorporate a smart water network to automatically notify issues with the campus water network. The smart water network could improve network efficiency, resulting in large savings of both water and money. [7].

What is it?

A smart water network is a solution that enables utilities to proactively diagnose and monitor problems, manage maintenance issues and use this data to help make the water network as efficient as possible [7].

What are the Benefits?

Enhanced decision making on capital expenditure.

Improve system performance such as leakage and pressure management.

Smart water network packages best suited to UCD:

Smart Network Leakage

Smart Network Optimisation

Low Flow Networks

2 years

Why Retrofit?

30%

It is possible to significantly reduce the water demand in a building without affecting the comfort of the occupants. Measures include: kitchen and appliance retrofitting. This includes the installation of dual flush toilets, economy washing machines and low flushing urinals and faucets.

Case Study: Aerators

Aerators added to/part of outlet's water flow, are a small investment but yield large water savings. An aerator is an attachment that can be fitted at the end of a water tap/shower, these can also be inserted inside the spout.

How Do Aerators Work?

They are small units between that break up the flow of water into multiple small streams, adding air in between them.

By dividing the water stream into air, aerators significantly reduce the volume of water flowing.

They do this while maintaining the feeling of a high pressure flow [8].

Why Invest?

1 gallon per minute aerators can reduce water use by 50%. Depending on design, an aerator can save 3 to 10 gallons of water per day.

193'500 l

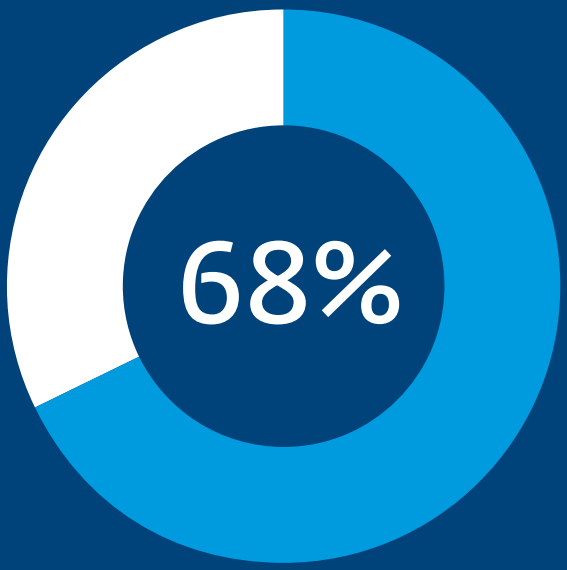
Figure 7: Two examples of group posters

Results and Impact

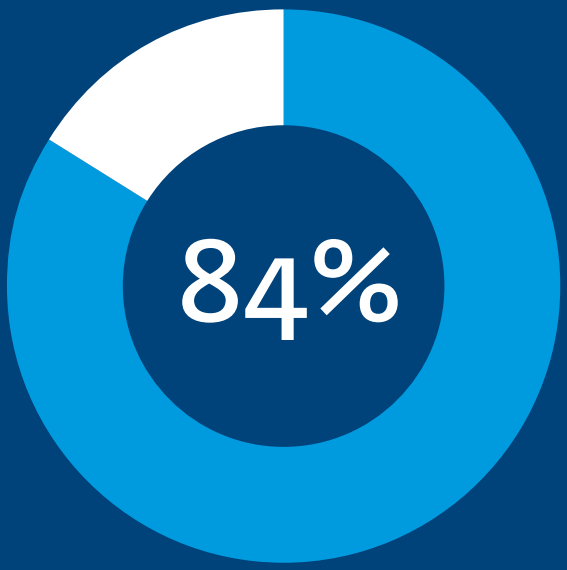
Meeting the Objective

The objective of the project – to increase the diversity of teaching and assessment modes – was achieved. The changes made involved the inclusion of group work, problem-based learning and (virtual) laboratory experiments. All students who responded to the online survey in 2020/21 thought there was clear communication, flexibility in assessment, and flexibility in learning styles (given the constraints of online learning). The majority of respondents felt able to participate in class, with several noting breakout rooms supported this. However, there are still barriers to address here, with one student commenting that speaking out online can be "daunting".

Students commented that, "the group poster assignment and the breakout rooms were a great way to get to know the class" and "working with students from [other] courses made the groups more interesting and good for getting different points of views rather than us all having the same pool of knowledge". This was raised in the initial post-it note survey, where several students suggested the poster project could have been a group task. In a Zoom poll at the end of the module, 84% stated they enjoyed researching the topic in their poster, 68% reported they liked working in groups, and 100% suggested they liked making a poster.



liked working in groups



enjoyed researching the topic

liked making a poster

Several students referred to the worked exercises in tutorials, commenting these were, "helpful for practicing the numeric material". This addressed concerns from the previous post-it note survey, where students asked for more opportunities to practice the examples provided during class.

Evidence of Impact

There was a lower response rate to the online inclusive teaching pilot post-it survey in 2020/21 (<10% students registered) than the number who completed in-person the previous year. As such, feedback was collated from a wider variety of sources including the online survey, the general module feedback collected on UCD InfoHub, and via informal emails from students.

Student feedback on InfoHub is collected as Likert responses to five statements:

Q1. I have a better understanding of the subject after completing this module
Q2. The assessment was relevant to the work of the module.
Q3. I achieved the learning outcomes for this module
Q4. The teaching on this module supported my learning
Q5. Overall I am satisfied with this module

There was an increase in overall student satisfaction (Q5) with the module from 4.25 in 2019/2020 to 4.5 (out of 5) in 2020/2021. Feedback suggested students liked the "very detailed and well-structured content" which was "well delivered with a mix of live classes and mini assignments". There was acknowledgement that, "very varied assessment types" were used, and that these assessments required a "mix of technical understanding and applied knowledge". The Likert responses suggested the assessments were relevant to the work of the module (4.83 / 5, Q2) and the teaching on this module supported student learning (4.5 / 5, Q4). The overall module grade distribution was consistent with previous years, despite disruption caused by the pandemic. One student commented that the lecturer had been "so responsive over the semester" helping to "calm students" and create a "really enjoyable module".

Lessons Learned

There were a range of suggestions for how this module could be further improved. The initial design of the module – which intended to accommodate the aforementioned challenges related to online and blended delivery – was intended to be diverse (i.e. 1 live lecture, 1 recorded lecture and 1 guided workbook) and inclusive, particularly for students who may be traveling between campus and home, or for those experiencing Zoom-fatigue. However, some feedback suggests this was, with hindsight, not enough "screen/face time". This will be addressed in the 2021/22 term, when there will hopefully be a more substantial return to campus activities, and less need for pre-recorded video which offers little direct engagement.

Furthermore, feedback suggested students would still like more lab work – but acknowledged this was difficult due to COVID-19 restrictions. A challenge moving forward will be implementing this with this module's relatively large group size and timetabling constraints. Laboratory classes for water quality are difficult to implement in a one or two hour time slot – and would be more feasible if a morning or afternoon session was dedicated to this instead. Additionally, even if social distancing requirements are removed entirely, the laboratory space in the School of Civil Engineering is able to accommodate less than half of the class at any one time. Whilst efforts were made to include virtual labs and tutorials, students expressed a preference for more hands-on experience, but acknowledged that this "wouldn't work this year". Realistically, this is likely to be a longer term strategy to evaluate how to incorporate real, hands-on practical activities feasibly into this module.

Recommendations and Advice for Implementation

Some of the tools and resources used in this case study arose as a direct consequence of online learning and a heavy reliance on Zoom. These tools may, or may not, be relevant when returning to on-campus activities, but can potentially be slightly adapted to fit an in-person format. For example, by enabling students to take more control over their learning, through the use of 'offline workbooks', some students engaged in deeper research, following up with emails and questions based on their self-directed interest in the subject. This was not uniform within the class; the remote format may have widened gaps between those comfortable conducting self-guided work and those who, perhaps, need a little more direction. In future years, these workbooks could be adapted to a flipped classroom format, which would make use of the time invested in the planning and design of these activities, whilst delivering benefits for a wider variety of students.

The use and co-development of the rubric with the students, was a success, and will be taken forward. However, this was a small first step and can be further built upon in subsequent years. The students showed a much better understanding of the poster task than the previous year, which may be a result of it becoming a group activity or due to the co-creation of the rubric. Future implementation of this could involve an iterative process, which may not all be achieved in the first academic year. The creation of the rubric provided a method of facilitating a conversation around grading; increasing the clarity and transparency of the task with expectations set early in the process. This process could be improved through student validation of the rubric, achieved by asking the students to grade a selection of sample posters from previous years, using their agreed-upon rubric, to see if it is fit-for-purpose.

Simulations and videos of laboratory protocols were developed from scratch for inclusion in the virtual laboratory workbooks. These were designed for use during the Covid-19 pandemic when module delivery was entirely online, but it was hoped that they would have longevity beyond that. Whilst these resources took a substantial amount of time to create, they enable information to be conveyed in a time-efficient manner, enable a greater number of labs to be delivered than if physical labs alone were relied on, and can be rewatched and revisited to reinforce learning. Previous studies have shown that students are generally positive about the use of virtual technologies, so long as they are not used to replace in-person learning entirely, and instead are used as an additional tool. Further work will be done to evaluate how a hands-on laboratory session can be incorporated into the module, perhaps blending hands-on activities with some virtual components. These resources were time-consuming to produce, but there is now a vast amount of guidance and information available online to support the planning and creation of this material (see below).

Resources

Instructional Resources

University College Dublin, Showcase (Ms Mairead O'Reilly). **Video Production Fundamentals for Practical's & Instructional Videos**

UCD Teaching & Learning, Showcase (Dr Sarah Cotterill). **Improving Access to Practical Elements of Environmental Engineering**

UCD Teaching & Learning, Showcase (Dr Kevin Nolan). **Digital Animation for Educators**

University of Sheffield, T**he Remote Practicals Playbook** from University of Sheffield

Readymade Resources (freely available)

New Mexico State University, **Learning Games Lab** (includes labs on water quality sampling and testing (CONSERVE) and infiltration and runoff (Western Soils) etc.)