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Impact of the COVID-19 Pandemic on Chemistry Student and Staff Perceptions of their Learning/Teaching Experience

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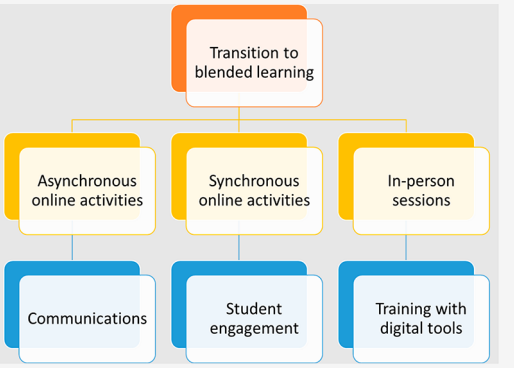
ABSTRACT: In response to the COVID-19 pandemic, the University of Leicester introduced a blended teaching model to continue delivery of their undergraduate Chemistry courses in 2020/21. The transition from in-person to blended provided a good opportunity to investigate student engagement in the blended environment, along with the attitudes of faculty members adapting to this mode of delivery. Data from 94 undergraduate students and 13 staff members was collected using surveys, focus groups, and interviews and analyzed using the community of inquiry framework. Analysis of the collected data found that, while some students felt unable to always engage and focus with the remote material, they were pleased with the University's response to the pandemic. Staff members commented on the challenges of gauging student engagement and understanding in synchronous contact sessions because students did not make use of cameras or microphones but praised the array of digital tools available that helped to facilitate some degree of student interaction. This study suggests there is scope for continuation and wider implementation of blended learning environments to provide additional contingency for further disruption to on-campus teaching and to provide new teaching opportunities, and it also presents recommendations as to how to reinforce the community of inquiry presences in blended learning.



KEYWORDS: *Students Perceptions, COVID-19 Pandemic, Undergraduate Chemistry Courses, Blended Learning, Virtual Learning Environment*

CONTEXT OF THE STUDY

The emergence of the coronavirus SARS-CoV-2 and the related illness COVID-19 at the end of 2019[1] had a profound impact on most, if not all, aspects of life.[2,3] The persistence of the pandemic over the summer of 2020 resulted in educational leaders focusing on how to deliver courses safely and effectively in the 2020/21 academic year. The required changes to curricular structures had to be completed quickly while maintaining academic rigor and a positive student experience. A high-quality student experience in an e-learning environment has been broken down into four key facets: appropriateness, design, interaction, and evaluation.[4] Institutions around the world faced similar challenges as the pandemic and their own local lockdown measures persisted throughout 2020 and 2021.[5,6] The worldwide adoption of online teaching techniques resulted in an influx of innovative remote-teaching practice, with both new pedagogical practices being developed and existing techniques adapted and refined.[7−10]

Historically, issues have been raised regarding student enthusiasm for and engagement with such remote teaching techniques,[11] and an emphasis has been made on the lack of suitable training for students and staff to effectively use e-learning courses.[12−15] Despite these objections, some have viewed the rapid integration of remote techniques as a catalyst for change[16] that has forced innovation within higher education (HE) teaching.[17] This paper serves to contribute the experiences of a UK institution and its students, as a catalyst for evidence informed change and conservation of remote teaching practices in HE as a whole.

EDUCATIONAL CONTENT AT THE UNIVERSITY OF LEICESTER

The School of Chemistry at the University of Leicester offers two broad classes of undergraduate degree course: a three-year Bachelor of Science (BSc) degree and a four-year integrated

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Master of Chemistry (MChem) degree. All students studying these degrees take exclusively chemistry focused modules for the duration of their studies. Table 1 highlights the different chemistry courses available at the University of Leicester.

Table 1. Chemistry Degree Courses Available at the University of Leicester

BSc courses	MChem courses
Chemistry[a]	Chemistry[b]
Chemistry with Foundation Year	Pharmaceutical Chemistry[b]
Chemistry with Enterprise[a]	Chemistry with Forensic Science[b,c]
Pharmaceutical Chemistry[a]	

[a]This course has a year in industry variant. [b]This course has both year in industry and year abroad variants. [c]This course was available at the time data was collected; however, it has since been discontinued.

Prepandemic educational content was provided by a mix of in-person lecture and laboratory classes, problem classes, and small-group tutorials (Table 2) with some supporting materials provided online (e.g., the notes, lecture recordings, the coursework assessments, self-test quizzes, additional reading, etc.). Students typically first encounter material in their lectures and/or directed reading. Problem classes and tutorials provide a mechanism for students to apply what they have learned and provide opportunities for students to interact directly with instructors (e.g., for help/clarification). Final examinations are held in a period after each module with reassessment examinations held in August.

Practical work constitutes a significant component of Chemistry degrees.[18] Students are allocated time in the laboratory each week, during which they complete a series of scheduled experiments. The scheduled experiments cover the fundamental techniques in years one and two before progressing to investigative practicals that prepare students for future careers. Practical work is followed by a proforma or report submission, where students are required to write-up their results, discuss their findings, and answer questions that test their understanding of the chemistry of the experiment. The students are also assessed by their demonstrator (teaching assistant) for their competence, safe-working, effort, and data.

For the COVID-19 affected 2020/21 academic year, a new blended teaching framework was developed by the University of Leicester. Table 2 summarizes the key aspects of the teaching approaches used before and the blended model (named Ignite by the University of Leicester) used during the pandemic. Ignite consisted of a mix of asynchronous lecture videos, large-scale remote synchronous teaching, in-person tutorials, remote practical tasks, and in-person laboratory classes. The in-person events followed government guidance around social distancing.

Blackboard Collaborate Ultra was used to facilitate the synchronous/live remote aspects of the Ignite model. The large group audio/video conferencing features available and the availability of various digital tools including running polls, drawing/writing on the screen, running breakout groups, and a feedback response system proved most effective.

To maintain social distancing some modifications were made to how the in-person teaching activities were run. First, tutorial groups were moved from academic offices to larger venues, and the group sizes increased to ensure all students could participate. Second, the teaching lab capacity was halved and students were granted access every other week. To mitigate for the reduction of in-laboratory contact time, a series of "dry" laboratory experiments (largely physical chemistry-based) were designed for students to complete in the weeks they did not have laboratory access. In these "dry" experiments, students were provided with data and asked to manipulate and analyze it as if they had collected it themselves. These sessions were held online where students were assigned to a group Blackboard Collaborate Ultra room along with a PhD demonstrator to provide support.

Exams were moved online, and questions were designed to focus on problem-solving rather than bookwork in order to recognize that students would have unpoliced access to their notes. The time for students to complete the examinations was doubled, in order to factor in the additional time to download the paper and then to upload their answers.

RESEARCH QUESTIONS

At the time of writing, most research undertaken in the wake of the pandemic looking at the consequences of rapidly integrating remote learning in HE focuses on student experiences,[19,20] tending to focus on the quantitative aspects (e.g., attendance rates and student attainment)[21] and not exploring the qualitative facets of student experience: satisfaction and perceptions of teaching and learning experience. There are even fewer papers studying the impact on academic staff, both in terms of their personal circumstances and how they felt their educational practices were

Table 2. Comparison of Teaching Methods at the University of Leicester before and during the COVID-19 Pandemic

aspect of teaching	prepandemic	during the pandemic
lectures	in-person lectures (recorded and uploaded to the VLE)	per week: one live lecture session hosted online (on Blackboard Collaborate Ultra) and two lecture videos recorded and uploaded to the VLE.
lecture notes	printed lecture notes	digital copies of the lecture notes
tutorials (problems submitted and marked in advance)	small (5−6 persons) group meeting with instructor	small/medium (∼10 persons) group meeting in-person
problem classes (problems received on day and completed in pairs/groups)	in-person sessions with two instructors	problem elements incorporated into live sessions *vide supra*
virtual learning environment	discussion boards, additional/supporting material, and self-test quizzes are available on VLE	no change
laboratories (small/medium (10−12 persons) groups of students, roster of experiments)	"wet" practical each week	sessions shortened, staggered start/finish time, and alternation between "wet" and "dry" practicals
exams	closed book examinations held in-person; closely time controlled, ranging from 2 to 3 h based on length of exam.	open note examinations sat remotely; closely time controlled with students having twice as long as usual to complete (4−6 h)

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Table 3. Breakdown of the Educational Experience According to the Community of Inquiry Framework Proposed by Garrison et al.[24]

educational experience					
setting content		supporting discourse		selecting resources	
teaching presence	social presence	cognitive presence	social presence	teaching presence	cognitive presence

affected.[22,23] This provides a real opportunity for this paper to explore the qualitative aspects of the topic, for both students and staff, and consequently, three research questions were developed for this novel study:

- Were Leicester chemistry students and staff satisfied with the remote education they received/provided during 2020/21, and why?
- How effectively did the blended learning experience engage Leicester chemistry students throughout 2020/21?
- What were the significant challenges of delivering a remote chemistry education through the model employed by the University of Leicester?

THEORETICAL FRAMEWORK

This study utilizes the Community of Inquiry (CofI) theoretical framework to assess the suitability of the remote teaching approach employed by the University of Leicester. Garrison et al. developed a CofI model for use by educational practitioners in developing online and blended learning environments, focusing on supporting critical thinking, critical inquiry, and student and teacher discourse (Table 3).[24] The CofI model was therefore ideal for scaffolding this research and the resulting discussion and conclusions, as the deconstruction of "educational experience" allows for each part of the teaching method to be assessed. The CofI model breaks down learning into a combination of three "presences": social, cognitive, and teaching, with individual aspects of learning procedure explained by the interactions between these "presences".

The social presence of the CofI model relates to the ability of participants to identify with, meaningfully communicate with, and develop relationships with those other members of the community, so that they are perceived as a "real person" in the digital space.[25,26] The social presence has been widely researched and has been accredited with influencing student satisfaction[26,27] and online interaction and learning,[28] and a "positive significant relationship between a sense of community and cognitive learning" has been found.[29] This supports the interconnected design of the CofI framework, with a good social foundation facilitating the cognitive presence.

The cognitive presence refers to the extent to which participants can construct and understand the meaning of knowledge presented to them within a CofI.[30] This higher order knowledge gain and use means cognitive presence is often used when referring to the facilitation of critical thinking in HE research.[31] Course design, structure, and leadership have been shown to affect how learners interact with course material and apply critical thinking to their studies; thus, the role of the teacher has been shown to be crucial in facilitating the cognitive presence within a CofI.[25]

The teaching presence represents the design, facilitation, and direction of the cognitive and social processes to develop meaningful learning outcomes that provide sufficient educational experiences.[30] The teaching presence has been summarized into three facets (Table 4) and has been attributed to determining "student satisfaction, perceived learning, and sense of community".[25]

Table 4. Teaching Presence Broken Down into Its Components with Definitions

component	definition
instructional design and organization	the plan and design of the structure, processes, interactions, and evaluation of HE courses[32]
facilitating discourse	the way in which students interact with and build upon information provided in course materials[32]
direct instruction	how the educator provides subject knowledge to students through intellectual and scholarly leadership[32]

The central component of the CofI framework is educational experience, aligning to our research questions. The breakdown of this into the three presences and their overlap to facilitate different aspects of education are shown in Table 3. The CofI model has also been used to develop lesson plans, both before and after the pandemic,[33,34] further highlighting the suitability of comparing the CofI presences between traditional and blended teaching.

METHOD

To ensure a representative sample, data was collected from undergraduate students across all four year groups and staff members who experienced the affected teaching year (2020/21). A total of 107 participants took part in the survey portion of this study, while 19 participants attended the focus group interviews afterward. A breakdown of the sample is provided in Table 5.

Table 5. Breakdown of the Number of Participants in Each Cohort for Both the Survey and Focus Group Interview Sections

cohort	survey participants	focus group interview participants
first year	21	9 (42%)
second year	32	3 (9%)
third year	24	0 (0%)
fourth year	17	4 (24%)
staff	13	3 (23%)
total	107	19 (18%)

Data was collected using a mixed methods approach that followed the workflow shown in Figure 1. This mix of quantitative and qualitative methods was used as the data produced from the surveys provided an overview of the thoughts of a relatively large and homogeneous sample, while the qualitative data provided the greater level of depth needed to address the research questions.

SurveyMonkey (an online tool) was selected as being sufficient for the purposes of the quantitative research based on appropriate functionality and researcher familiarity. Survey hyperlinks and project information were distributed via e-mail

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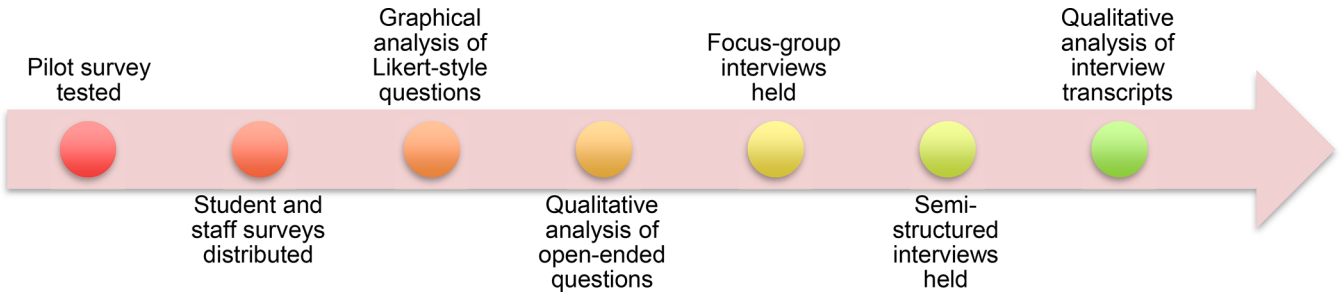

Figure 1. Workflow for collecting data in this study.

using the cohort-specific mailing lists. Copies of the surveys can be found in the Supporting Information.

A pilot survey was created first to ensure the data produced from the selected questions could be interpreted as required. Online surveys were most practical under COVID-19 restrictions and featured nine four-point (strongly agree, agree, disagree, strongly disagree) Likert scale questions and one short-form response (the first-year students received a slightly different survey with seven Likert-style and two open-ended questions with less of an emphasis on comparing the teaching styles as they had not experienced the prepandemic style of teaching at university). Likert scales provide a useful insight into attitudes toward certain topics compared with similar aspects.[35] Research has been done looking into the effects of including or omitting a middle option, and there are benefits and drawbacks to both techniques; while removing the midpoint prevents respondents from misusing it as a quick response, it can prevent the respondent from expressing a true neutral opinion.[35] The decision to omit the middle response was to make the data collected simpler to interpret and prevent respondents using a neutral option as a *dumping ground* for responses. The Likert scale questions covered:

- support during the transition to the blended model of teaching and learning
- quality of communications regarding changes/updates during the pandemic from the University/School of Chemistry
- suitability of the VLE for the new teaching model
- how appropriate the 2019/2020 exam format was
- how well the institution handled the shift to remote education
- whether the institution improved its implementation of the remote teaching model over the summer
- satisfaction with how lab sessions are run in the new model of blended learning

The single open-ended question in the survey asked participants to list three things they thought the University had done well in their response to the pandemic and three things they thought could have been handled better. Responses to this initial survey helped shape the direction of the follow-up focus groups and semi-structured interviews held with participants who responded to the surveys. Focus group interviews were selected as a tool to probe group consensus and to differentiate this to individual opinions.[36] Participants were recruited via email and an in-session advertisement.

A series of initiator questions were asked to the group, probing their response to the handling of the pandemic by the University. An interview guide approach was adopted, allowing for systematic collection of data by predetermining the covered topics, while sacrificing comparability of this data due to variations in the delivery of questions between participants.[37] While the wording changed between groups, questions addressing the following themes were posed (Table 6):

Table 6. Major Themes Discussed with Participants during Interviews

focus group interviews (students)	semi-structured interviews (staff)
things that had gone well during blended teaching	thoughts on how the University/School handled the switch to blended teaching
things that could be improved about the blended methods	support for staff during the transition to blended teaching
thoughts on the integration of digital tools	appropriateness of the changes to exam style
motivation to participate in the work	issues surrounding student motivation/participation with the work
lab experience	opinions on the continuation of lab sessions
understanding of the blended model of learning	understanding of the blended model of learning

Transcripts of all the focus group interviews and guided interviews were created, and responses to the open questions of the survey were added to the same document for inductive coding analysis (HB and NC) and calibration (RARB and DPW).[38] The themes drawn from the survey responses were used in a combined deductive/inductive coding process of the interview transcripts.

RESULTS AND DISCUSSION

Blended Learning Model

The use of digital tools during online live sessions was intended to simulate the interactions afforded during in-person sessions, such as asking the class a question about the content, drawing on the presentation slides, or asking students to discuss with their peers. In practice, the range of digital tools available (e.g., breakout rooms, anonymous chat boxes, anonymous polling) exceeds the activities possible in an in-person setting. Student and staff responses to the digital tools were broadly positive (>69%) (Figure 2); however, some participants in the second- and third-year cohorts (6% and 9%, respectively) strongly disagreed with the suitability of the digital tools available. This difference may be due to variations in the experience of students in these year groups compared to fourth-year students. Fourth year students had more experience with traditional styles of teaching, and an increased familiarity with the VLE than the younger years.

One complaint students voiced, specifically about the asynchronous component of blended learning, was their inability to stay focused on the prerecorded videos (six responses), finding it harder to learn than lectures as "*it's a bit*

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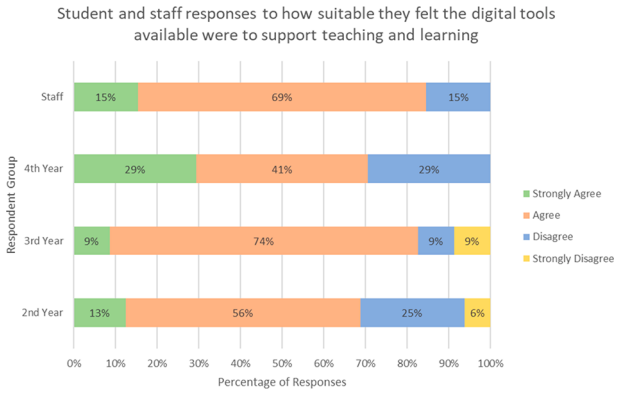

Figure 2. Student and staff responses to how suitable they felt the digital tools available to them were to support teaching and learning in a chemistry degree; staff $n = 13$, fourth year $n = 17$, third year $n = 23$, and second year $n = 32$.

like teaching yourself". This reinforces the importance of the teaching presence of the CofI framework in improving student satisfaction with their education,[39] suggesting that some (inter)active component introduced to the asynchronous content would improve this rating. There may also be a negative impact on the cognitive presence of the CofI framework, if students are provided with an insufficient understanding of the material presented to them by not engaging with the asynchronous content (for an overview of the most recurring themes, see Table 7). Exploring this effect in greater detail fell outside the scope of this study, and it is difficult to accurately determine due to changes to examination style.[20]

Engagement

Students reported that the digital tools available to them were able to promote their engagement during the live sessions with an emphasis on favoring interactive activities such as drawing/writing on the lecture slides. One student felt *"more engaged with lecturer A's lectures because they draw on the slides, whereas lecturer B draws on paper,"* suggesting that students prefer the PowerPoint slides to always remain on screen during a lecture. It might be worth considering planning empty spaces on slides that would benefit from additional comments or a diagram, to facilitate this preference. Other students said they felt less motivated to participate in the live sessions and thought "*quizzes would help*" retain their focus; another student agreed with this sentiment, saying they find it "*hard to be more engaged staring at a computer screen*", indicating a reduction in the social presence, as the student cannot generate a connection with the "real" person behind the screen.

Interestingly, not all lecturers felt confident with, or saw the advantages in, using these interactive features during their live sessions, which resulted in some inconsistency in student experience between modules. This led to preference for individual lecturer styles among students, favoring an approach that appropriately used as many tools as possible each session. This hesitation to use digital tools may stem from a lack of formal training and support for staff, agreeing with the general unfamiliarity with online teaching that has been investigated elsewhere.[40]

While student attendance rates were comparable with prepandemic teaching, staff members reported most, if not all, students did not use their camera or microphone to interact with the live sessions, unless specifically asked. Many students instead opted to use the chat function, which facilitated some interaction. Chat box capabilities have been popular in other studies looking at changes to teaching during the pandemic; LeSuer and Reed employed a chat function in their lectures with a designated instructor monitoring and responding to student messages that produced a high level of satisfaction (87% positive responses).[41] This suggests that additional forms of communicating with instructors are crucial to promoting engagement during synchronous online sessions; students may feel more confident asking questions via text-chat, as messages posted can be addressed without disrupting the session and the lecturer(s) can in turn engage with the class more. One lecturer found they could "*engage really well with people online*" by using the chat function; however, there were issues when gauging student reactions, as they "*can't tell how all the students feel, or if they all feel the same way*" without the visual confirmation afforded by seeing students' faces in person.

Support

Understanding the level of support staff received was as important as the support received by students; the introduction of a new educational model will only be successful

Table 7. Five Most Recurring Themes Mentioned by Participants during Both the Survey and Interview Stages, Separated into Positive and Negative Views and Accompanied by a Representative Quote

theme (N)	sample quote
	positive
mix of synchronous and asynchronous learning (27)	*"I like the idea that there's pre-recorded lectures, so I've got time to think and then I can ask my questions in the interactive room, rather than having an in-person one and having to email my questions later as such."*
good communication (24)	*"The chemistry department have been excellent in keeping us up to date and helping us out."*
COVID safety (22)	*"I like that it's not too intimidating with COVID, with the systems in place it doesn't feel terrifying and feels normal."*
digital tools (21)	*"I use the whiteboard functionality on Teams and that seems to be quite good, especially because it's anonymous, you can feel more confident if you make a mistake,"*
response to the pandemic (20)	*"Closing promptly in March was, I feel, the right decision and no one was forced to put their education ahead of their safety."*
	negative
poor communication (31)	*"At some point it actually became overwhelming and became impossible to follow because there was way too much coming in every day, and we were swamped already."*
timetabling (22)	*"The timetabling is so much different to last year. Now you have to watch the lectures and go to the live session when am I supposed to have done the work for then? It's a lot to do and so little time."*
more technology support (15)	*"I also think the university wasn't all that great in terms of giving staff access to the right technology to get the job done."*
lack of value for money (12)	*"We shouldn't be paying the same amount if we are mostly at home watching video lectures."*
workload (12)	*"The workload is a lot and it's harder to get work done at home with distractions and it's a setting that's hard to get used to."*

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if both students and lecturers receive the necessary support to take part.[42,43] Surface-level training in new software, provision of technology, mental health support for students and staff, and physical health support relating to COVID-19 was provided centrally. At a school level, tailored/targeted instruction was given to staff and an "open-door" policy for students to ask lecturers questions was in place.

Feelings of support during the change in teaching approach varied among cohorts (Figure 3). Staff members reported they

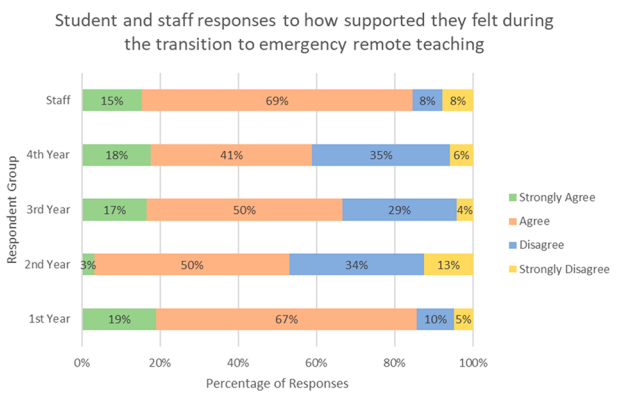

Figure 3. Student and staff responses to how supported they felt during the transition from prepandemic teaching methods to ERT methods; staff n = 13, fourth year n = 17, third year n = 24, second year n = 32, and first year n = 21.

felt supported in the transition to remote teaching (84% agreement) and that students were provided with adequate support (84% agreement) throughout their studies. First-year students felt supported during the transition from prepandemic teaching methods to the Ignite approach (86% agreement). However, second-year students felt the least supported (53% agreement), claiming the amount of work set was "not realistic" for the time they were given. It is worth noting that Leicester chemistry students have reported an increase in workload between their first and second years for a number of years and it is not thought that this comment relates wholly to the measures taken in response to the pandemic. A perceived increase in workload has been experienced and reported by Eberle and Hobrecht: their evidence suggests that this "workload related stress" was linked to issues surrounding lecture lengths and upload delays—in line with reports from students in our study—but the issues were mostly due to an increase in content complexity.[44] It is possible that the transition to a new teaching approach may have exacerbated this as students adapted to learning in a new environment.

The most common requests were for more support related to the use of technology. Students and staff fed back that they would have appreciated more help in using digital tools. This is a problem when it comes to remote teaching methods facilitated by new technology, and extra steps need to be taken to ensure that all students and staff receive suitable digital training and support. The lack of technological support felt by educators may influence the teaching presence of the CofI framework, if faculty are unable to take full advantage of the available digital tools, they will not be able to direct their teaching in a way that generates a sufficient educational experience.

Laboratory Teaching

Students responded positively to the continuation of laboratories during COVID-19 restrictions, reporting that the blended model was able to deliver a satisfactory laboratory experience (Figure 4), with a preference for wet laboratories

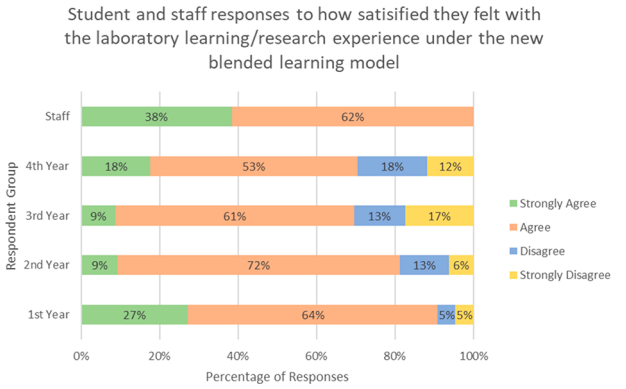

Figure 4. Student and staff responses to how satisfied they were with the students' laboratory experience under the new blended learning model; staff n = 13, fourth year n = 17, third year n = 24, second year n = 32, and first year n = 21.

over the virtual equivalent. The virtual laboratories were not necessarily disliked, and some students appreciated the extra support they received from the demonstrators for these experiments. Staff were overwhelmingly positive about the continuation of laboratories. One lecturer did feel that the COVID-19 safety measures in laboratory sessions seemed "*a bit grim*" and that it had compromised the "*joy of the science*" but they were being run "*effectively [and] efficiently*".

CONCLUSION

The disruption caused by the COVID-19 pandemic was far-reaching; however, this presented an opportunity within the teaching sphere to develop and adopt novel online teaching methods. This switch to blended teaching represented a significant change for many HE instructors, who required specific training to make full use of the technologies available to them. This paper contributes the experiences of students and staff at one UK university during the teaching year 2020/21, when a blended teaching method was employed. Several key lessons were learnt from using this teaching method: (1) blended learning models can produce high levels of satisfaction among students and staff, (2) anonymizing student contributions can encourage participation and engagement, and (3) training needs to be provided to familiarize students and educators with relevant technologies.

It is clear from this study that blended learning models can be well-received, that student experiences and perceptions of their studies are broadly positive, and that there is a place for retention of such methods as HE returns to more traditional methods. While the appearance of traditional blended learning models differs slightly from those employed during 2020/21, the underlying principles are the same. As such, the international adoption of these techniques needs to be a learning point for educators to improve the "educational experience" within these teaching models.

The lessons from this study have been used to generate a list of recommendations (Table 8) to improve and create new teaching opportunities. Students on placement or taking a year

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Table 8. Recommendations for Future Blended Education Practices to Ensure Fulfillment of CofI Presences

recommendation	CofI presence
present materials in ways that make your thought process clear (e.g., by annotating materials thus showing your application of a problem-solving approach)	cognitive
practice guides should be provided for unfamiliar activities (e.g., working from home for extended periods)	cognitive
use digital tools (e.g., quizzes and polls) to stimulate engagement in synchronous sessions	cognitive (and social)
anonymizing student contributions (e.g., to polls and quizzes) can encourage participation and engagement	social
timely, relevant, and concise communications are needed to help structure student learning	social (and teaching)

abroad will continue to use distance learning techniques and could benefit from positive changes to improve their engagement and perceptions of learning. Finally, there is an opportunity, and a call, for HE institutions to collaborate and determine the best course of action with respect to designing (or redesigning) programs. These designs could be new programs, ongoing review, or another forced switch to remote teaching in a future emergency (global or local). By having a uniform approach students and staff are likely to feel more supported and more confident in the education they are receiving and delivering.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available at https://pubs.acs.org/doi/10.1021/acs.jchemed.2c00856.

Copies of the distributed surveys (PDF)

Table of recommendations for future blended education practices (PDF)

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Notes

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