Reshaping education. Part 1: Practical Thinking in a Pandemic.

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Reshaping education

2020 has seen unprecedented disruption in education, with a lack of practical teaching and laboratory access threatening to hit science education particularly hard.

With uncertainty about when and how many students will be allowed back in the lab, and further waves of disruption likely, *The Biologist* is pleased to present this special double feature on overcoming the challenges of teaching virtually...

PART I: PRACTICAL THINKING IN A PANDEMIC

The move to virtual teaching has been especially challenging for practical science, but it is also an opportunity to develop new approaches and skills

By **Dr Prachi Stafford**, **Dr Dominic Henri**, **Professor Ian Turner**, **Dr David Smith** and **Dr Nigel Francis**

Be it laboratory, practice or field work, practical learning experiences are an integral component of the student experience. Students get to apply their subject knowledge directly, problem solve together and develop key skills for becoming a bioscientist. Practical learning also has a sizable impact on student motivation, attainment and employability.

Yet providing meaningful practical experiences through governmental and institutional responses to COVID-19 has been tumultuous for lecturers in the UK. As the number of COVID-19 cases increased, universities shut their physical doors and teaching was transferred online almost overnight. Academics had to adapt to new methods of delivery, modify existing resources and develop new assessment tools, all under considerable time pressure.

Now that it has become apparent that we will be living with COVID-19 for the foreseeable future, life science academics are also having to rethink and re-imagine their practical classes' curriculum to address issues such as social distancing and shielding. In institutions where labs can be delivered, classes will be in smaller groups, with students working individually.

SHARING RESOURCES

While the breadth of these classes will be reduced, it will still be essential to meet the learning outcomes and ensure that students develop the relevant core skills. Indeed, this is seen as a requirement for many programmes, including those accredited by the RSB. Standards and proficiencies need to be maintained as the aim of higher education remains the development of competent scientific practitioners who can meet unknown future challenges.

While challenging for all, this can also be seen as a positive opportunity to re-evaluate our teaching approach, upgrade and embed new skills, and teach the curriculum of the future. The COVID-19 crisis has led to a community-wide response from the biosciences higher education sector, with those with expertise in pedagogical approaches embracing new teaching platforms and readily sharing resources within the community through collaborative networks such as #DryLabsRealScience.

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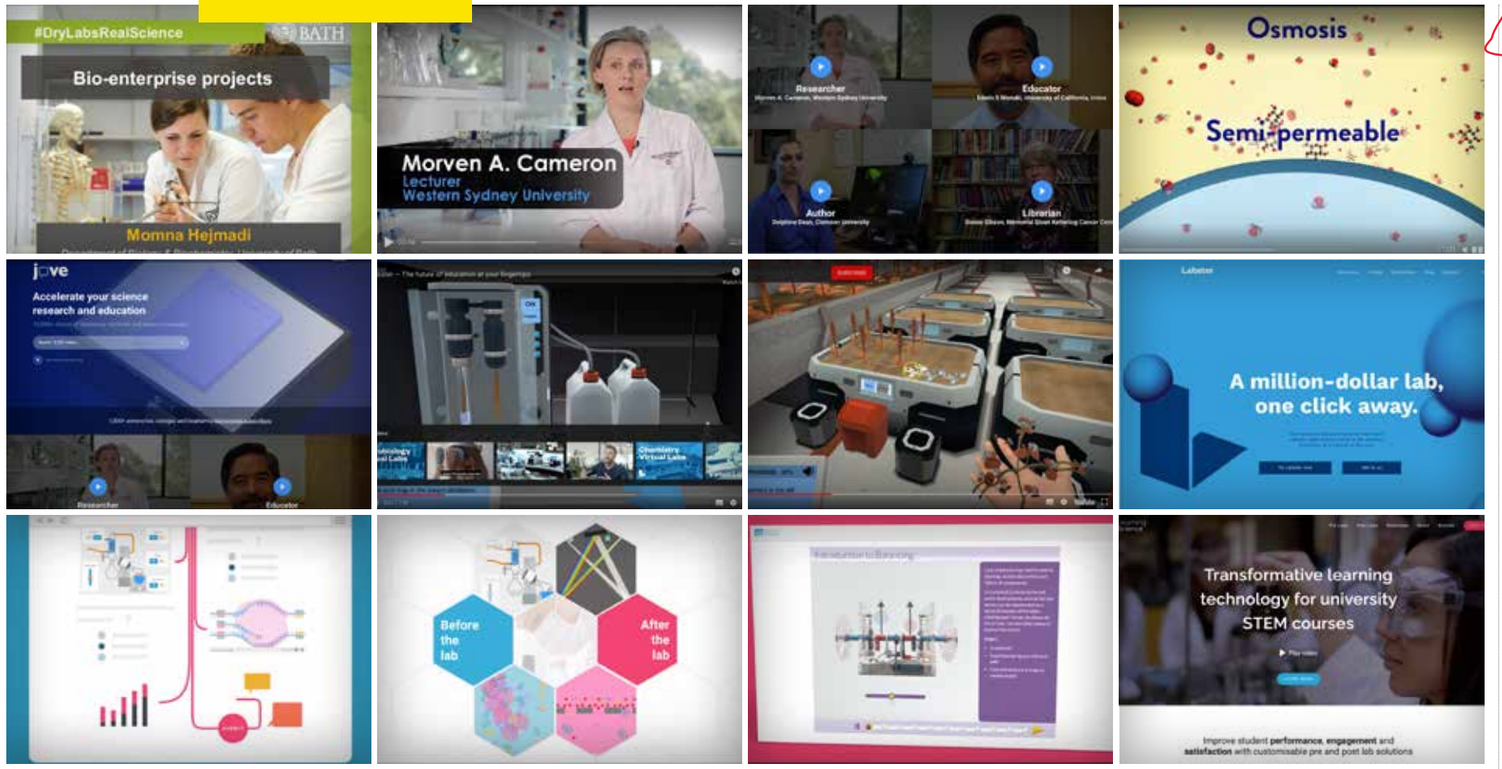
New screenshots to come



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Pre-practical learning activities lead to an enhanced learning experience as students arrive ready to perform the physical practical

One of the most immediate and tangible responses was the increase in resources focusing on the remote delivery of content (including the traditional lecture). One such resource is Lecturemotely (see 'Further reading', opposite, for links), a collaborative resource hub created to support both lecturers and students. The site houses a wealth of information ranging from novel teaching and assessment methods to ways to support students during remote teaching, and ideas and alternatives to final year capstone research projects.

PRACTICAL ALTERNATIVES

To support and aid transition to 'dry' or simulated labs, Dr Nigel Francis, Dr David Smith and Professor Ian Turner hosted fortnightly webinars for the bioscience community to share good practice, experiences and other tips. Sessions covered a range of topics from the use of simulations in pre-lab teaching, provided by commercial companies such as Labster and Learning Science, through to academics sharing examples of successful adaptations of practicals to the remote world.

Recordings of the webinars can be accessed online through the Lecturemotely website, alongside supporting 'how-to' walkthroughs and free resources guides for a wide range of topics. Videos demonstrating an array of techniques have been created and collections of free resources to support learning have been shared on this and other sites, including an open-source list of field ecology resources (see 'Further reading', opposite), which includes invitations for guest lecturing opportunities (much enhanced by a blended learning environment). Science video archives such as JoVE have also made content available.

Sessions highlighted the importance of simulations and virtual experiences to prepare students for their practical experiences, and where laboratory time is limited using that time to develop psychomotor skills. Follow-up materials and group activities are subsequently delivered online. Alternative capstone research projects were also presented and highlighted the breadth of ways in which students can demonstrate critical analysis and knowledge generation (covered in more detail on p29). These ideas have been used to create a series of one-page how-to guides such as using video to capture practical and the use of augmented reality

Bioscientists from across the world have been collating and sharing inspiring digital resources to invigorate learning experiences at a scale not experienced before, building a global community of practice. The willingness of individuals to share best practice has been a hallmark of this network, as exemplified by the team from De Montfort University, consisting of Dr Jo Rushworth, Dr T J Moore and Dr Beth Rogoyski, who developed the Lecturemotely website to share these and other resources produced by the global bioscience community.

As we prepare our curriculum we academics have had to reassess and reflect on our provision to identify exactly what core skills our graduates need. Utilising these resources as part of a remote delivery plan will enable students to maximise their experience in physical practical classes and ultimately improve both engagement and understanding. Limited time and smaller laboratory groups will mean that delivery will have to be targeted at core skills and will give the opportunity to identify directly what practical skills are essential.

Asking students to engage with online pre-lab learning will also have the added benefit that questions will be more targeted, or about technical aspects of procedures, thus allowing for a deeper appreciation of why and how techniques are used.

The value of pre-practical activities is well established in chemistry[1], but less so in the biosciences. However, this is changing, with recent publications[2, 3, 4] demonstrating that students value these virtual pre-practical learning activities and that they lead to an enhanced learning experience as students arrive ready to perform the physical practical. These approaches also enable students to take control of their own learning, developing independent skills, and improving outcomes and attainment.

The change in standard laboratory classes has also led to academics being more ambitious in what they are prepared to try for the final year capstone research projects. Studies on educational development, public perceptions of science, science communication, commercial and technical reports and many others have been undertaken.

Right: Dave Lewis, University of Leeds, is leading the development of capstone research projects

Dr David Lewis from the University of Leeds has been developing capstone research projects and has created a range of resources for colleagues to use that all address the RSB accreditation standards, which is explored in more detail on p28.

The inclusion of these multifaceted assignments and other enquiry-based research can encourage students to develop a multitude of transferable skills, including research, time-management, planning, team working, critical thinking and presentation, all of which are valuable in the workplace.

DATA SHARING REVOLUTION

The expansion in 'omics' studies, coupled with the development in bioinformatic analysis, has led to the generation of a wealth of data that is often made accessible to other scientists via data-sharing platforms. As we move into the future, bioinformatics and data handling are as much the tools of a bioscientist as the pipette and quadrat, and are more easily reproduced virtually. Similar changes driven by growth in citizen science, open-access data repositories and remote imaging dramatically expand the possibilities in ecological inquiries – who doesn't want to study brown bear behaviour in Alaska via a webcam in real time? There is now the opportunity to mine these databases as part of our practical experience in a bid to answer relevant research questions.

Until now, those without the established expertise have been reluctant to embrace this approach. However, with COVID-19 and the acknowledgement that engaging in these large-scale data analyses can yield novel and insightful results, there has been an incentive for academics to push and engage with relevant training as well as include some aspects within their curriculum.

The way we do science is evolving at a fast pace, and the incorporation of such new skills will undoubtedly benefit students and will feed into employability and new careers routes.

The COVID-19 pandemic has forced academics to re-evaluate approaches to teaching and provides wide-ranging opportunities for novel, imaginative teaching interventions, especially in the areas of lab and fieldwork. Rather than seeing the current situation as a negative, educators are reframing and looking for the opportunities that the situation presents. This is the time to try new approaches and propel teaching in higher education into the 21st century. These changes to our shared practices will inevitably have long-term impacts on the way we teach and will reshape and transform the future and evolution of biosciences in higher education.

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Professor Ian Turner is professor in learning and teaching in higher education at the University of Derby.

FURTHER READING

1) Lecturemotely. www.lecturemotely.com
2) Labster. www.labster.com
3) Learning Science. www.learningscience.co.uk
3) List of ecology field resources. bit.ly/Ecology_field_resources
4) Peer reviewed science experiment videos from JoVE. www.jove.com
5) Professor Ian Turner demonstrates how videos can be used in practical science. bit.ly/view_from_the_socs

REFERENCES

1) Agustiana, H. Y. & Michael, K. S. Reasserting the role of pre-laboratory activities in chemistry education: a proposed framework for their design. *Chem. Edu. Res. Prac.* **4** (2017).
2) Coleman, S. K. & Smith, C. L. Evaluating the benefits of virtual training for bioscience students. *High. Educ. Pedagog.* **4**(1) (2019).
3) Cann, A. J. Increasing student engagement with practical classes through online pre-lab quizzes. *J. Bio. Ed.* **50**(1) (2016).
4) Scott, P. H. *et al*. Enhancing theoretical understanding of a practical biology course using active and self-directed learning strategies. *J. Bio. Ed.* **52**(2) (2018).

PART II: REIMAGINING THE FINAL YEAR PROJECT

New alternatives to traditional final year bioscience projects, borne out of necessity during the pandemic, can actually help improve student experience and employability

By **Dr Sue Jones**, **Dr Dave Lewis** and **Michelle Payne**

The global pandemic and lockdown hit the UK towards the end of the academic year for most undergraduate students, just before the research project for master's students, and in time to cause severe disruption to the lab-based science and fieldwork of postgraduate research students, post-docs and academic staff.

One of the joys of teaching biology-based programmes is the power of practical classes and fieldwork to put theoretical knowledge into context for our students, culminating in their primary research experience in level 6. However, how on Earth can we deliver an authentic research experience in the post-COVID-19 environment? The expectation is that some laboratories may still be closed at the start of the upcoming academic year or, if open, have social distancing requirements in place. This means that we urgently need to find alternatives to traditional laboratory or fieldwork projects.

A possible pedagogical silver lining of the COVID-19 pandemic is that we must move beyond just laboratory-based final year projects to a broader, US-style 'capstone' (or culminating) experience. Not because we have to, but because it is the right thing to do. Developing a broad portfolio of capstone opportunities – including new formats while retaining some traditional approaches – will enhance the student learning experience by increasing ownership of their education and enabling them to decide what they want to achieve.

It is clearly important to explain the benefits of the different types of capstone experience to students, and align their choices with their skill sets and preferences for future employment or further study. Capstones can take many different formats and are both transformational and translational; they provide the opportunity for students to showcase their knowledge, understanding and skills to us as academics and potential employers.

Developing a broad portfolio of capstone opportunities will enhance the student learning experience by increasing ownership of their education

Additional drivers for change in final year projects are that employers increasingly require graduates with different knowledge and skill sets, while higher education providers, facing significant financial constraints, will need to provide high-quality education with decreased resources. This perfect storm provides a unique opportunity to collectively revamp our provision and move from a content-driven approach to a more personal and professional development-based one. In short, to better prepare our students for the 21st century workplace.

A BROADER APPROACH

A research project remains a requirement of the QAA Biosciences Benchmark Statements for biosciences and biomedical sciences. Replacing these en masse with critical literature reviews would not be acceptable to professional, statutory and regulatory bodies, nor would it be popular with students. By happy coincidence, both the RSB and the Institute of Biomedical Science (IBMS) have recently made substantial changes to their accreditation criteria, informed by the work of co-author Dave Lewis on broadening the scope of acceptable research projects.

Both the RSB[1] and IBMS[2] allow broader formats of capstone, including those that are team-based – as long as the individual contribution can be distinguished and provided the capstone experience includes opportunities for analysis, synthesis and critical evaluation of primary or secondary data, and a defined output.

Building on Lewis's extensive experience of delivering a range of capstone projects that are highly valued compared with traditional research projects, we (the co-authors) designed interactive workshops to enable colleagues to embrace this new way of thinking. Our three online workshops in the summer of 2020 were supported by the Heads of University Biosciences and Heads of University Centres for Biomedical Science organisations.

In these events we asked participants to put aside their preconceived ideas on research projects and work collaboratively to share ideas and create outputs. We engaged with more than 200 attendees to introduce different professional-body-approved formats of non-traditional projects/capstones. We suggested ideas to tackle issues and facilitate the introduction of multiple formats of projects/capstones into bioscience degree programmes (nationally and internationally).

Capstone experiences

Briefly, the capstone experiences approved by both the RSB and IBMS include virtual laboratory, bioinformatics/big data, computational modelling/simulations, systematic reviews with or without meta-analysis, surveys/focus groups, and educational development. Capstone experiences approved by the RSB only[3] include virtual fieldwork, grant proposals, scientific writing, commercial/technical reports, and professional education and science in schools or public engagement.

Key to the capstone experience is students applying their knowledge and skills gained in earlier years to an enquiry-based problem and creating an output as a solution to this problem. Non-traditional capstones, all of which are deliverable solely or predominantly remotely, are thus an ideal solution to our pandemic predicament.

The feedback on our events has been excellent and together we have increased knowledge and understanding of different formats of non-traditional projects/capstones. We have shared our co-created outputs and extensive resources (see 'Further reading', below right, to find links) on appropriate learning outcomes, generic grading criteria, authentic assessments, suggestions for scaffolding required in levels 4 and 5, and support for colleagues, plus addressing student expectations.

OPEN-ACCESS RESOURCES

All of our outputs have been shared as open-access resources[4]. Lewis has also created 'how-to' guides[4] for each type of capstone experience. These are publicly available and offer simple information on how to design and implement them. Take-up of these has been amazing, with 800 downloads from 45 countries in one week.

A selection of open access resources[5] is also available to support the delivery of post-COVID-19 capstone experiences. Importantly, the subject-specific and transferable skills and knowledge our graduates will achieve will not be compromised and may even be enhanced in this brave new world. What we can't do is return to our old ways – the worlds of work and education have changed forever.

Dr Sue Jones MRSB was named the RSB's Higher Education Bioscience Teacher of the Year 2020 and is associate head of school for biosciences at York St John University.
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Michelle Payne is a senior lecturer in healthcare science at the University of Sunderland.

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FURTHER READING
For a full list of the open-source outputs and resources created by the authors, visit [link to online version]

REFERENCES
1) RSB Accreditation Handbook 2019. bit.ly/RSBaccreditationhandbook
2) IBMS Final Year Research/Capstone Projects. bit.ly/IBMS_capstone
3) RSB capstone projects. bit.ly/RSB_capstone_suggestions
4) Final Year Research, Honours or Capstone Projects in the Biosciences. "How to Do It" guides. bit.ly/BiosciCapstones
5) A database of open-source bioscience datasets. bit.ly/open-source-data-sets