



Case Study

Lockdown labs: Pivoting to remote learning in forensic science higher education

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ABSTRACT

Forensic Science training and education is reliant on the application of knowledge to casework scenarios and the development of key practical skills that provide a platform for career development in the field. The COVID-19 pandemic introduced a number of challenges to effectively deliver practical content online and remotely, whilst still meeting intended learning outcomes, accreditation requirements, and attaining a high level of student engagement and experience. The MSc Forensic Science programme featured in this study is a one-year degree programme with a strong emphasis on the practical elements of forensic science, and a diverse international student cohort. Therefore, the restrictions associated with the pandemic made it very difficult not only to plan the delivery of material but also to adapt the content itself for effective online and remote learning.

By focusing on the intended learning outcomes, a number of innovative teaching practices were developed to successfully transition from face-to-face teaching to online and remote delivery. A range of online and practical resources were developed, including a laboratory home kit, demonstration videos, online practical technique simulations (produced by Learning Science), data analysis tasks, and interactive workshops and activities, all designed to consolidate student learning and build confidence, in preparation for such a time that on campus practical teaching could resume. The initial feedback received from these activities from both staff and students was extremely positive and the transition from classroom to online teaching was a success, as reflected in student attainment and later student feedback. Students reported that they had a better understanding of what was expected of them, including knowledge of protocols and techniques, and felt much more confident moving into the next stage of their learning development. Even though the practical laboratory sessions were the most significantly affected by the restrictions associated with the pandemic, and resulted in reduced interaction for the students, this was counteracted by virtual sessions and workshops, which gave students the opportunity to engage with each other and communicate their thoughts and opinions, ultimately building key presentation and group working skills.

This case study will detail the pivot to remote learning, as well as critically evaluating the feedback from students and discussing the changes that are likely to be retained as longer-term teaching practices, versus those that were a necessary temporary addition or adjustment in response to the pandemic.

1. Introduction

The SARS-CoV-2 pandemic, more commonly referred to as the COVID-19 pandemic, had a major impact on teaching and learning when campus-based degree programmes in higher education institutions moved to fully remote teaching platforms in March 2020 [1]. This was also true of the MSc programme discussed in this case study and the pivot to remote teaching required an immediate review of the course material to ensure students continued to meet intended learning outcomes (ILOs) by remote platforms, that assessment methods were aligned with ILOs taught at a distance, and accreditation requirements set out by the Chartered Society of Forensic Sciences continued to be

met. Flexible pedagogies already integrated into the programme were reviewed along with the e-learning capacities of the University to identify areas that required enhancement and support due to the impacts of the pandemic [2]. The programme has a strong focus on practical teaching, with 120 of the 180 credits being practical-based, and so a further challenge was the limitation of student laboratory experience and the consequences of this in terms of reduced opportunities for a new cohort to develop a sense of community whilst working remotely.

Further to the challenges resulting from the impact of lockdowns, social distancing and health and safety measures [3], there were several logistical and resource management challenges to address, with the student experience at the forefront of this. With the programme cohort

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size showing an increasing trend over recent years, there has consistently been a focus on ensuring the staffing resources, course content, and delivery methods remain suitable and manageable for the number of staff and students. With an average student to staff ratio of 10:1 it was imperative that student-staff interaction and student engagement levels were maintained in the transition to online and remote teaching. It was important to continue to meet the required component standards for accreditation from the Chartered Society of Forensic Sciences (CSFS) [4] and develop the skills and knowledge detailed in the QAA Benchmarking standards for Forensic Science [5]. The component standards were reviewed throughout the process of adapting the programme, and the CSFS provided support and advice on adapting teaching methods. The teaching team were also proactive in seeking out examples of good teaching practice, innovative teaching methods, and readily available resources that could be integrated into the programme, for example becoming involved in the #RemoteForensicCSI network [6] and utilising resources developed and shared via the LectureRemotely platform [7].

This case study will report the new teaching innovations created and implemented during the 2020/21 academic session to ensure high quality teaching was maintained, whilst sustaining student experience and community.

2. Teaching practices case presentation and discussion

2.1. Home kits

Students complete a practical module that normally runs in the first eight weeks of the academic year, and this includes completing a series of laboratory sessions to provide a broad overview of essential techniques and procedures in forensic science. To ensure students could achieve the ILOs of this practical module, the intended learning outcomes were reviewed:

- Explain and demonstrate competence in a range of methods used for the location, recovery and analysis of commonly encountered forensic evidence types, including microscopy.
- Evaluate and correctly interpret results from a range of forensic examinations, including the use of statistical tests.
- Demonstrate an understanding of, and adherence to, safe laboratory working procedures.
- Produce structured, contemporaneous notes and write balanced, unbiased reports appropriate for the intended recipients.

Five of the twenty individual laboratory activities that contribute to this practical module were identified as potential experiments that could be converted and safely conducted at a student's home. The aim was to create a kit that was accessible, innovative, and cost effective, which provided students with an 'at home' laboratory experience and the opportunity to develop essential lab skills. Similar approaches have been seen previously with regards to safe experiments that can be carried out at home and the creation of science kits [8,9]. Although more complex, the Laboratory Examination Exercise (LEE), a group-working activity developed for students to gain experience of forensic evidence examination, was also identified as an activity that could be carried out at home. The remainder of the twenty practical activities were delivered online by either providing an appropriate data set to interpret and evaluate or developing an interactive activity to consolidate the key theory of the activity. The home kits provided an additional opportunity to develop a sense of community amongst the new student cohort through the use of social media to share their results and opinions. The programme social media platforms allowed students to connect and communicate with each other during the pandemic, creating a supportive educational community which was critical during remote delivery [10]. All materials required for completion of experiments at home were packaged into a 'Home Kit' (Fig. 1). Some examples of the items provided in the home kits are detailed in Table 1 and an



Fig. 1. Contents of the Home Kits that were sent to students; each activity was clearly labelled with information provided on the items required for each activity.

Table 1

Home kit items.

Item	Associated task
Digital USB microscope	Fingermarks, comparison of toolmarks
Blu-tack	Comparison of toolmarks
Scene suit, gloves, masks	LEE Exercise
Tamper evident bags, swab tubes, petri dishes, production labels	Packaging and labelling

illustration of one of the activities is provided in the box below.

The first five weeks of the academic year were delivered fully online, providing the students with videos and online activities that would introduce them to the laboratory environment. The first step was to present the students with comprehensive health and safety training including videos on personal protective equipment (PPE) in the laboratory plus the correct use of glassware, pipettes, and fume hoods. Students' health and safety knowledge was further cemented using interactive activities on the virtual learning environment using H5P software [11].

The constraints on laboratory activities in terms of space and time meant that it was a priority to ensure students could maximise their time once they were allowed in the laboratories. To this end, videos of standard operating procedures for practical tasks (e.g., glass refractive index measurement, electrostatic deposition analysis, presumptive tests) were presented to the students to show them what to expect in the laboratory. Chemistry and Bioscience Learning Science Simulations (LabSims) [12] were also utilised, and while covering relatively basic skills, they were still very useful. The application of these Learning Science Simulations for remote forensic practical work has been highlighted and praised through a number of platforms, including the #RemoteForensicCSI Network, which has a number of YouTube videos on their channel sharing good practice and innovative teaching methods in both forensic science education and industry communities [13]. These interactive simulations provided the students, who come from a wide range of different undergraduate backgrounds, with an understanding of various biological and chemical techniques such as microscopy, use of pipettes, IR spectroscopy, and thin layer chromatography.

The four other tasks that were contained in the Home Kit demonstrated a range of forensic science techniques covering the examination of footwear marks, comparison of toolmarks, saliva presumptive testing (with the option of using samples containing amylase from fruit or for students to provide their own saliva to prevent biohazard risks) and the

Home kit: Fingerprint enhancement and identification experiment

One of the tasks adapted for the home environment was a fingerprint enhancement and identification activity. The fingerprint task was composed of three parts:

- Enhancement of fingerprints using an inkpad
- Enhancement of fingerprints using superglue
- Comparison of suspect's reference prints and recovered crime scene prints

For the first part of the task an inkpad was used to study how different levels of finger pressure applied would affect the fingerprints produced. The second part of the task was adapted to explain to the students the basic concepts in cyanoacrylate (superglue) fuming [14]. Using petri dishes, water-soaked cotton balls and a small amount of superglue, the students were able to create a miniaturised superglue fuming cabinet (Fig. 2). This created an opportunity to demonstrate an understanding of the basic mechanism of polymerisation with cyanoacrylate fuming.

For the final part of the task, students were provided with known digitised prints to compare with a digitised recovered crime scene mark to understand the challenges in fingerprint comparison. The use of digitalised prints made it possible for students to modify the images, highlighting the pattern characteristics and different minutiae of the various prints.

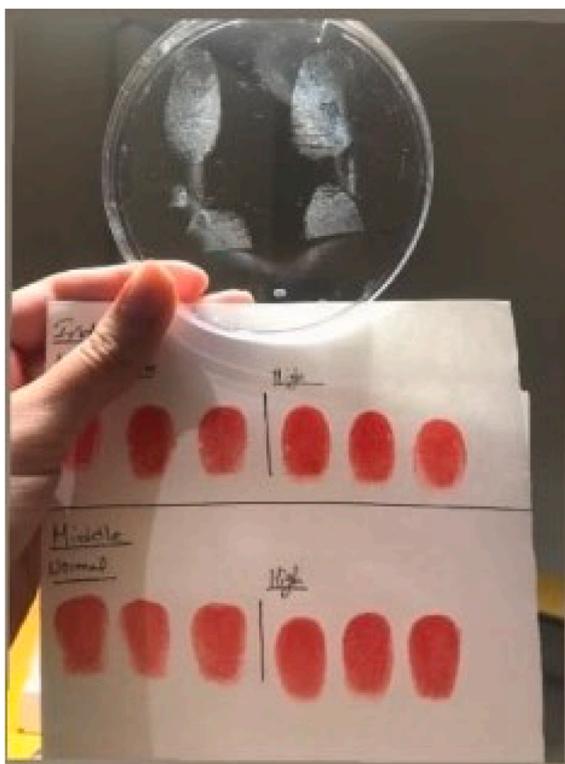


Fig. 2. Example of the fingerprint experiment carried out remotely by students.

packaging and labelling of evidence. Conducting these exercises at home allowed students to complete them at their own pace and get to know the techniques. Activity completion was monitored using the virtual learning environment allowing staff to identify any non-engagers. In

cases of non-engaging students, they were initially approached with gentle reminders via email. This was supported by our personal development adviser (PDA) system which included regular online meetings to support students throughout the academic year. Each student was allocated a PDA to act as their point of contact for any concerns and signpost them to appropriate support where necessary. This also became particularly important when supporting students who had COVID-19 related personal circumstances that were affecting their ability to engage with the course. The students who participated in these experiments provided positive verbal and written feedback through module evaluations and staff-student meetings, illustration of which can be seen in the feedback section below. From a staff perspective, there was general agreement that students were better prepared to undertake on campus practical laboratory work and were better organised to use their time to full effect when compared to previous cohorts.

2.2. Laboratory examination exercise

The Laboratory Examination Exercise (LEE) is an integral part of the practical module delivered in first semester and was designed as a formative activity to put theoretical principles from core lectures into practice and to increase students' confidence in the laboratory in preparation for practical work done later in the semester. These normally face-to-face sessions that focus on the core skills required to document and perform the examination and recovery of evidential material was then adapted for remote and online teaching. This was a significant logistical challenge with many aspects that had to be considered, including health and safety and students' access to resources and consumables. Online workshops, discussion tasks, group work, individual practical activities and formative assessment were combined along with providing instantaneous, actionable feedback to the students. A dedicated online resources page was created to bring all materials together as a single point of reference for the students including a supporting theory manual, guidance on Good Laboratory Practice (GLP), and video demonstrations of examination procedures and techniques.

The LEE began with a 2-hour online workshop covering the aims and objectives of the activity centred around GLP, anticontamination measures, integrity and continuity. Discussions were had surrounding common laboratory issues, examination strategies, evidence recovery techniques and complications that could be encountered to encourage students to use their critical thinking skills and to develop a clear understanding of effective laboratory practice. Group working activities were implemented so students could contribute and discuss their opinions relating to forensic clothing examinations, using the clothing worn within their group for reference, what techniques would be the most appropriate, and the importance of prioritisation. Following this

workshop, students followed the Case Assessment and Interpretation model [15] to perform an assessment of a mock case scenario and develop a suitable examination strategy. Students were supported in this task through the use of a live student-led drop-in session to discuss their case with staff and to ask any questions. This built on lecture content covered earlier in the semester which focused on the pre-assessment, evaluation, and interpretation of evidence and the consideration for approaches to different evidence types. This activity provided a combination of online staff-student interaction, independent student learning, and group working, which allowed students to process and apply key elements of forensic interpretation. This delivery involving different learning environments, both online and offline, supported the findings in the article by Tidy & Parker (2021) and highlights the importance of incorporating student home environments into remote and online teaching [16].

To overcome the logistics of providing physical productions, for the purpose of this exercise students examined productions that they had generated in an earlier home kit activity. Students were required to set up an examination bench at home, complete the examination of a production in line with a written strategy and clear away, all in accordance with GLP and standard operating procedures. Specific elements of forensic examination were required, such as taking photographs and using equipment such as a USB microscope for laboratory skill development. Due to the health and safety restrictions of home working, no body fluid testing could be carried out on the items they were examining. However, it was still possible for them to perform key examination procedures such as recovering hairs and fibres via tapelifting, brushing/shaking for debris and minitaping for wearer DNA. Students were observed live by a tutor during the entire session via video link. The tutor provided instantaneous and constructive feedback to correct errors and provide advice for efficient and accurate examinations. This was the first time the students had performed a casework exercise, and this provided an opportunity to put examination techniques into practice in a supported environment, allowing students to experience a virtual 'laboratory environment' without the restrictions of social distancing. Even though students were not able to observe their peers as they would in a laboratory, it provided a more interactive and social platform to learn from each other and feel more comfortable in their home environment.

A feedback session was held to address any common errors and discussion points, such as time management, errors in examination procedures and strategy writing, to provide advice on how to achieve the most effective outcome. The feedback from students was very positive, stating they appreciated the opportunity to perform effective adapted laboratory examinations off-campus in a relaxed environment, with the addition of key real time feedback. Students were also encouraged to share photographs and comments about their experience on social media which were then shared on the programme social media platforms, further enhancing the sense of student community.

Considering the future delivery of this activity, it was felt that it is more beneficial to deliver this type of content face-to-face in a laboratory environment, however the online delivery provided a new way for students to engage and communicate with each other and could provide an alternative option for future students who are unable to attend on campus. It was also concluded that the online delivery of this activity did not impact the ability of students to develop essential practical skills, based on staff observations of benefits in student competence and confidence when in the laboratory environment later in the semester. Ultimately, it was an opportunity to create useful and reusable online resources and to consider future hybrid learning practices for this essential activity.

2.3. Online workshops

Due to the very limited on campus teaching during the pandemic, prioritisation was put on practical laboratory sessions, meaning

theoretical content was transitioned to online recorded asynchronous delivery. This provided much more flexibility, not just with regards to the time dedicated to lecture delivery but also providing the ability for students to engage with this material in their own time, enabling access to captions, and the option to pause and rewind the videos to accommodate their needs. In normal circumstances, there would be opportunities during face-to-face teaching to ensure students were engaging with the material, either through group discussions or the presentation of their opinions and ideas, and this was essential to maintain in remote delivery. Therefore, a number of online workshops were developed to support the different themes delivered in the theoretical content. These were designed to encourage and develop problem solving and communication skills and to provide an opportunity for students to engage and collaborate with each other.

An example of this is the use of 'Kahoot!' quizzes as a quick form of assessment of students' knowledge and understanding on evidence types. Another workshop implemented the well-known teaching method of "Jigsaw Learning" [17] where students were divided into groups and provided with forensic case studies to review. Each group was both the "expert" and the "learner" as they were required to identify key elements in their specific case and feed this back to other groups, who would in turn disseminate their specialist knowledge, creating a teaching and learning environment for students to share information with their peers. This practice builds research, communication, and presentation skills, and encourages collaboration in group working.

The development of these adapted online workshops also encouraged the use of available software and technology to create a more engaging experience for students, considering the challenges of accessibility and inclusivity in remote teaching. A further workshop that was delivered centred around the key principles of crime scene investigation and management and implemented the method of problem-based learning [18] to develop critical thinking and problem-solving skills. A virtual crime scene scenario was created using Google Earth which consisted of an investigative narrative of how a crime scene investigator approached and managed a crime scene, which the students followed and then evaluated in line with the theoretical content. The University obtained licences for an app (Crime Scene Assistant) that was developed by forensic practitioners for first responders and outlines the key principles of crime scene security, preservation, and recovery. Students were provided with individual licences for the app which they could access via their mobile phones and use for the duration of the MSc programme. Feedback received from students stated that they enjoyed the opportunity to learn in a different way and that it was a great supporting activity and tool that assisted in developing their learning and understanding of future practical elements of the programme, for example the flagship mock outdoor crime scene exercise. Further information on the application and outcomes of this workshop is detailed in the article by Davidson (2021) [19]. This innovative teaching practice was shared on the #RemoteForensicCSI platform [13] and has subsequently been adopted by educators for application in other institutions and areas of teaching.

Students fed back through the module evaluation that they felt they benefitted from the group discussions as they could hear different perspectives from their peers and have constructive debates on certain topics, which ultimately improved their critical thinking skills. The Kahoot! Quizzes allowed a relaxed and enjoyable platform for students to test and consolidate their knowledge while adding an element of friendly competition. Students appreciated the opportunity to be challenged and having workshops centred around case studies allowed them to demonstrate an understanding of real-world applications. These online workshops illustrate the importance of student engagement and providing a platform for communication, collaboration, and inclusivity. The design of these workshops allows adaptations for different levels of learning and applications to both classroom and remote teaching, however going forward they may be influenced by factors such as class size, time and room capacities, and student engagement.

2.4. Community

As knowledge of pedagogy and teaching practice has evolved, emphasis is now given to the creation of a vibrant community of students to align with the modern understanding of social constructivism in education [20]. This approach is relatively simple in everyday on-campus education, when students have various opportunities to gather in communal places (i.e., lecture theatres, laboratories, libraries) and create a community of peers with which to get acquainted and help each other in the learning process. It soon became apparent that this result was much harder to achieve with the implementation of COVID-19 restrictions and teaching being moved online.

To create a strong community of students working remotely on the MSc programme, the framework used within undergraduate teaching practice entitled the Seven Principles of Good Practice [21] was implemented. The framework aims to provide an enhanced level of student-staff contact and encourage collaboration and communication among students. To support student-staff and student-student communication, discussion forums were extensively used and encouraged, along with the use of Zoom for multiple “ice-breaker” type activities. Discussion forums were implemented as early as the first week of study when students were asked to introduce themselves and communicate with each other. This approach was used to encourage engagement between peers and create a sense of community building.

These first online engagement opportunities made the students more at ease with the online environment, which was reflected in good engagement with more serious online discussions and live workshops during the course of the teaching weeks. Staff reports on student attendance and engagement illustrated improvement compared with the previous student cohort. The goal was to encourage students to do things on their own as well as with staff, to build both on their independent working skills and communication and team working skills. The sense of community within the class of students was facilitated by adopting a multi-pronged approach; employing discussion forums, live workshop activities, live Q&A sessions, a timely turnaround of emails, critical feedback from staff, and the organisation of live online social events. The latter were spread throughout the academic year and focused on fostering socialisation between students, providing a more informal and less structured platform for engagement. The programme’s social media platforms were also utilised throughout the year to highlight these events, share information about the programme, and to encourage student engagement through student takeovers and sharing content posted by students.

2.5. Mock court

Across the first two semesters of the programme, students carry out a crime scene to court exercise, during which they work in teams to preserve and search major outdoor simulated crime scenes. Teams recover evidence, which is brought back to the laboratory for examination, and then report the results of their examinations in a court report. In second semester, students participate in a courtroom exercise carried out in collaboration with the University of Strathclyde Law School, in which Diploma in Legal Practice students act as prosecution and defence teams on these cases. The forensic science students all present evidence under oath in a real court setting, in Glasgow Sheriff Court, in front of real Sheriffs.

In the 2020–21 academic year, the programme was given permission to run the crime scene exercise, subject to COVID-19 restrictions relating to social distancing, laboratory capacities, wearing PPE, etc. However, as a result of the impact of the COVID-19 pandemic on the Scottish court system, it was not possible to get permission to run this courtroom exercise on-site in Glasgow Sheriff Court. Therefore, an alternative means by which students could get experience of acting as expert witnesses in court was developed.

Given that many Scottish court hearings were being conducted

virtually, the courtroom exercise was developed as a synchronous online activity, with trials running on Zoom, presided over by real Sheriffs. The approach of delivering online or virtual mock trials has been implemented by other universities throughout the UK during the pandemic to ensure both forensic science and law students gain this critical and beneficial experience. A documented example of this approach can be seen in the #RemoteForensicCSI repository via a presentation regarding a remote court room assessment that was delivered during the pandemic [13].

Trials proceeded with each forensic science student being called to give evidence in turn with the Sheriff taking an oath/affirmation before their testimony. In addition to the forensic science students acting as expert witnesses and the law students acting as the Procurators Fiscal/Defence Advocates, additional forensic science students attended trials to act as jurors; as well as reaching a verdict at the end of the trials, these students also provided written feedback for their peers giving evidence.

The main challenge encountered in the courtroom exercise related to difficulties in presenting productions during trials, however this was overcome by using verbal references during testimony. One of the key benefits of running trials online was that it meant there were no restrictions in terms of the amount of time needed to access courtroom buildings and the number of courtrooms required. As a result, more trials were run than usual, opting to run each trial twice, one week apart. This meant law students could work in smaller groups, giving them more experience of examining witnesses, and forensic science students could receive feedback from their first trial and incorporate this into their testimony at the second trial. Given that all students were present on the Zoom session throughout the whole trial (rather than being called into a courtroom one at a time), they were also able to observe their peers giving evidence, allowing them to reflect on the good and less good aspects of their own and others’ testimony.

Feedback from forensic science students was very positive, commenting that they found being able to give evidence twice particularly beneficial, as it meant they were significantly less nervous at their second trial and could therefore enjoy the experience more. Several of the Sheriffs also commented that the trials were realistic reflections of the way real trials were operating at the time, which reassured the forensic science students that the experience they gained was valuable.

3. Student feedback

In order to obtain student feedback on their experiences of the remote activities delivered during the pandemic, an evaluation survey was developed using Qualtrics software (see Supplementary Material). Students were invited to complete this evaluation survey voluntarily, with a focus on the Home Kits, the LEE, and the Google Earth Workshop. The survey was administered in accordance with the University of Strathclyde Code of Practice on Investigations Involving Human Beings, and ethical approval (reference number DEC22/PAC02) was granted by the Department of Pure and Applied Chemistry Ethics Committee. 63% of the class responded to the survey, giving a maximum of 32 responses for each question. Students were also asked to complete module evaluation surveys for specific teaching modules (as part of a University wide programme of evaluation) throughout the degree programme, which encompass some of the other teaching activities that were delivered. The figures in this section illustrate the overall trends seen in the student feedback; due to some questions having free text answers, these results have been summarised and, in some cases, paraphrased to collate and present the data.

Fig. 3 illustrates students’ opinions on their favourite element of the Home Kit. It shows a good range of responses including physical components of the kit, the experiments themselves, and also the element of being able to complete the experiments in their home environments. The USB microscope was the most favoured component of the kit, along with the activities associated with this, however some student feedback included that the USB microscope was difficult to use at times. This is

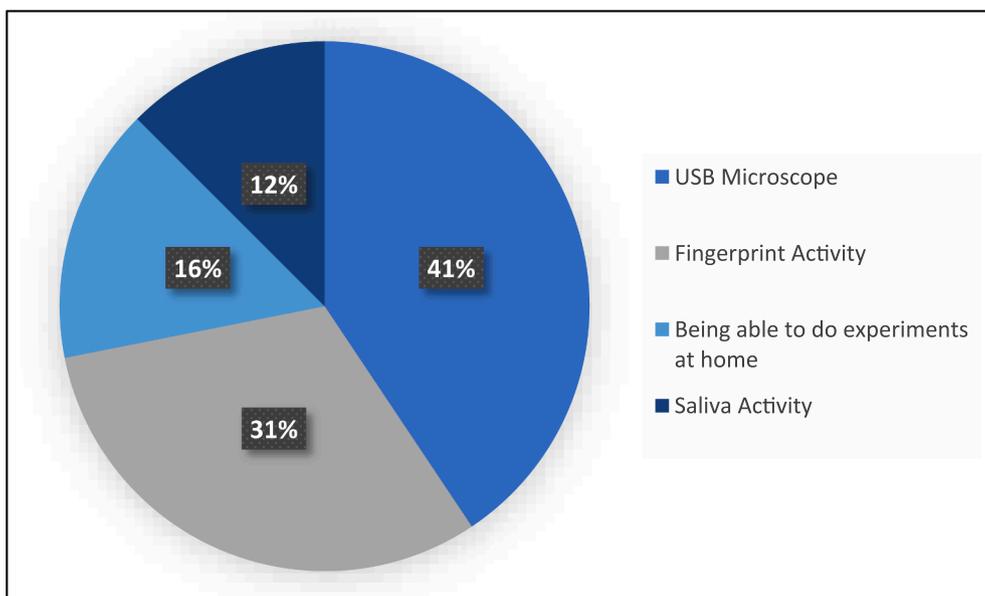


Fig. 3. Summary of the student responses to what their favourite part of the home kit was (Q5).

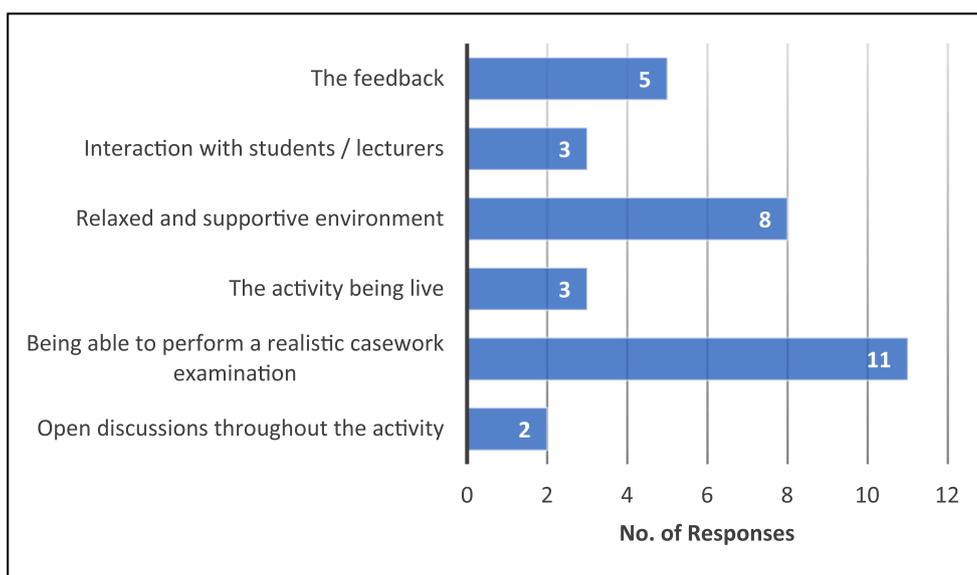


Fig. 4. Summary of student responses to what their favourite part of the LEE was (Q13).

something that could be considered in future and addressed by reviewing equipment in more detail and providing further support to students with using such equipment to ensure activities can be completed to the best of their abilities. Students also appreciated the branded products that were included in the kit with many of them sharing images and comments on our social media platforms, highlighting the sense of community we created by providing these unique home kits.

Moving onto the LEE, Fig. 4 presents a summary of student responses to the most favoured elements of this activity. Staff were somewhat apprehensive about how the LEE was going to be delivered remotely, as traditionally this was delivered 100% in the laboratory, however the overall response to the activity was extremely positive and this is supported by the student feedback. The most frequently made comment from the student feedback was that the most positive aspect of the activity was the ability to perform a realistic casework examination, which illustrates the success of the transition of this activity from in laboratory

to remote delivery. Students also provided positive feedback on the relaxed and supportive environment that was created during this activity, along with the benefits of receiving constructive and actionable feedback from tutors in real time, which is a critical element of this exercise. 97% of respondents completed all the components of the LEE activity, with a further 84% stating this activity aided them in preparing for the practical crime scene exercise (see Fig. 8). Despite the success of the remote LEE, the opinion of staff was that this activity should be delivered in a laboratory setting where possible. This is due to some areas of development that were highlighted, including the monitoring of individual student progress in this environment and limitations of student home environments to effectively carry out this task.

Even though the Google Earth Workshop did not replace a core teaching activity on the programme, this was used as a supportive and interactive resource for students to aid in their preparation for the outdoor practical crime scene exercise. Student feedback (Fig. 5) illustrated appreciation of the interactivity and problem-solving aspects of

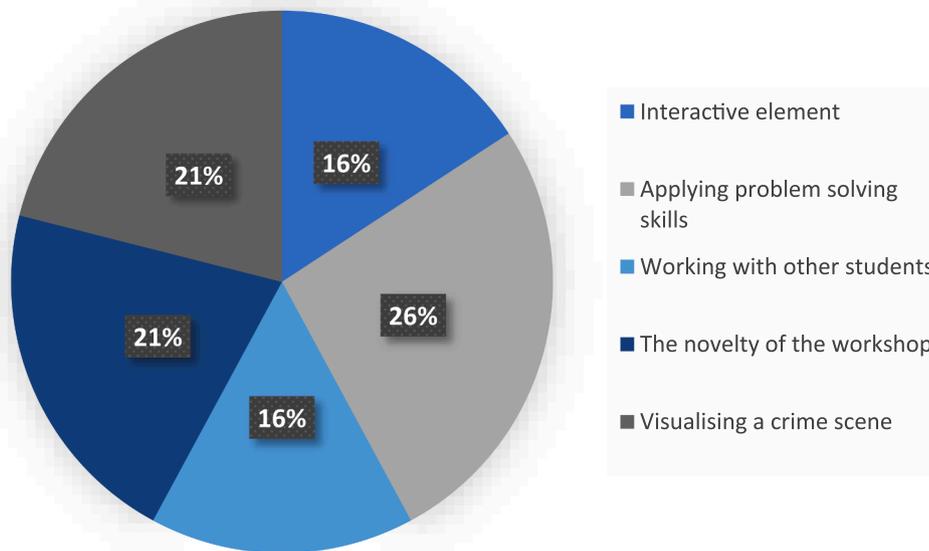


Fig. 5. Summary of student responses to what their favourite part of the Google Earth Workshop was (Q19).

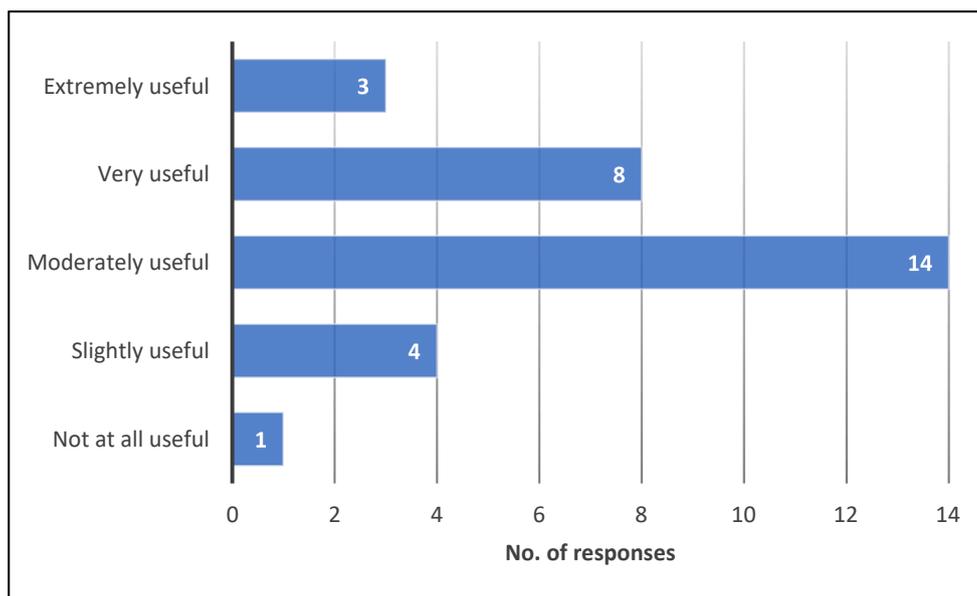


Fig. 6. Summary of student responses to how useful the laboratory simulations were (Q25).

the activity, along with the opportunity to collaborate with their peers. For many students on the programme, this was the first opportunity for them to visualise a crime scene and experience the key concepts involved in crime scene investigation and management. From both staff and student feedback, the workshop would have benefitted from a longer timeframe to allow students more flexibility to work through the content at their own pace and to have more in depth discussions on each topic. Ultimately, there are many applications for this workshop design, both for consolidating and assessing material, and it has the flexibility to be adapted to varying education levels and programmes.

With regards to the laboratory simulations, the majority of respondents found them useful, but to varying degrees (Fig. 6); this variation may be linked to students’ previous lab experience and knowledge. On reflection, staff believe this feedback demonstrates solely using the laboratory simulation resources is not as effective as combining these with recorded demonstration videos to help students visualise how the

experiment would take place in the specific laboratory setting they would subsequently be using.

From Fig. 7, it can be seen that the expectations of the students in relation to the remotely delivered activities was met, if not exceeded in most cases. The LEE and Google Earth Workshop activities demonstrated a higher level of positive feedback, and this may be due to these being tutor-led activities with some form of instruction or staff involvement. The home kits were created for application to specific experiments with instructions on how to complete these, however as the first practical module delivered on the programme this may have been a little overwhelming for students to complete independently at home. As a programme, there is definitely some learning to take from the feedback obtained from this cohort. A key consideration from the activities delivered remotely, notably the home kit, is that it was felt that more information could have been disseminated to students to make it clearer before starting what these would involve and what would be taking

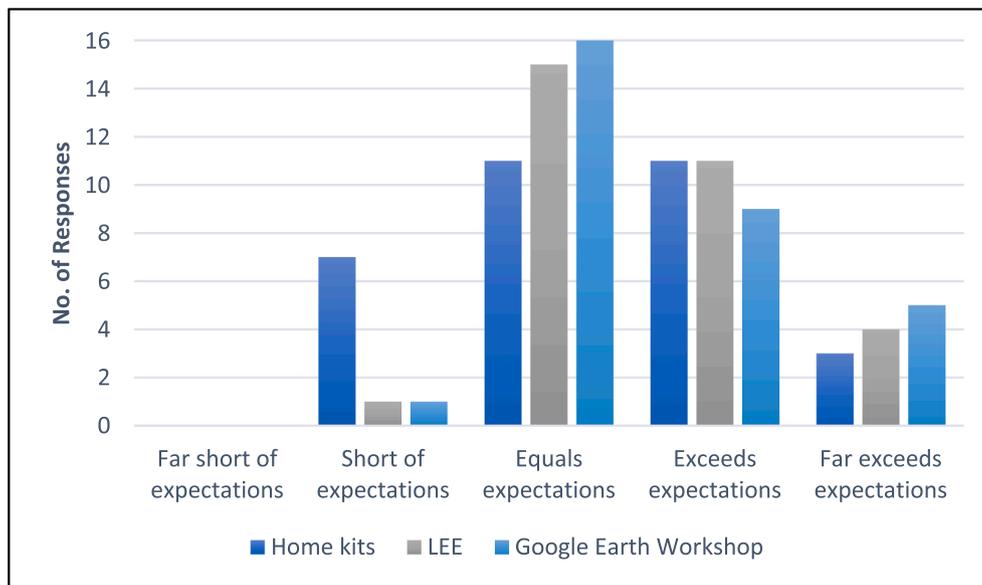


Fig. 7. Summary of student response to whether the remote learning activities met expectations (Q3,10,17).

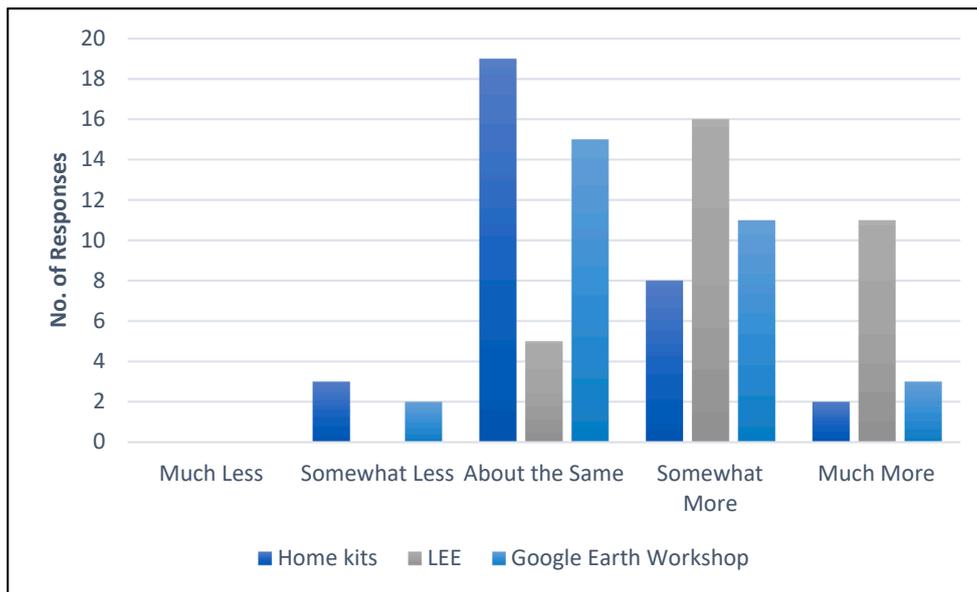


Fig. 8. Summary of student responses to whether they felt more prepared for on campus teaching after completing the remote activities (Q4,11,18).

place for each activity. Due to the rapidly changing circumstances of the pandemic, there were last minute changes that needed to be made before going live and this was seen to have an impact on the expectations of students. Therefore, based on the feedback received on how the activities met student expectations, it is critical to ensure that in future students are well informed of expectations but also the limitations that are encountered with the delivery of this type of material, such as health and safety aspects. The overall response from students was very positive but this highlights the need for consideration on how to manage student expectations overall.

As stated earlier in the study, staff felt students were more prepared in the laboratory sessions once on-campus teaching returned, due to the remote activities, however it appears students may not have been of the same opinion. Fig. 8 indicates the majority of students either felt equally prepared or somewhat more prepared after completion of the remote activities. This could be due to lack of confidence in laboratory skills or uncertainty as to the specific skills the remote activities were preparing

them for. Therefore, a further area of development identified would be the review of materials to ensure students understand the links between what they are doing and how it will help them in the laboratories. Notably, the feedback does highlight that the LEE activity was particularly successful in preparing the students for on campus teaching, specifically the laboratory sessions related to the practical crime scene exercise, as observed by staff.

Within the evaluation survey, students were also asked which remote or online activities they would like to maintain, even with the return of on campus teaching. Along with comments made on the usefulness and flexibility of recorded lecture materials, students felt they benefitted from the laboratory simulations and equipment demonstration videos, as well as the online workshops to consolidate the theoretical content. This illustrates that students do not want remote activities to occur at the expense of on campus teaching but to have them as additional supporting resources. With regards to this, considerations about time and workload capacities need to be taken into account for the pivot between

on campus and online teaching, along with student preferences for learning.

4. Conclusion

There is no doubt that the 2020/21 academic year was incredibly challenging, as was the final part of the 2019/20 academic year. However, the challenges provided opportunities to review teaching practices and identify the key teaching aspects that need to be covered in person on campus. This has resulted in some changes to the material delivery methods that are likely to continue even after restrictions are fully eased.

While the home kits and online LEE are unlikely to be repeated for an entire year group, they, along with the remote data-based activities, have demonstrated that it is possible to develop student laboratory skills even if they are unable to attend laboratory sessions. This has the potential to make the course more inclusive and allow a more structured method for students to catch up if they are absent for any significant period of time. Increasing the pre-laboratory work to help students maximise their practical laboratory time has seen real benefits. Students have arrived better prepared, allowing for less discussion before starting and more hands-on experience. This was supported by decreasing the numbers of students present in the laboratory, and it is likely that smaller groups will also be retained in future.

The content developed for many of the online workshops could translate to in person delivery, with the potential of hybrid delivery of the material, which would again make the course more inclusive. The Google Earth workshop in particular, could be even more successful if carried out in person rather than in virtual breakout rooms. The additional activities to complement the recorded lectures are also likely to continue with the potential to move more permanently to a 'flipped classroom' model of teaching. Due to the success of online engagement activities and the positive feedback received from students, these were delivered again this academic year (2021/22) and will continue moving forward, even when on campus teaching is resumed.

The mock court exercise will hopefully return to the courtroom. However, the use of Zoom for a smaller mock court at undergraduate level is something that is likely to continue as it provides additional flexibility on timings, and student feedback has demonstrated that it still provides students with a feel for giving evidence. The format of the mock court where students gave evidence twice was seen to be a real benefit but there are questions as to whether it would be possible to repeat this with in-person trials.

Overall, the experiences of the 2020/21 academic year demonstrated that for some activities, in-person on-campus teaching is really critical, however there are many areas where online delivery can provide an equivalent or even enhanced experience. The challenge now is to take this learning forward and implement it effectively and this is where initiatives such as #RemoteForensicCSI have an important role to play. Sharing good practice across institutions, and equally sharing what did not work so well, will allow the forensic science higher education sector to evolve and thrive as we move into the age of 'living with COVID'.

5. Novelty statement

This case study details the approaches taken for the delivery of an MSc course during the global pandemic. These approaches were innovative in developing teaching methods that could be delivered remotely while continuing to develop the practical skills of the students. The case study evaluates the success of these approaches and identifies those aspects of teaching that could continue to be applied even when full face to face teaching resumes.

CRediT authorship contribution statement

Katie J. Davidson: Conceptualization, Writing – original draft,

Writing – review & editing. **Penelope R. Hadrill:** Writing – original draft, Writing – review & editing. **Fabio Casali:** Writing – original draft, Writing – review & editing. **Bronagh Murphy:** Writing – original draft, Writing – review & editing. **Lorraine Gibson:** Writing – review & editing. **Margaret Robinson:** Resources. **Alexander Clunie:** Resources. **James Christie:** Resources. **Lynn Curran:** Resources. **Felicity Carlisle-Davies:** Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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