Final Report for eSTEeM Project: Blending labcasts and remote/virtual experimentation: students' perception in practical skills development

Keywords: labcast, live event, broadcast, StadiumLive, chemistry, practical science, skills, community, remote instruments, student perception

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Executive Summary

Online practical work is now established across the OU STEM curriculum, in many modules and programmes. As well as playing an integral function in bridging the gap between theoretical and practical knowledge (Brewer 2013), it provides students with an opportunity to develop both practical skills and general skills such as problem-solving (Reid 2007) important for employability.

Chemistry students, in particular, need to develop a range of practical skills as part of their studies. The four main types of practical skill include: (1) manipulation; (2) observation and recording; (3) processing and interpretation of data; and (4) ability to plan experiments (Johnstone 2001). Online study is especially suited to items (2) to (4). However, the teaching and learning of manipulative skills is far more challenging online, especially with regard to synthesis experiments which present greater challenges. To mitigate this the School of Life, Health and Chemical developed a range of residential lab schools to provide students with the opportunity to develop these skills and for those not attending the labschool, an online interactive (using Unity gaming software), where students carried out a synthesis in a 'virtual laboratory'. Unfortunately, the latter was overtaken by changes in browser functionality and had to be withdrawn so a new activity was required.

In the process of exploring alternative experiences to hands-on laboratory work, the Stage 2 Chemistry (S215) module team decided to run a pilot of a 'live-lab', streamed directly from one of the labschools. In this set-up, it was the intention that volunteer students who had already carried out the experiment, would complete a synthetic procedure, live, over the course of a whole afternoon (Fig. 1). During the event remote students would watch the procedure unfold and interact via a chat facility that a tutor would monitor. This would then be followed by a 'remote-experiment' analysis of the compound synthesised, using IR spectroscopy. The experiment was intended as a direct illustration of some of the theoretical topics covered in S215. This idea was based on the perceived success of other live chemistry labcasts, generally held in the evening and lasting about an hour.

There is anecdotal evidence that students do not value virtual experiments as much as those based on real equipment in campus laboratories that can be run remotely, even if the 'practical skills' are the same. Work has also shown that use of webcams that place the student 'in the laboratory where the instrument is situated increase the value of the experiment for students (Sauter 2013). So, the pilot also aimed to evaluate student perception and 'value' of the "live" experience.

Aims and scope of project

To assess the viability of running a half day live event during the on campus labschool: SS021 *Laboratory Skills for Chemistry* and to ascertain student's perception of its value in developing an awareness of practical laboratory techniques.

Given the nature of this project – a number of questions and challenges were identified.

1. How disruptive would the event prove to be to other students attending the labschool? Conversely, what benefits would having other students present give to the live event?

2. How many remote students would attend such a long event during the day? Almost all labcasts up to this point had taken place in the evening when most students were in their home environment. The one other event that had been run at lunchtime had had a much lower audience. although this was an introductory level 1 event and not important for assessment and thus might be viewed as lower priority. The chemistry labcast was to involve a small data collection task that would lead into a report that was part of a summative TMA, a so might be viewed as higher priority.

3. Given the length of the event, would students stay the course and interact with the chat and widgets? In addition, would they return after the break in the middle?

4. How well would students who had attended the labcast perform in the TMA report as compared to those who did not and to those who attended the residential lab school itself?

5. Was the experiment managed well enough for remote students to understand what was happening? Did the student volunteers 'perform' the experiment clearly enough? How did the guidance tutor role play out?

6. How realistic is it to try and teach manipulative skills through remote demonstration?

7. Were the studio set-up and shot angles well designed, so that remote students could see the required close-ups and understand what was happening? Such a complex, long experiment is tricky to film live. Could our standard studio set-up adequately cover all the angles required? Did we have enough crew to cover all roles?

Activities

There were two strands of activities - the pilot labcast itself (run on 11th April 2018) and gathering data from the following TMA report. As far as the labcast was concerned we aimed to observe how it unfolded without too much intervention. The experiment had been planned, rehearsed and then storyboarded so that the studio crew could plan their studio layout and the tutors could plan the experiment set-up. After the event the success of camera angles, tutor interventions, widgets, chat and the experiment itself were assessed using the recording and data and text files derived from StadiumLive analytics. The TMAs were also analysed in terms of the number of students selecting to write-up the experiment as well as the quality of the write-up. The only student feedback collected was from the chat box during the labcast itself, in part due to delays in approval for the project. It had been intended originally to repeat the pilot for the next presentation to collect feedback from students to answer the questions above, however the labcast was not presented the following year and so in this report evaluation from the student perspective is limited.

The Pilot Event

Link to event: http://live.kmi.open.ac.uk/webcast/f7f7dq207

In April 2018, during an SS021 residential labschool, three volunteer students came onto the Walton Hall campus to run a parallel live event one afternoon. Two of these were studying chemistry at Stage 3, (both had successfully completed the Stage 2 chemistry module S215) whilst the third was studying S215. So, all were well prepared to carry out the experiment. Figure 1 shows the pilot event in progress.

The experiment was the synthesis of the geometric isomers of copper glycinate. This is a standard laboratory experiment in an undergraduate chemistry course (O'Brien 1982). In S215 students could choose to write this up in TMA05, which forms part of the examinable component of the module (an alternative simulation of a different experiment was also available).

Figure 1 The event in progress with three students, tutor and moderator at the lab bench in the studio lab.

The event ran for 2 hours, 45 minutes, beginning at 13:30 and ending at 16:20. It was split into two sections with a tea break during which time the synthesised compound was undergoing extended heating under reflux.

Students attending online 'joined' the labschool remotely at the beginning of the session.

The technology employed was Stadium Live which is used routinely in labcasts. There are limitations with this means of broadcast, in particular associated with the time lag between recording and the audience viewing the stream which would make a live dialogue, one of the original aspirations, impossible. The team had originally discussed whether it might be possible for the students in the audience to have audio contact with the volunteers in the lab but the technology to do so was not in place for the pilot.

The event began with an introductory briefing to *all* students (including those attending the labschool) from a tutor (Rob Janes), at the flipchart, running through some background theory to the experiment. Following that, he handed over to the volunteer students to begin carrying out the experiment. The intention was for them to explain what they were doing and for the tutor to highlight key considerations and processes as they went along.

It was planned that the remote students would engage via six interactive widgets (in reality only three were included), as well as two short questions sessions during the briefings. On reflection, for such an event this is a little on the low side. Furthermore, they were concentrated on the first portion of the event, leaving the latter part with low interactivity. In an hour-long event we would normally have around six widgets, therefore a three-hour event should have had around 15-18. However, the usual labcasts are carefully planned demonstrations with pauses built into them to allow for interaction, whereas the copper glycinate experiment was complex and free running with few pauses long enough for the students to interact with others given the issues with the time lag. The students joining remotely were however able to ask questions using the chat function which was monitored throughout by the moderator.

Following the labcast the students were able to analyse the isomers prepared in the labcast themselves using a remote IR spectrometer, which they were able to book, access and operate from home.

Findings

1. Observations from the labcast

The students worked as a team to tackle the practical issues as they arose. The tutor was on hand throughout to provide support where necessary. This support ranged from help with understanding the ongoing chemical processes, to assisting and guiding the students on how to use the equipment required.

This approach of explicitly explaining both the science and how the equipment was selected and handled, was designed to give remote students the best possible experience of the lab work. For example, there was a discussion point around the level of accuracy required for weighing the copper glycinate in the early stages. The tutor kept a close eye on proceedings and frequently intervened to explain what was happening and to discuss the next steps thus keeping the students on track. In part, this was because they were so engaged with the 'doing' of the experiment that they forgot to vocalise their actions for those watching.

The experiment itself went mostly according to plan. However, the students did make one mistake and it was interesting to record how such a thing could be handled. In this case it was discussed with the tutor who gave guidance on how to proceed. Interestingly, this is exactly the sort of benefit that students who attend a labschool derive from their experiences. Another aspect we did not anticipate was that, in using students who had already done the experiment, there was potentially less of a need to explain the equipment and how it was to be set up than might have been the case if they had been doing it for the first time.

2. Success of studio set-up

The lab studio was set up with seven video feeds (see studio plan, Figure 2 and view from cameras 1-4, Figure 3), of which one was a laptop with the StadiumLive, in a browser window, to show chat and widget responses. Our choice for camera placements was somewhat constrained by the presence of other (non-live) lab school students. The camera arrangement was as follows:

- A main, locked-off tripod camera (CAM 1) was set up opposite the lab bench to capture a wide view of the whole experiment.
- A subsidiary, locked-off tripod camera (CAM 2) was adjacent to the main one to capture the action at the flipchart, which was to the side of the experiment bench.
- A second subsidiary, locked-off tripod camera (CAM 3) was set up beside and slightly behind the flipchart. This was angled towards the moderator who was sat behind the lab bench at the laptop.
- The remaining three cameras were all positioned with the aim of capturing close-up shots. One was positioned directly in front of the experiment on the bench (CAM 4). The last two were paid and tilt cameras on the ceiling - one at either end of the bench (CAMS 5 and 6). The latter two cameras were controlled from the Edit Suite where the vision mix was taking place. They are both programmable cameras and we had set up numerous pre-set angles on both to capture various views of the equipment and action.

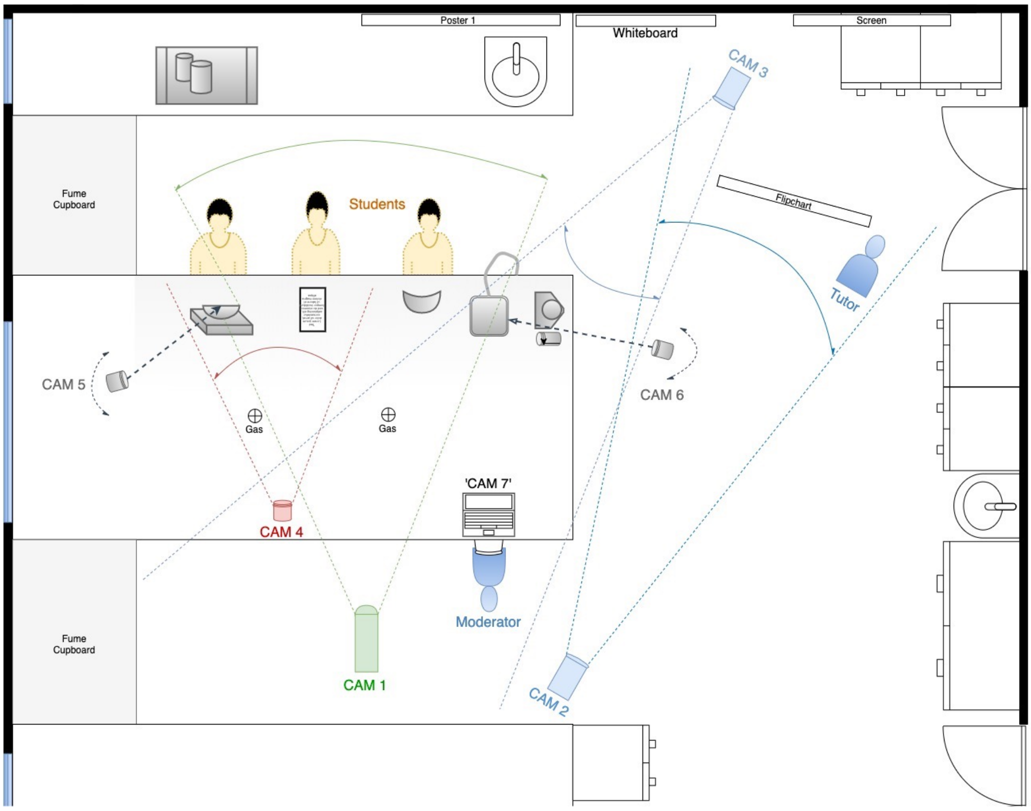

Figure 2 Lab studio plan showing placement of cameras and positioning of students and staff.

Figure 3 Views from cameras 1-4

Note that there was a floating producer occasionally manning the cameras opposite the bench who was able to make minor adjustments to CAMS 1, 2, and 4. In addition, CAM 4 was left recording during the tea break to monitor the action.

As we wished to give the shoot a spontaneous feel, to convey the students' explorative experience, it was decided not to have a rehearsal with the students (although they were given a short briefing immediately prior to the session). This meant that we were not able to anticipate where they would stand and how they would behave, with the result that some of the cameras were not in quite the right places. The tutor also found it difficult to know where to stand and would sometimes end up half in and half out of shot. Therefore, the clarity of the proceedings was sometimes hampered by poor camera angles or other equipment. For example, when a temperature was being measured in a beaker, CAM 1 was selected by the vision mixer so as to show all the students, but the experiment was hidden by CAM 4 which sat on the bench (Figure 4). This photo also shows how the students did not always set up their equipment in the ideal position: the student in the dark lab coat is on the far left edge of the shot. In retrospect, it would have been wise to have drawn clear work-areas onto the bench as a guide for the students, so that they stayed properly in shot.

CAM 3 turned out to be almost redundant as it mostly tended to show people's backs (Figure 3, photo 3) when they walked in front of the camera - not realising that it was in use at that time. It would have been better placed opposite the bench, to the left of CAM 1. There it could have been used to capture more of the medium wide to close-up action on the bench and also to track the participants when they moved out of shot of CAM1. This would have necessitated a dedicated camera person. Such a position would have made it easier to follow the tutor in and out of shot too.

The participants were mic'd up with wireless radio units and lapel mics in order to capture clear audio and reduce the background noise of the air conditioning and the on-going lab school. On the whole this was successful, yet it still fell foul of student's habit of whispering amongst themselves. In other

Figure 4 Example of a poor camera positioning, showing obstruction of experiment. CAM 4 obscures live action

words, they behaved like all the other students in the lab - they spoke *sotto voce* in an effort to not disturb others. This was reflected in the fact that they rarely looked into the camera although it had not been made explicit to the students, or indeed was the expectation, that they would be 'presenting' to the students which is the general format used in labcasts.

3. Participation and Interactions

The students in the lab interacted well with each other working as a team to carry out the experiment. One common pattern of activity was for a pair of students to work on something whilst the third setup the next piece of apparatus or went to fetch some equipment. Such pairs did not always consist of the same students, just whoever happened to the around at the time. Rarely did all three work together. This may have been because the experiment was designed for a pair only. It might have been better with just two students, or with the third monitoring the chat and interacting with the remote students to see what they thought should be done next, for example.

Whilst we had not anticipated a large remote audience due to the timing of the event, we were disappointed when only four remote students joined us online. They were essentially a passive audience with little chat and only three widgets to answer. The tutor interacted mostly with the students at the lab bench and on occasion with the academic moderator and more could have been done to 'pull in 'the remote audiences too by explaining directly to them what was going on and the issues that arose.

60 students however watched the recording afterwards demonstrating a strong preference for watching at their own convenience.

Indeed, some interesting patterns can be observed in the recording data (Figure 5). Overall, the number of viewings gradually rose from the live date until the 26th April and then they fell off sharply. The TMA submission date was at the end of April, so the view patterns tally with assignment preparation.

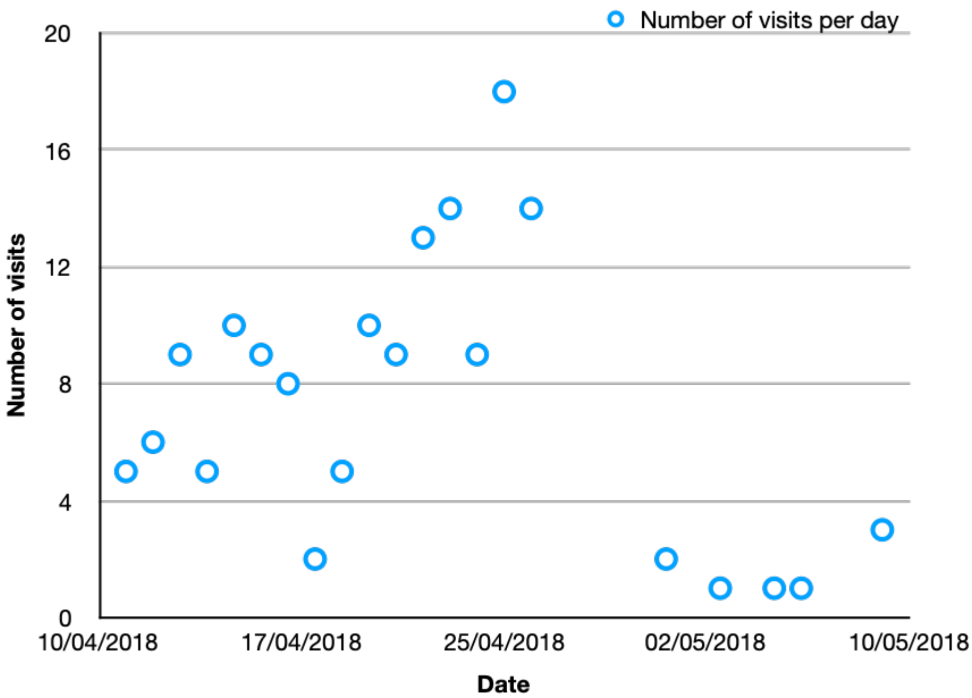

Figure 5 Number of visits per students shown by date

Some students visited the recording more than once (Figure 6). Of the 60 who watched the recording, 24 only watched it once whilst at the other end of the spectrum one person viewed it 12 times. Undoubtedly this was not to watch it in its entirety each time - maybe only to watch it in small chunks to make it more digestible. Thirty students visited more than once - between 2 and 5 visits. It is also likely that some of the students who completed the experiment themselves during the labschool watched aspects of the recording to aid with the experimental write-up for the TMA.

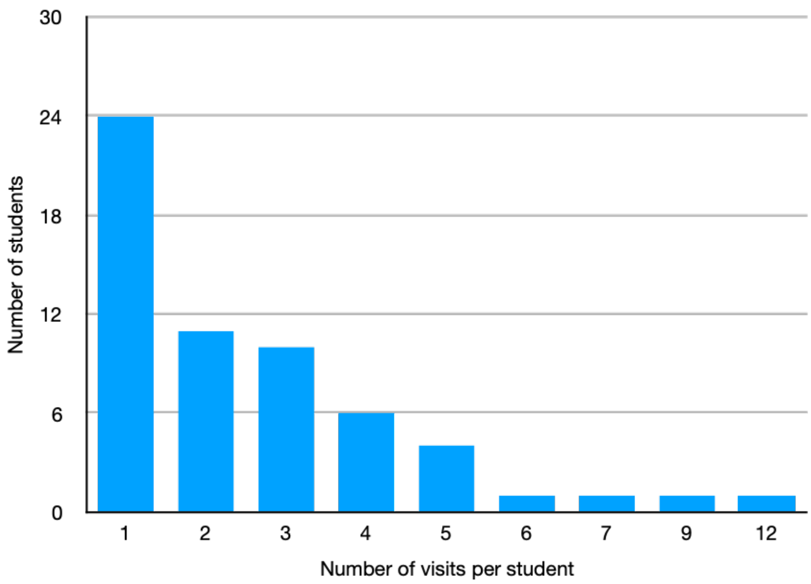

Figure 6 Number of visits to the recording per student. For example, 24 students only visited once.

Interactive widgets

During the event only three of the originally planned six widgets were actually posed, reducing the level of interaction for the remote students. All three questions related directly to the experiment itself in the first part of the event before the tea break:

1. What type of filtration would you use to recover the blue solid? [28 minutes in]
2. What is the composition of the blue filtrate? (Figure 7) [44 minutes in]
3. What property of molecules is probed by infrared spectroscopy? [75 minutes in]

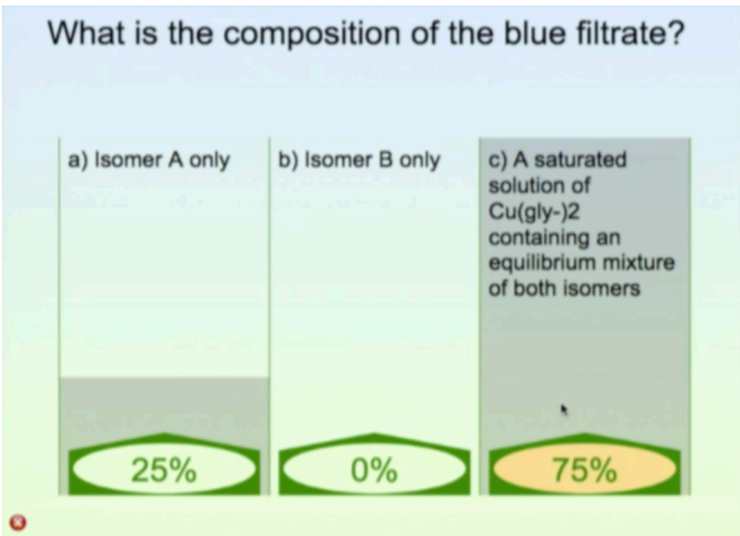

Figure 7 Example of interactive widget responses. Students only see others' responses once they have entered their own, eliminating tendencies to choose with the majority.

Only two students replied to the first widget whilst the other two had three each. One possible reason for low participation in the first one is that the vision mixer did not switch cameras to focus on the academic moderator posing the question and their audio was lost amongst that of the students. Widgets 2 and 3 were posed as part of the natural flow of the event - W2 as part of the experiment and W3 as a follow on from a piece of flip-chart teaching, meaning that the remote students were able to pick up on them more easily. One of the chat comments indicates that the remote students appreciated the widget questions, so perhaps more could have been used to help support remote students.

One notable omission, given one of the aims of the live event was to help with appreciation of manipulation of equipment, was the absence of any widget questions relating to knowledge and setting up of kit. Ideally, questions of this type would have been posed by the volunteer students completing the experiment themselves, but in part this reflected the issues to do with the time delay in the system as it is not clear what the volunteer students would have done while waiting for the response. These sorts of interactions would have to be carefully planned into an event and rehearsed so that the volunteers would have something to do whilst waiting.

The chat box was moderated by the academic moderator. Student participation was low: there were 27 messages in total, 13 of which were by OU staff. However, it might have been more dynamic if it was moderated by one of the students behind the bench so that a proper dialogue could be initiated with the people carrying out the experiment, allowing the remote students to contribute to the way it was being carried out. This may have also improved their eye contact with the camera. With careful planning it might also have compensated to some extent for the lack of technology to prevent real-time interaction between the volunteers and students joining remotely. To get around the time lag, the moderator could have asked the students to explain what they were doing. As this had not been discussed with the volunteers at the outset it was felt that it would be putting the students on the spot to ask them to do this 'live'.

There were two significant pieces of chat dialogue:

Piece 1

Student A: 14:35. Can you speak a teeny bit slower please?

Lead Tutor: 14:36. Will do - sorry

Student A: 14:36. No problem!

Lead Tutor: 14:36. is there any bit of that calculation you would like us to cover again

Student A: 14:37. All of it, really. I missed a bit and spent too long trying to work out was said, so missed the rest. Sorry!

Student A: 14:38. Thank you!

This referred to a briefing that the tutor provided to all the students in the lab (the volunteers as well as the students at the labschool) going over one of the calculations at the board. This sends a clear message that perhaps the tutors were rushing through things too fast, suggesting an important point - whilst the pace may be acceptable in face-to-face situations, it seems that it's more difficult to follow whilst watching online. It is also possible that the students in the lab were too polite (or put off by the fact that it was being recorded) to ask for clarification, especially as they could ask for clarification at a later point away from the whiteboard.

Piece 2

Student A: 15:06. It's good to see actual experiments being done. I am more of a visual learner, and I've struggled with so much of the content being online. It would be good if key measurements of the reactants etc. could be typed on here somewhere for note-taking. And the talking slower was really helpful. I have mild hearing loss, and when you can't see someone speaking, speaking just a bit slower helps me make out words a bit easier.

Student A: 15:07. The interactive questions were good too.

Student A: 15:11. Also, a good look at the crystals forming would have been nice. Maybe not necessary to see (and I'm assuming health and safety prevented the camera from being closer).

Student A: 15:11. Anyway, that's my twopenneth! Thanks for doing this.

These are the sort of comments we were hoping for. Not only were we able to assist a student with a mild disability, but we got some feedback on how to improve delivery for another time.

Although their comments were not recorded, the students carrying out the experiment felt it was a worthwhile experience. It was a shame that the remote students were also not able to engage in teatime informal discussions (which took place in another room) as it would have would have helped build their sense of community. During preparation for the event this was not taken into consideration.

Low participation by remote students ultimately made live repeat events untenable for the time being. One factor that should be considered for any future such events would be the time of day they are broadcast. This time had been selected to coincide with the experiment in the labschool. In practice, as the other students were 'off-camera', there was no advantage in doing this and if anything, hindered discussion among the volunteers so not to distract the other students. Many students are at work during the daytime and so find evening live events far easier to attend. In the teaching of fieldwork, in another module, this is handled by having multiple events across several evenings to spread out the teaching and practical work in a more manageable manner. Alternatively, it might be better as a labcast which focused specifically on lab skills and handling equipment via some straightforward experiments. However, the role of a 'real' student is not to be underestimated as remote students will undoubtedly identify more easily with them and they are also more likely to ask student-style questions. In a sort of 'half-way house' to this, the labcast recording was edited down to a more manageable length and made available to students on the following presentation of S215.

Although this experiment was assessed, students only needed to record a couple of key data points from the labcast to write up their report. Perhaps if we assessed lab skills or some other aspect of the event more explicitly, then maybe more students would participate. For example, a critique of how equipment was handled. This has been taken on board in the redesign of the practical component of the module for 19J (see below). There was also a choice of experiment that students write up for the TMA and around two thirds of the students on the module selected the other experiment, which was an extension of a virtual experiment that they had completed previously in the module and so might have been perceived as being more familiar.

Experimental write-up in the TMA

A total of 52 students wrote up this experiment for the summative TMA (and 90 the alternative). Of these, 30 had attended the lab school and completed the experiment themselves. The remaining 22 students had watched the labcast, either live or the recording. Anecdotally, it was not evident from the write-up itself whether the student had actually completed the experiment themselves or engaged with the labcast and there was no difference in the quality of the report for the different groups. This is similar to what had been observed in previous presentations when comparing the report from those students who had completed the experiment at the labschool or using the Unity virtual experiment.

Impact

a) Student experience

- In what ways has your project impacted on student learning?

Volunteer students learnt something about group work in a lab situation, working to an audience in front of a camera. The ability to chat with the tutor and students, allowed remote students to ask for information to be repeated or clarified. They also appreciated the visual aspect of seeing an experiment done rather than just reading about it or watching a video: real-time experience.

- How is your project contributing to increasing student success (i.e. retention, employability, etc.)?

Employability was not investigated as part of this project, but it appears that the recording helped students who wished to choose to answer a practical lab experiment for their TMA answer. Two of the three students who volunteered to run the experiment have now started PhDs and referred to this experience in their applications.

Although again not investigated, it would be interesting to see whether filming an experiment in real-time might encourage participation at future labschools as some students are worried about attending.

- Have there been or will there be any benefits to students not directly involved in your project?

The eSTEeM project gave us time to review and analyse a chemistry labcast in which an experiment was carried out by students in real time. This can tell us something about how students perform in groups in the lab and highlight any issues they have with following a lab script of their understanding of the science/experiment. This information will be fed back into the creation of any new labcasts so that they are better designed and the production workflow is improved.

In addition, the event created a recording that was used in future presentations of S215, allowing students a choice of experiment to use in their TMA. It has also informed how we video practical work more generally. For example, it has informed filming of a new experiment for use in the module, which has since replaced the experiments for TMA05 for all the students on the module. As well as informing the filming, reflecting on the aims of the labcast produced for this project and its link to assessment also influenced the TMA itself with a greater emphasis on the techniques, handling of equipment (and potential sources of error) and greater alignment with the learning outcomes related to this aspect of the module.

b) Teaching

- How have you affected the practice of both yourself and others within the OU?

Ultimately, in part due to the issues associated with this event (e.g. time of day, audience figures, shot angles) the pilot was not rolled out to mainstream production. As noted above, the recording was used for the 18J presentation and, a different synthetic experiment was demonstrated by central academics to replace the copper glycinate question in the assignment for the 19J presentation. However, lessons learnt here will be applied to the development of future labcasts. Once restrictions due to COVID-19 have eased, it is possible that the module could explore running the experiment live as a series of labcasts and involve student volunteers where appropriate, or indeed re-record a video with student participants rather than academic colleagues.

- What has been the impact of your project outside the OU?

None directly from this, but labcasts *per se* may have helped with the Royal Society of Biology and recent Society for Natural Sciences successful accreditation submissions.

c) Strategic change and learning design

- What impact has your work had on your Unit's or the University's policies and practices?

Experience has been fed into the development of labcasts in two practical science modules recently in production, S290 and S285, both of which are planning live events.
This live event has been replaced by two offerings: a recorded practical demonstration of a synthesis experiment on S215 led by two central academics and a new labcast aimed at all Stage 2/3 students with a wider brief ('enrichment for chemists').

Recommendations

How will this inform use of this sort of format in the future?

- If inviting a student to carry out the experiment, it would be advisable for them to attend a rehearsal beforehand to plan their actions more carefully. Greater interaction of the volunteer students with the audience would also be encouraged.

- Clear planning of equipment locations on the bench should be carried out in advance with such locations being mapped onto the bench top for ease of reference for the participants. This will allow better camera angle planning and setup. Close-ups at key moments should be identified in advance and supported by appropriate cameras.

- Ideal setup might be with one student and one tutor – a sort of masterclass situation. This would allow for much more explicit 'teaching' and demonstration of both the science behind the experiment and the manipulative aspect of setting up and using the equipment.

- Camera shot of notebook to capture notetaking and observations would be useful.

- Schedule such live events in the evenings to maximise attendance. Whilst running the live event alongside a lab school gave the event authenticity, it also hindered flexibility on the technical side and there was no apparent advantage of running the two together.

- Ensure that as much of the content of the event as possible is usable by students in the audience. Preferably make the content assessable.

- Interactions with remote students' needs careful consideration. Ask yourself: What are the learning points you wish to highlight? How might you use the widget questions to best achieve this? Plan the interactions into the experiment, perhaps allowing for choices that affect the outcomes: if you do A, this happens, whereas if you do B, that happens. Remote viewers need to feel that they are at least partially in control of proceedings. Such interaction needs careful planning so that the presenters are kept occupied whilst waiting for responses from remote students. Ideally the technology should be such as to allow real-time interaction between the students in the lab and those joining remotely.

- Chat needs a dedicated moderator, out of shot or sat at the end of the bench, who can encourage and answer questions. The role of the moderator and the way they are to interact with both the presenters and the remote audience needs to be carefully considered at the planning stage.

- Widgets should be made more explicit and posed to the participating students in the lab too. The video should show the tutor actually asking the question before putting up the widget question, in order to capture the attention of the remote audience.

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Deliverables

- Storyboard for crew, tutor and moderator
- Lab studio layout figure
- Video recording of the experiment

Appendix

Questions for the lab:

1. How might we promote dissolving?
2. So far we have referred to our isomers by the labels A and B, but which is which? Which is cis? Which is trans?

Interactive widgets:

1. What type of filtration would you use to recover the blue solid?
   a) Suction filtration
   b) Gravity filtration
2. what is the composition of the blue filtrate?
   a) Isomer A only
   b) Isomer B only
   c) A saturated solution of $Cu(gly^{-})_2$ containing an equilibrium mixture of both isomers
3. What proper of molecules is probed by infrared spectroscopy?

a) bond vibrations

b) electronic transitions

molecular rotation