

Teaching chemistry Down Under in an “upside down” world: Lessons learned and stakeholder perspectives

Elizabeth Yuriev*, Andrew J. Clulow, and Jennifer L. Short

Faculty of Pharmacy and Pharmaceutical Sciences, Monash University,
Parkville, VIC 3052, Australia

* Email: elizabeth.yuriev@monash.edu

Teaching first-year students presented additional challenges for online chemistry education in the times of COVID-19 pandemic. While addressing these challenges, we also had a year-long opportunity to try new teaching approaches, evaluate their effectiveness, adopt the things that worked and dispense with those that did not. Our students were able to provide us with ongoing feedback on their experience and had an ongoing and supported opportunity to get to grips with online learning. Together we – students, academics, and teaching associates – had an opportunity to grow as a community of teaching and learning. Having an extended two-semester-long and connected experience also allowed us to consider the pros and cons of our choices in three domains: technological (unfortunately this domain took priority at the beginning), pedagogical (this domain gradually reclaimed its primacy), and finally – affective. In this chapter we describe our decisions and experience in the context of these three domains. We also draw on perspectives of three groups of stakeholders: students, academics, and teaching associates.

Chemistry education has been making great strides in online spaces by taking advantage of technology (1) and developing online courses (2). Based on this accumulated body of knowledge and practices, the chemistry education community was able to react quickly to the onset of COVID-19 pandemic. Many practitioners shared their early experience of emergency remote teaching spanning a range of hot topics and hotly debated challenges: pedagogical course design decisions (3, 4), delivery of labs online (5, 6), student experience in general (7-11) and specifically student interactions online (12, 13), assessment (6, 14), and educators working together in a virtual international community of practice (15).

The sheer volume of what has been published in the first 12 months of the COVID-19 pandemic – in publicly-accessible and, increasingly, in academic space – makes the task

of writing a chapter on online teaching and learning in chemistry extremely challenging. What can we say that hasn't already been said? What advice can we give or teaching implication can we highlight that would add to the body of knowledge that has been produced during 2020 around teaching and learning online? What is unique and informative about our own experience? One aspect of our experience is that we taught first year students. While not unique, it presented additional challenges of supporting a student population lacking prior higher education exposure and the associated expectations, both of the university and of themselves. Another aspect is that the start of the pandemic coincided with the start of the academic year in Australia, almost to the day. And even though we did not know it at the time, we had a whole academic year ahead of us to teach fully online since Melbourne, alone among Australian cities, had two major COVID-19 waves during 2020, one at the onset of each semester. Lastly, the Monash University Bachelor of Pharmaceutical Sciences (BPS) degree program (16) entails two consecutive general chemistry units in the first year (Monash "unit" is an equivalent of "course" in the United States). These units are taken by the same cohort of students, convened by the same academic, and the workshop sessions are facilitated by the same group of teaching associates. The confluence of these three aspects of our's and our students' experiences meant that we had an opportunity to try new methods, evaluate their effectiveness, adopt the things that worked and dispense with those that did not. Our students were able to provide us with ongoing feedback on what worked and what did not work for them. They also had an ongoing and supported opportunity to get to grips with online learning. Together we had an opportunity to grow as a community of teaching and learning. Finally, having such a longitudinal and connected experience allowed us to consider the pros and cons of our choices in three domains: technological (unfortunately this domain took priority at the beginning), pedagogical (this domain gradually reclaimed its primacy), and finally – affective. In this chapter we describe our decisions and experience in the context of these three domains. We also draw on perspectives of three groups of stakeholders: students, academics, and teaching associates.

Context and Data Collection

Teaching Philosophy and Approaches

Teaching within the Bachelor of Pharmaceutical Sciences (BPS), Faculty of Pharmacy and Pharmaceutical Sciences, Monash University, has undergone two major renewal actions in recent years that prepared us to a great degree to handle the pivot to online teaching and learning. In 2012-2013, a whole-of-institution teaching overhaul resulted in significant flipping of the curriculum (17-20). The teaching and learning model that has been adopted by the Faculty is called DEAR (21). The learning cycle that students undertake for each topic includes the *Discovery* stage. Then they *Explore* new knowledge in interactive lectures and *Apply* it in small classes (e.g., workshops). Finally, they *Reflect* and *Revise*, while preparing for in-semester and end-of-semester assessments as well as engaging in skills coaching and formal reflective practice through e-Portfolios.

In 2018, a newly re-structured curriculum was rolled out, with a focus on professional and employability skills: communication and teamwork, problem solving and critical thinking, and laboratory skills. In addition to the undergraduate programs, we have developed and have delivered multiple iterations of a massive open online course (MOOC) "The Science of Medicines" (22, 23). All of these changes and activities involved an extensive development of online resources: videos, interactive quizzes, wikis, crosswords, Moodle Lessons, to name just a few.

As a result, we were arguably in a relatively advantageous position to tackle the pivot to emergency online teaching. However, together with the rest of the higher education field world-wide, what we were not as well prepared for was the speed with which the changes had to be made. Furthermore, our arsenal of resources was developed for asynchronous delivery. The need to do some of the teaching and learning synchronously still left us faced with many challenges.

Units of Study

This chapter describes teaching and learning experience in first year general chemistry units with a focus on physical chemistry. Both are *core* program units, which means that they are pre-requisite for students to progress through the degree program. Historically (pre-COVID), these were flipped units with traditional teaching activities such as interactive lectures, tutorials, workshops, and laboratory classes. In these units, the students are assessed on both theory, laboratory practice, and graduate skills.

Data Collection: Learning Analytics

To collect the data on student engagement with teaching resources on the Learning Management System (Moodle) and the video hosting platform (Panopto (24)), we have used the learning analytics tools available on both platforms. Learning analytics data collection for quality assurance and education research purposes is approved by the Monash University Human Research Ethics Committee (MUHREC, project approval 16974). Students are informed about the project during year one orientation and are provided with an opt-out link via a PharmSciHub Moodle site. They can withdraw their data from analysis at any stage during their undergraduate studies and afterwards, while they still have access to the Moodle platform.

Data Collection: Stakeholder Voices

Two instruments were specifically developed to get an insight into the perceptions of teaching and learning online during the pandemic-affected semesters. Teaching Associates (TAs), involved in teaching both semester 1 and semester 2 chemistry units were interviewed after each semester. Students were invited, at the end of the academic year, to complete a Qualtrics survey about their experiences of learning online during 2020. Both projects were approved by the Monash University Human Research Ethics Committee (project approvals 26828 and 23346, respectively).

Dilemmas, Decisions, and Teaching Implications

This section consists of three parts. We will start by briefly describing technological and pedagogical decisions we made, and sometimes the dilemmas we faced when making them. This first part will provide the academic stakeholder view on how we have re-imagined the usual elements of the unit – discovery, interactive lectures, workshops, laboratories, and assessment – in the online space. Then, we will present findings from the TA interviews and student surveys to give insight into the other two stakeholder perspectives on the online teaching and learning experience.

Teaching Online

Discovery

The discovery stage was relatively easy to adapt to online modality as it was designed to be delivered fully online and asynchronously in the first place. The discovery stage usually includes “something to watch”, “something to read”, and “something to do”. For something to watch, we have previously created a range of Animations (Figure 1). These came in handy during 2020, when our ability to draw things in front of students, in order to explain complex concepts, was terribly diminished.

For something to read, we use traditional textbooks. During lockdown restrictions, students could not come on campus to access the library. So, for reading, we looked for quality online resources to give students short bursts of reading material. The LibreTexts website (25) provided most of the required reading. And finally, for something to do, there was usually a short check-your-learning quiz.

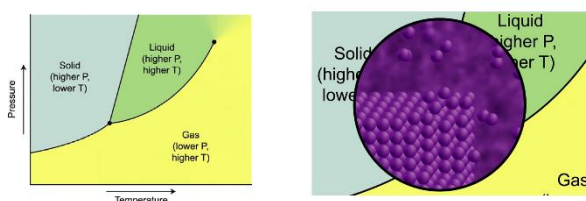


Figure 1. Animations used for Discovery. Snapshots from the animation of a single-component phase diagram animation are shown as an example.

Content Delivery, or “Interactive Lectures”

The first of the two biggest dilemmas came up when considering the interactive lectures (Figure 2). Should we run them synchronously or asynchronously? If they are pre-recorded for asynchronous delivery, should they be scheduled or not? This was likely one of the biggest dilemmas of 2020 for most educators internationally, see for example Ref. (4). For synchronous delivery, we briefly considered running live lectures, streaming them, and recording for students who could not watch live. Recording lectures was not a new practice in Monash in 2020, and our past experience showed limited student attendance of live lectures and their preference for having access to recordings (20). Based on that experience, we opted for pre-recording lectures, cutting them into short single-concept videos, and integrating them with self-testing activities (Figure 3). These pre-recorded lectures were uploaded to Panopto (24), the video hosting platform used by our university. The greatest advantage of pre-recording the lectures was that they allowed students to work at their own pace and at the time of their choosing. Considering the multitude of personal issues induced by the pandemic and barriers experienced by students while studying online (*vide infra*) as well as a wide range of students’ personal preferences, the decision to use pre-recorded lectures was sensible and balanced. Various, and sometimes conflicting, student preferences were still manifested in the end of year survey, for example:

“The discoveries and lectures are all online, which makes uni life easier”

“[I prefer] live (rather than recorded) lectures (for all units)”

The duration of the recordings in each lecture was about 30–40 minutes, leaving time for students to solve problems and answer quiz questions. Students had unlimited attempts at the quiz questions, which contributed a very small mark to their final unit grade. A very important element of these lectures was a request for students to note the ‘muddiest point’, that which they found most difficult to grasp. These questions were then raised and addressed at a live Q&A session the following week. This feature was later noted by students as one of the highlights of the chemistry units and one of the strongest contributors to student learning.

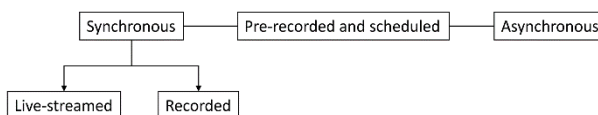


Figure 2. Possible delivery modes considered for interactive lectures.

AB1_8 Acid hydrolysis and acidity constant

Acid hydrolysis: $\text{HA} + \text{H}_2\text{O} \rightleftharpoons \text{A}^- + \text{H}_3\text{O}^+$ (Ionisation, dissociation, deprotonation)

Simplified form: $\text{HA} \rightleftharpoons \text{A}^- + \text{H}^+$ $K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$ (special equilibrium constant, acidity constant)

Examples:
 Strong acid: $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{Cl}^- + \text{H}_3\text{O}^+$ (product dominant)
 Weak acid: $\text{HCOOH} + \text{H}_2\text{O} \rightleftharpoons \text{HCOO}^- + \text{H}_3\text{O}^+$ (reactant dominant)

Using $\text{p}X = -\log_{10}X$: $\text{p}K_a = -\log K_a$

Acid strength ↑ K_a ↑ $\text{p}K_a$ ↓

Select the strongest of the following weak acids

Select one:

- a. Phosphoric ($\text{p}K_a = 2.1$)
- b. Carbonic ($\text{p}K_a = 6.4$)
- c. Benzoic ($\text{p}K_a = 4.19$)
- d. Nitrous ($\text{p}K_a = 3.37$)

Check

Figure 3. Snapshot of interactive lecture components. Top: a pre-recorded lecture segment; Bottom: a corresponding test-yourself question.

There are two additional aspects associated with using pre-recorded lecture videos. Firstly, should the videos from the previous year (in this case, those recorded in 2019) be used? Some of our colleagues selected this option. It is our opinion that such an approach is not appropriate. Students studying online in 2020 were already disappointed by not being able to learn on campus, meet new people and make friends. They were already experiencing stress and mental health issues (as we will demonstrate later). The very least they should receive is a tailor-made instruction designed with their needs and circumstances in mind.

Another aspect is related to an organizational, or motivational – depending on how you look at it – question to ponder. This is: should these pre-recorded lectures be scheduled or not? Largely this decision was out of our control, because the University and to some extent the Faculty made the decision about timetabling. In the first semester, when any decision had to be made very quickly, and the timetable already existed, these lectures were left in the timetable. Learning analytics showed that most students completed or at least started these interactive lecture activities towards the start of a week as per their timetable (Figure 4).

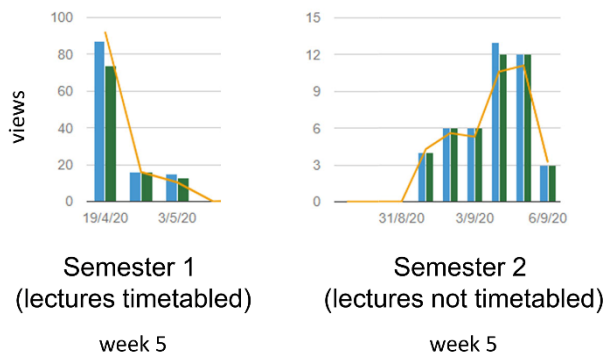


Figure 4. Student engagement with recorded lectures, exemplified with week 5 learning analytics. For each week: left column, views and downloads; right column, unique viewers.

In the second semester, when the University and the timetabling administrators had more time to plan for pandemic/lock-down conditions, the decision was made not to timetable these activities. On one hand, logistically it made sense. Putting together a timetable was easier and allowed for more flexible and streamlined scheduling. It also gave students more flexibility with respect to their time management. However, learning analytics are already showing us that, while some students actually did complete these activities earlier in the week, a significant proportion of students left it until the very last moment (Figure 4). Some students noted the lack of scheduled lectures and expressed the preference for scheduling in their end-of-year survey, for example:

“...a bit stressful, mostly cause I procrastinate quite a fair bit since most lectures are recorded and there's no fixed deadline for lectures.”

Q: What changes would have improved your online learning experience?

A: A more rigorous timetable, set times assigned to watch lectures

These data show that if, in the future, lectures are to be online and are not to be timetabled, proactive measures are needed to make sure that students, particularly transitioning first-year students, are staying on top of their learning.

Small-group Activities (Workshops)

The biggest smorgasbord of choices, and therefore decisions to be had, were around small class activities. The decisions, largely because of the speed with which they had to be made, revolved around technology choices: should it be Zoom? or Teams? Or should we use a forum? But once the technological decisions were made, the personal orientations, of both instructors and students, came into play. And here we come to the second major controversy of teaching and learning online in 2020: should the webcams be ON or OFF? And the answer to that particular dilemma in turn led to pedagogical decisions. How do we ensure effective and fair teamwork? Do we assess participation? And if we do, then how do we do that in the digital environment?

When it comes to cameras on or off, there are strong opinions either way (26). There are good reasons to allow students to keep their cameras off in large classes. However, for small groups, our experience based on both students' and TA's perspectives (discussed below), is that the use of cameras is a significant factor in maintaining effective teamwork, better interactivity and social climate in classes, all of which contribute to improving learning.

The other tool that allowed students to work effectively in small-group activities was the use of Google Docs in parallel with Zoom. Google Docs allowed students to interact verbally as well as digitally. Importantly, each Google Doc performed several additional functions. It served as a permanent record of the work students had done in class, which they could return to later during study or revision. It allowed TAs to monitor the work of several small groups, while only being able to be present in one Zoom break-out room at a time. It also provided academics with the record of student contributions to the class work, thus enabling us to identify and reach-out to potential students-at-risk.

Laboratories

For chemistry educators, laboratories were probably the most difficult aspect of moving teaching and learning online. In our units, we opted for recording the videos of the experiments (Figure 5), providing students with data to process, and supporting their calculations and conceptual questions related to labs with SCORM exercises (Figure 6). Videos allowed us to show students what happens in an experiment. Regrettably, this approach suffers from not being able to support students in developing their practical skills.

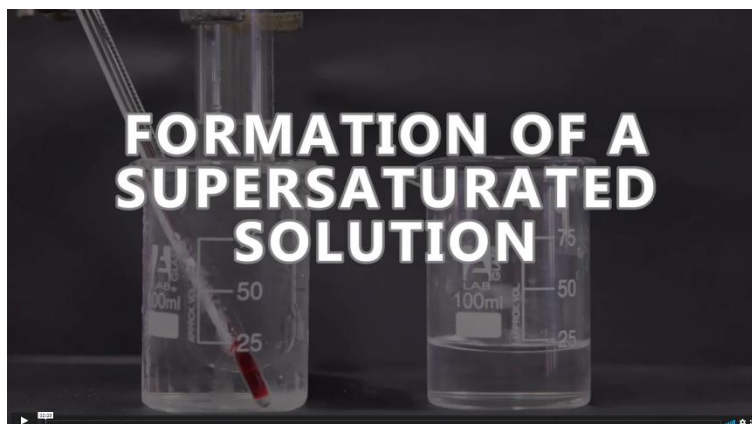


Figure 5. A front-on screen shot of one of the video demonstrations.

Exercise 1

Below is a titration curve illustrating the calculations you have done on the previous page. Note: the exact volumes and pH values may differ from your calculations. The titration curve is labelled with points A to D. Match each point to the correct description from the drop-down menus underneath the graph.

Point	Description
A	Choose the correct answer
B	Choose the correct answer
C	Choose the correct answer
D	Choose the correct answer

Exercise 2

Obtain a stock solution of acetic acid of concentration 1 M. Dilute 3 mL of this solution to 30 mL (first dilution). Repeat the dilution step 2 more times. Enter the concentrations of all solutions into the table. Predict the extent of ionisation of each solution based on the experimental pH values provided in the table. Enter the calculated values (in percentage) into the table, quoting to 1 decimal place.

Acid	Concentration, M	pH	Extent of ionisation, %
Dilution 1			
acetic acid	0.1	3.4	0
Dilution 2			
acetic acid	0.01	3.8	0
Dilution 3			
acetic acid	0.001	4	0

Feedback

Parameter	Feedback
Concentration	Correct
Extent of ionisation	Incorrect

Figure 6. Snapshots of a SCORM exercise on acids and bases.

SCORM (Sharable Content Object Reference Model) is a programming language that can be used to develop activities for students to perform data processing with randomly generated data sets. SCORM applications are great for practice, in that students can look at the same experiment multiple times and be provided with new data sets. SCORMs automatically generate feedback, thus reducing the need for TAs to tell students whether they are on the right track. It is possible to incorporate small quizzes into SCORMs that go beyond just calculations. Finally, SCORMs integrate very well with most Learning Management Systems.

Communications

Most of these activities – interactive lectures, workshops, online labs – happened every week. And so it was very important to help students stay organized. With that in mind, we provided students with weekly activity tables (Figure 7). This was done similarly across all

undergraduate units and thus created expectations on the part of the students and consistency for them. In addition to the activity tables, we also provided students with weekly wrap-up and planning recordings.

Week 5 activities (Aug 31 - Sep 4)

#	ACTIVITY	DESCRIPTION	WHEN
1	Applied Q&A	Join Elizabeth for the interactive Q and A session via Zoom. Check the Workshop and Applied links section for the correct link.	Monday 10 am
2	Workshop	Virtual workshops will take place during your scheduled workshop times (check your timetable via Allocate+). In this workshop, you will work together with your team to solve problems for tonicity adjustment. Check the Workshop and Applied links section for the correct link.	Monday (2 pm and 4 pm) and Tuesday (9 am, 11 am, and 2 pm)
3	Topic Quiz	This Quiz contains conceptual and calculation problems similar to the ones in the interactive lectures and the workshops.	Open Mon 9 am to Sat 5 pm. Two attempts available, 2 hrs each. DUE Sat 5 pm
4	Discovery	Complete Discovery (week 5) , Solubility (lectures 1-3)	Before completing the interactive lectures below
5	Interactive Lecture	Join Elizabeth for the interactive lectures. Lecture notes will be available here . Links for lecture recordings are integrated into the participation quizzes. Week 5, Lectures 1, Week 5, Lecture 2 Have Discovery- or Lecture-related questions? Ask on the General Discussion forum.	Any time during the week. Note that you will need to have completed the interactive lecture activities prior to week 6 Online Lab

Activity tables for previous weeks are available in the Unit Schedule section.

Figure 7. An example of a weekly activity table.

Assessment

Assessments, particularly the end-of-semester exams, are a big issue that deserves a chapter (or a book?) of their own. They presented us with a multitude of questions and choices to be made: Do we need invigilation or not? Our Faculty went for an un-invigilated option. Is the exam going to be open book? An un-invigilated exam is an open-book exam by its very nature. Should the exam be open note, considering that it is already open book? We encouraged students to prepare summary notes as they would do any other year for an open-note exam. The feedback received from students was that preparation of notes was extremely useful, even in an un-invigilated open-book assessment. Next came designing the exam itself. Do we randomize questions? Do we set time limits on each question? Do we allow free navigation, where students can go up and down the exam? Or restrict them to answering questions sequentially, so that students would only be able to go forward? And finally, how do we ensure academic integrity?

In the end, the experience of administering un-invigilated open-book exams left us with more questions than answers. At the time of writing, we are about to embark on a second year of online teaching and learning, with most of the activities still delivered remotely, and the laboratory classes being the only ones planned for on-campus delivery. The process of designing an appropriate examination regime is still currently underway, but one lesson from the previous year is clear: the most important aspects of un-invigilated, open-book online assessments are that they have to be robust, fair and not overwhelming to students.

Feedback from Students

After Semester 1 was finished, we asked the students to answer three questions about the unit: What to keep? What to start? And what to stop? Thirty-six year-one students provided responses. Student answers were largely consistent among them, and the common representative themes are summarised in Table 1. Interestingly, for the ‘keep’ part, the answers were largely centred around technology and organization. However, for ‘starting’ and ‘stopping’, that is what student felt were missing or things that they did not like, the suggestions were very similar to what we get in a so-called normal year. Students want: more model answers, more past exam questions. Students do not particularly like being

marked on their problem-solving process and prefer being marked on whether their answer is correct or not. And, as in any so-called normal year, we will continue the conversation with students about why we do certain things in the way we do. However, this ‘normalcy’ of student responses indicated to us that they were able, to some extent, to get to grips with the disruption of fully online study and managed to focus on the tasks in front of them

At the end of Semester 2, a more detailed survey was undertaken probing student experiences and perceptions of a whole academic year spent entirely online. Fifty-seven year one students completed the survey. The detailed analysis of student responses is currently being performed and will be published elsewhere. Here, we focus on student perceptions about the activities that contributed most to their learning and what factors significantly reduced their ability to study (Figure 8). The answers to the first question are critical to our design of the student learning experience going forward. The answers to the second question, combined with qualitative data (Table 2), give us a deeper insight into student overall experience.

Table 1. Student and TA Responses to the Keep-Start-Stop (27) Questions

	Common student responses (<i>N</i> = 36)	Common TA responses (<i>N</i> = 9)
Keep	SCORMs Zoom & Google Doc Integrated recordings and quiz questions Weekly activity tables	Zoom for small classes Communication back-channels
Start	Model answers for quiz questions More past exam questions More conceptual questions	Technology solutions for seeing student thought process Cameras ON in small group work to see whether students understood
Stop	Forums as communication channel for workshops Marking the problem-solving process Uploads of workings to the forum	Non-engaging students affecting the experience for other students Students not working with each other but working concurrently on the same tasks

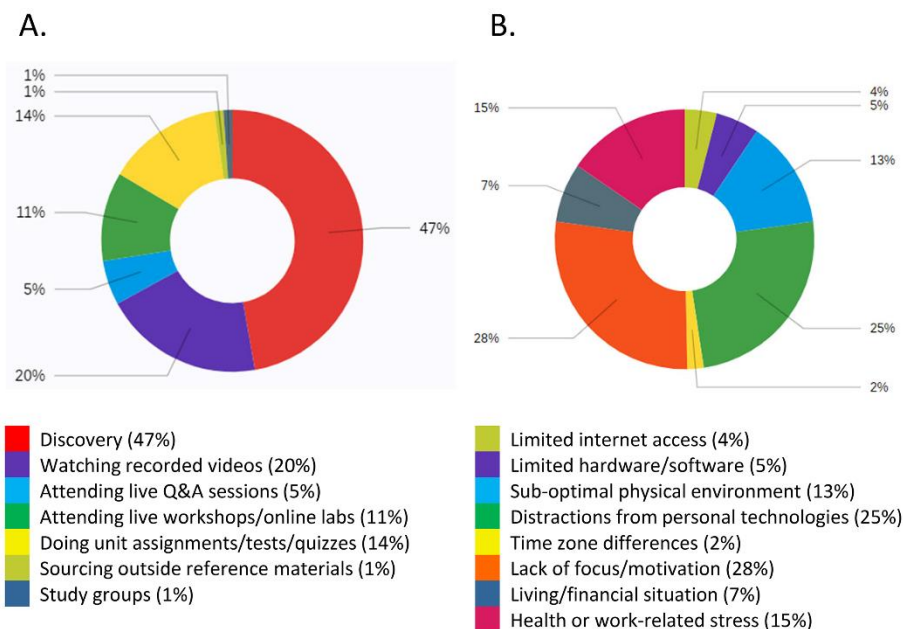


Figure 8. Summary of student responses to survey questions at the end of the academic year. (A) Activities that contributed most to online learning. (B) Factors that significantly reduced the ability to study.

Table 2. Common Themes in Student Responses to Open-ended Survey Questions

Issues	Student quotes
Isolation and lack of human interaction	<i>Cannot make new friends</i> <i>Feeling disconnected from lecturers and students</i> <i>Human interaction makes the learning experience 100% better so without it, felt very pointless and dry.</i>
Lack of privacy	<i>To have a less distracting learning environment. I live with my family and I have 4 sisters, so it can get noisy at times and we are all sharing the internet bandwidth.</i>
Merging of study and personal spaces	<i>I think it's easier to stay on top of your work if where you work is separated from where you eat, sleep and relax.</i> <i>There was no separation between uni and the rest of my life. Uni work felt like I was bludging at home, and relaxing felt like I was at uni and had to go do more work. It all just felt the same</i>
Workload	<i>The sheer workload has been unforgivingly overwhelming this semester</i>

Stress and mental health issues	<p><i>Mental health issues - being cooped in home all day whilst having to just study all day took its toll</i></p> <p><i>I feel overwhelmed</i></p> <p><i>since I am living alone, the lockdown situation and online learning has been overwhelming and so it affects my mental health which affects my motivation to study</i></p>
Concerns about lack of lab skills	<p><i>...lots of labs have been canceled. And this makes me very hard to understand the lab skills</i></p> <p><i>Not being able to apply theoretical concepts in laboratories or other interactive opportunities, which sometimes makes it challenging to understand certain concepts.</i></p> <p><i>On campus Lab, pleeeeeeeeeeeeeeeeeeeeeeease.</i></p>
Frustration about non-participating team members	<p><i>I feel like online learning has given more opportunities for people to avoid their responsibilities in group based work/assignments and unless I get to choose who I work with, chances are I would be the one that has to put more effort than others into completing the task satisfactorily. I believe that online teaching has certainly given more "cover" for students to act selfishly which otherwise wouldn't happen to the same effect in a physical environment.</i></p> <p><i>Working in teams with strangers we have never met and are not willing to contribute has been the most stressful and annoying factor</i></p> <p><i>Dealing with teammates in workshops who refuse to contribute</i></p>
Cameras ON/OFF	<p><i>[need] Students having their videos on and engaging in conversation more</i></p> <p><i>a bit hard when I was in classes with people who I didn't know and didn't even know what many of them looked like.</i></p> <p><i>It has been very frustrating to deal with quiet breakout rooms</i></p>
Motivation	<p><i>Initially, I could cope with online classes as I was enthusiastic about starting uni and determined to make a good start. However, as the year progressed, I found it harder to keep myself in check and found myself slacking more. With face-to-face classes, I find it easier to check in with my peers on their progress and to keep myself motivated.</i></p> <p><i>I am generally more motivated in face-to-face learning because it is much easier to work with your peers in person and there are generally no other distractions such as those that there may be at home. For online learning I find that I tend to lose focus and tune out much more easily therefore decreasing my motivation.</i></p>

	<p><i>In-person I feel there is more competition as motivation for me to perform better, seeing my classmates and wanting to do better. Online, I don't know or feel like I have classmates so I feel very alone in studying so I have very little motivation. There's also feels like there's no physical goal for me to look up to, like a teacher.</i></p>
Positive experiences	<p><i>My online learning experience was mostly positive as I had adequate access to materials and didn't feel it was compromised majorly aside from no physical presence in classes/lectures.</i></p> <p><i>Zoom classes have really improved my confidence, because I know that I never would've contributed to open discussions or asked questions in a lecture theatre but I have no problem doing it over Zoom</i></p> <p><i>I feel generally good as I can avoid commuting and get more rest. I also find it very draining to be around people, so online learning is less stressful than on campus learning</i></p> <p><i>It's hard but rewarding</i></p> <p><i>Overall, quite satisfied. I made sure to stay on top of my work and engage during classes.</i></p> <p><i>As for online learning, since I am a shy girl, I am afraid to share my opinion face-to-face, however, I am confident to talk something using chat. And also, as for online learning, I can watch lecture video as many times as possible at home to ensure I get the knowledge</i></p> <p><i>Online learning should not disappear with the return to campus, I think it gives a lot of students the option to learn flexibly, depending on their own learning habits.</i></p>

Feedback from Teaching Associates

Similar to students, TAs were asked to provide a brief Keep-Start-Stop feedback at the end of the Semester 1 (Table 1) and a more detailed in-depth debrief at the end of Semester 2 (Table 3). Similarly to the students, only a small section of feedback had to do with technology concerns. What worked for TAs was having Zoom for small classes where they could catch mistakes and provide immediate feedback. They appreciated regular and timely communication, in particular communication back-channels between TAs and between TAs and the lecturers during workshops. When it came to the 'start' part of their response, it became clear that teaching online for less experienced educators is a huge challenge, even if they sometime do not recognize it themselves. Seeing students thought process and facilitating problem solving is not easy, even in a face-to-face classroom. The online environment makes it manifold more challenging, particularly when cameras are off. How do you judge whether students understood your explanation? That question was absolutely on the top of TAs' list of questions. In the 'stop' part of their response, the lack of teaching

experience was again clear. What TAs wanted to stop was students being students: saying ‘Yes’ just to get out of class and not working with each other. This is no different in an online classroom compared to face-to-face, just that much harder to communicate directly in some cases online.

The detailed thematic analysis of TA interviews will be published separately. Here we present common themes in these interviews that complement the picture provided by student survey responses and our own observations (Table 3). More in-depth interview answers revealed that TAs were developing approaches to reach students online where non-verbal cues were limited, particularly the body language and particularly when students elected not to turn on their webcams. TAs talked at length about working on establishing an emotional connection with students as well as facilitating students establishing connections with each other.

Table 3. Common Themes in TA Responses to Interview Questions

Issues	TA quotes
Developing pedagogical content knowledge	<p><i>... after they were explaining their solution and then I would reiterate the point that they did really well, just to revoice and reinforce what they did well. And then in terms of expanding if they had a good skeleton, but they were missing extra things, I would then expand on their solution and say “Great explanation, I’d add this, this and this to get the full ... explanation.” [Katherine]</i></p>
Engaging with students’ non-verbal cues	<p><i>And for Zoom I think that very good thing is I can see their facial expression. Whatever I try to rephrase something I always look at their facial expression. [Cate]</i></p>
Establishing an emotional connection with students	<p><i>That’s what I... that’s what I like to do in terms of that emotional component... When I first started, when I started my workshop, so I’d always ask them how are they, how they are doing. And I obviously.. you know in Zoom it’s not... they’re not like going to start therapy session, but they say, you know, ‘good’, or they say ‘they’re tired’ or something like that. And then I would say... it was like I’d kind of like ... ‘Yeah, me too’, like you know. ‘It’s... it’s it difficult, so I understand where you’re coming from’. Just to emphasize that I understand them and then unlocks it coming into the workshop expecting them to perform like you know at 110%. It’s more like ‘I understand how you feel, let’s just work together and help each other.’ [Katherine]</i></p> <p><i>... the talkative group were constantly asking me about you know, even things outside. Like sometimes they asked me what was my experience of studying face-to-face when I was an undergrad. So last conversations that were not necessarily related to the workshop, but it did help me connect with the students and in terms of providing feedback and motivating them. Just the fact that I was constantly going between... between the breakout rooms. Like they knew that I was there. So it made it easier for them to ask for help. Even the shy students that didn’t necessarily feel OK to talk. I would just say ‘I know this is a tricky question. But looks like you’ve made a good attempt at the first part. How are you going?’ ... I felt that if I did</i></p>

	<p><i>start with uh encouraging compliments and say their name, even if they're shy student that have webcam off... [Mary]</i></p>
<p>Facilitating students establishing connections with each other</p>	<p><i>As I got to understand the students more in terms of their personality, like level of communication and academic performance, I would actually couple students that were... you know... more interactive online with those that were more quiet. And so that would facilitate communication ... I think students communicate quite readily, when they communicate with each other. ... So I would take into consideration the personality and the level of academic ability and I found that really helped because a lot of students... I mean, I mean, just in general, if you know something, you want to communicate your knowledge. ... I found that to be very beneficial for students. They got out of their shell and then, once other students that struggled understood it more, they actually even started to encourage discussion. I found that towards the end of the semester, when I even started to do that and I even I noted, when they did that actually... came into the Zoom session like great assist, really good teamwork, things like that, reinforce that positive discussion that students were encouraged to do that... I actually thought where the struggling students at the beginning, really contributed and really helped other students towards the end. Because it was just like teamwork. I think they felt like they were 'one', like a team as opposed to just individuals. So that's how I encourage discussion in that way.</i></p> <p><i>I think what I achieved well is creating that... that space for students to feel comfortable with learning and asking... asking questions and making mistakes.</i></p> <p>[Katherine]</p>
<p>Differentiating approaches</p>	<p><i>Yeah, with the talkative group, ... I did feel like they were involved. Even though each person is assigned one particular problem, they were involved with other problems enough that they... But then I would say they are also strong group of people, so that's why it was a bit easier, whereas with my other group, I had a few strong members and a few weak members. But overall, they were very quiet, so if they were asking each other questions, it was because I was forcing them to ask each other questions and their questions were usually really simplistic ... [Mary]</i></p> <p><i>There was like a couple of students who are really engaged, I guess. And they were willing, always willing to kind of answer or even sometimes ask questions themselves but... the students, which you probably picked the first couple of weeks, were always very hard to get... They... they were expecting me to ask them to ask a question. I still found that they weren't necessarily proactive with asking the questions so much. It was still... I was sitting in the room going 'alright, so I guess, Miriam, you are asking a question on this one. What... do you have any questions?' [Colin]</i></p>

Cameras ON/OFF	<p><i>one of the biggest difficulties was missing non-verbal communication to students due to lack of camera usage compliance throughout the year, but especially in Zoom Sessions. This made it very hard to gauge how well students were responding to content or guidance; whether there may be having difficulties with what is being discussed, or whether they might be genuinely tired or frustrated, and thus easing off may be a better approach. As a TA, this meant that I often felt like I was 'shooting in the dark', as well as uncertainty as to what I was doing (or not doing) was effective. [Billy]</i></p> <p><i>Again, my quiet group most of the time... none of them had their camera on. My talkative group did have their camera on again. I think it's just a personality thing, but as a result of that my quieter group, I don't have much of, I guess, a personal connection with them or any conversation other than the work. [Mary]</i></p> <p><i>It was hard. It was really, really hard. I think particularly in my groups no one wanted to use their cameras. And there was probably... In each of the groups, there was one or two people who ... Don't know if extroverted is the right word... But they were more open and kind of willing to answer but a lot of the times you kind of felt like you were speaking into the void a little bit. [Interviewer: So how did you manage it?] Mainly it was calling on people by name. So it was very much like 'Well? Ok, I'm going to volunteer, say Jimmy. If you want to, can you answer this question for me. And then, yeah, there would still be a pause before they would be like alright. [Colin]</i></p>
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Stakeholder Perspectives

There are three players in this game we call higher education: us (called faculty or academics, depending on geography), students, and our sessional staff (teaching associates).

Students

Students have shown to be largely resilient, adaptable, and understanding during the year of online learning. But the transition to fully online learning was hard on many of them, particularly on first-year students who had at most one day of on-campus experience. They learned to grapple with, and even enjoy, accessing classes, their instructors, and support services online. However, they also missed the social – and educational – aspects of face-to-face classroom experience.

It was not a revelation, but we have definitely confirmed that structure is very important. That involves clearly sign-posting all activities and assessments, informing students about what happens when, keeping it simple, keeping it up-to-date, keeping it all in one place. It was also very important to not use too many different technology tools, at least not all at the same time. Communication is very important, it has to be a regular two-way communication between students and instructors. It has to support student-to-student

communication, both formal and informal. Communications in the learning management system should include instructions for students on ‘where, when, what, and how’. The communication must also include early and regular feedback *from* students on what does and does not work. Communication could be recorded, but the live sessions make students feel teachers’ presence. And finally, student well-being is critical and therefore pastoral care is critical.

Teaching Associates

Teaching associates have clearly risen to the challenge. They have mastered the technology and tackled the challenges of encumbered online communication. They have developed approaches to engage with students in an environment that was unfamiliar to both students and themselves. TAs have not only identified areas of further improvement in course design, but also the gaps in their own preparedness to teach online.

Teaching associates are an absolute cornerstone of our workforce, when it comes to teaching both on campus and online. So it is critical that we support them both before, during, and after each class, particularly for online classes. They need special training for online teaching that goes beyond how to use Zoom. They need training in appropriate teacher discursive moves and facilitation techniques.

Academics

We learned that we must adapt our pedagogy, and not just re-use our old PowerPoint lecture files. We must look for resources as we cannot develop everything ourselves. We should share our resources, as good citizens of the community of practice. We also could take this great opportunity to experiment with technology, but not go crazy with it. We need to continue engaging with education designers. We need to be flexible and agile. We need to be organized. Importantly, we need to remember to look after ourselves.

And finally, a big question: did students learn in 2020? Based on the experience in the two chemistry units discussed in this chapter, the answer is Yes. But, it is possible that some students achieved better learning outcomes than they would otherwise, whilst others were not as successful as they would have been in a face-to-face on-campus experience. So does it mean that the online environment favors students with greater prior learning and stronger self-regulation? Possibly. And here we may have a wicked problem that we must be aware of going forward.

Summary

Teaching and learning in the COVID-19 pandemic was a valuable lesson in what does and what does not work well in the online teaching environment. This natural experiment has provided a proof of concept that online teaching and learning is effective for some elements of university courses, even those courses that require students to develop practical skills, such as laboratory skills. We found that discussion forums did not work well when used synchronously and that pre-recorded lectures did not work well if they were not timetabled. On the other hand, Q&A Zoom sessions and weekly structures (activity tables and wrap-up videos) worked extremely well to keep students engaged, informed, and connected. Post-pandemic, keeping online what worked online and returning to the physical classroom what did not work online will allow instructors to truly take forward the concept of blended learning (28).

Curiously, and maybe unexpectedly, the urgent pivot to remote teaching caused many academics, especially those outside of the teaching-only or education-focused throng, to return to the values of pedagogy. All of a sudden, many had to re-examine “how we teach”, not just “what we teach” (29). We note that this return to valuing ‘good old’ quality teaching may be another lesson that had to be learnt. Technology, format, and modality are important, but teaching quality must reign supreme.

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