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DOI: <https://doi.org/10.1051/ejn/2020406>

## Moving teaching online during the COVID-19 pandemic

The outbreak of COVID-19 and the subsequent pandemic has caused, and continues to cause, a substantial upheaval across much of society, including higher education. The imposition of social distancing measures and eventually lockdown in early 2020 led to a rapid switch to remote and online learning. Academics had to support students to learn physics in a new environment with very little notice and minimal preparation. For the next academic year, though, there is at least some time to prepare, but the resurgence of the disease in areas where previously it appeared to be under control means that there is no realistic prospect of universities opening as normal in the immediate future. Universities across Europe have been planning for some kind of blended learning with a substantial proportion of teaching to be delivered on-line and there is little prospect of any on-campus, face-to-face delivery until some time in 2021. How will universities, and physics departments in particular, cope? In this short article, I present some of the experiences of academics from the UK. My own teaching had essentially finished by the start of lockdown and what follows is culled from the experiences of the contributing authors named above who were identified through a network established with the support of the Institute of Physics in London to help academics share practices and ideas, and support each other during this difficult and demanding time.

Currently hosted by Dr Helen Vaughan (Central Teaching Laboratories, University of Liverpool), the network runs a series of regular on-line community meetings which consist of two or three presentations on a single theme followed by the opportunity to join a breakout room to talk about the topic. For those unable to attend, the presentations are recorded and reports of the break-out room discussions are made to create a lasting resource (hosted here (<https://www.liverpool.ac.uk/central-teaching-hub/physics/the/>)). Attendance at the meetings is typically in excess of 100 from across the UK and Ireland and topics and contributors are sought from across the community. We have been able to discuss experiences and plans for teaching online; virtual and remote laboratories and ensuring students feel included with many more topics being suggested all the time. Accompanied by an email list-serve, it is intended that this network will support the UK

community through the current challenges and be a place to continue to collaborate in the future.

Stan Zochowski, from University College London (UCL) has been teaching a course in mathematics for physics on line to approximately 240 first year undergraduates per year for the last three years and shared his experiences with the network. The course runs over 11 weeks and is divided into eight portions, with each portion containing content, quizzes and a plenary session to summarise the content and address students' questions.

The biggest challenge that Stan reports facing was around technology: which technology to use and then how to master it. Stan chose to deliver the content by video and students reported liking the self-paced study that this affords. Once students have achieved a minimum level of mastery over the content in a particular portion, as evidenced by their score on the associated quiz, the next portion is made available to them. Learning is thus tailored to the individual, but the plenary sessions provide an opportunity to ask questions directly.

Delivering content in this way requires a lot of time to prepare the content. It is sometimes necessary to continue with a video simply because there isn't time to remake it, but, adjustments to video content notwithstanding, Stan is confident that he has a format that is effective. The level of engagement by the students is higher than with conventionally delivered material and students also appreciate the different way that this material is delivered compared with their other courses. This raises the prospect in the coming year that the on-line delivery of much of the other content that students will face will reduce the impact of Stan's teaching.

Jaroslaw (Jarek) Nowak, from Lancaster University, taught a complete course in quantum physics for about 200 first year students following lockdown. Delivered conventionally, this would comprise sixteen 50-minute long lectures over a period of five weeks with weekly tutorials, a designated office hour and weekly coursework. The electronic version comprised recorded lectures which students could access in their own time, "office" hours and two "live" interactive tutorial sessions delivered synchronously using Microsoft Teams. Four teaching assistants supported the live sessions and also assisted with marking.

At the end of each week students had to complete a worksheet on the recorded lectures, each of which was dedicated to a single topic. In consequence, topics that would ordinarily take a small fraction of a live lecture, and therefore could be easily overlooked by students, could be given more prominence. Lengthy mathematical derivations were written in LaTeX and also recorded separately in a video. Links to external resources, such as YouTube videos or simulations, practice problems and supplementary videos on background knowledge, such as the wave equation or complex numbers were provided to support students. Preparing all this material proved a real challenge, especially working at home, but there were also advantages to this approach. Each recorded lecture contained three questions aimed at providing feedback and the comments and questions provided by students were discussed during the synchronous sessions. As with Stan's course, students were in control of their own learning in as much as they could work at their own pace, accessing the recorded lectures and supplementary videos as needed, provided that they completed the work within the week. The main challenge is to get more students involved in the discussions, as these are not very effective with the numbers currently participating.

Laura Kormos, also at Lancaster University, delivered two different activities online. The first was a course in vector calculus delivered to 162 first year students in two 1-hour sessions per week live-streamed through Microsoft Teams. The lectures were supported by five 1-hour workshops per week for smaller groups of 35 students. These were organised by Laura, but run through Microsoft Teams by her and four teaching assistants. Students had to complete a Moodle quiz and three other worksheets by way of course work. The second course was in place of a laboratory class for second year students. Delivered to 54 students in one 7-hour session per week, students were expected to work with a partner to analyse the data from an experiment on the Zeeman effect. Supporting materials included a lab script and photographs of equipment, including fringes at different stages of the experiment. The students produced a logbook using LaTeX and recorded a presentation in conjunction with their lab partner.

On the face of it, Laura's predominantly synchronous approach appears to require less preparation than either Stan's or Jarek's predominantly asynchronous approach, but in fact it is no less demanding. In Laura's own words, "The biggest challenge was time and energy. The sheer amount of organization, of typing ideas, plans and changes, answers to students' queries,

sharing with the Director of Teaching what the plans were as they were evolving." Students could ask questions during both the live-streamed lectures and the lab sessions using the chat window. More students asked questions than would normally do so in a face-to-face lecture and other students could indicate their support for a question by liking it. Some even answered the question before Laura could. Although this is a positive benefit, it nonetheless caused difficulties: "I can type 90 words/minute but couldn't type fast enough to answer everyone's questions". Mastering the technology, including learning to use MS Teams and MS Whiteboard, was "tough" and took "a lot more time than my usual teaching."

Alison Voice, from Leeds University, identified seven key elements to successful online delivery that neatly summarise the issues raised above.

- 1) **WORKLOAD:** The pandemic arrived suddenly. Staff have a short timescale to adapt and students have to cope with more than normal. The solution should be simple and effective whilst allowing students to interact with staff.
- 2) **LEARNING OUTCOMES:** Focusing on the educational aims and important deliverables at the outset allows extraneous content or activities to be released.
- 3) **SYNCHRONICITY** puts learners at the heart of teaching, but **ASYNCHRONICITY** allows students to work at their own pace and places fewer demands on staff during teaching.
- 4) **CONTENT DELIVERY:** Technology affords creativity, freeing both staff and students from the constraints of 50-minute lectures.
- 5) **UNDERSTANDING** can be developed with self-testing and feedback. Delivery should thus be punctuated with regular short conceptual quizzes and/or practice problems with feedback.
- 6) **ENGAGEMENT:** For effective learning students need to be active, both individually and with other learners. Content liberally spaced with questions, videos or simulations will motivate, and group work will provide both social and academic stimulation.
- 7) **BELONGING:** With so much remote study we should take special care to ensure all students feel part of the class, and follow up individually those who are less engaged.

Teaching online is time-intensive in a way that lecturing face-to-face is not and it is open to question whether many universities are properly equipped for the transition. There is a strong community desire within the UK to share and seek solutions and colleagues across Europe are invited to join in the online meeting and discussions.



◀ Left to right:  
Laura Kormos, Jaroslaw Nowak,  
David Sands, Stan Zochowski,  
Helen Vaughan, Alison Voice