

TITLE

Bioscience laboratory practicals, projects and placements in a Covid-19 world

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Abstract

The aim of this review is to discuss alternatives to the traditional practicals, undergraduate projects and student placements that are presently being disrupted by Covid-19. We focus on bioscience higher education (biology, biomedical sciences) with an emphasis on the laboratory sciences. In the context of a shifting environmental and political landscape, we consider whether higher education institutions can deliver the latest bioscience skills and knowledge sought by employers through the use of virtual learning. To take the pressure off being in the laboratory, we suggest that there may be opportunities to reduce lab teaching, and in doing so, meet industry needs for more computational and policy-related knowledge. There may be opportunities for academic teams to build relationships with local business and industry partners to find new solutions, and think about how agility can be incorporated into curriculum design to accommodate the rapidly changing external environment. In this paper we share examples of how the authors work together to enhance student employability. Further research is required to understand the views of each stakeholder - student, academic and business or industry partner, in order to fully understand the context of the problems and possible solutions.

Keywords 5 - 6

SARS-CoV-2, Covid-19, laboratory practicals, undergraduate projects, student placements, bioscience, higher education, STEM

Introduction

The World Health Organisation characterised the coronavirus 2019 (Covid-19) outbreak as a pandemic on March 11th 2020, as caused by a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (WHO 2020). As a result, from mid-March 2020, all UK Higher Education Institutions suspended campus activity and moved to remote learning teaching (Kernohan 2020). The start of the Autumn term saw parts of the sector in lockdown once more after a brief respite. Researchers have discussed how to transfer lectures and tutorials online, and how to recreate a sense of learning community to facilitate interactions between students, their peers and their teaching staff (Turner 2020), and have also considered the implications for assessment and quality assurance for transferring practicals online in engineering and bioscience subjects (Gamage, Wijesuriya, Ekanayake, Rennie, Lambert & Gunawardhana 2020). However, there has been less conversation about how to accommodate student placements, critical elements within most biological and biomedical science programmes to enable students to achieve the knowledge and skills desired by potential employers. As universities have raced to convert face-to-face teaching to online delivery, perhaps the pandemic also provides an opportunity to reconsider some practicals, projects and placements as part of a wider transformation in response to changing local and global contexts.

Biological and biomedical science programmes, often termed 'biosciences' or life sciences, are estimated to include 500 hours of practical teaching over three years, integrated within modules and final year projects (Coward and Gray 2014). As a result of Covid-19, practicals were rearranged, and the sector received guidance on how to shift to data projects or use remote assessment including use of video (QAA 2020). Innovative solutions in the US included home-based and on-line lab experiments (The Conversation 2020). In the Autumn term, universities had begun to re-introduce practicals using social distancing measures.

For student placements the impact of Covid-19 is less clear but likely to be significant. An estimated 8.1% of science students take a sandwich year (at least a 6 month work placement), and for Biological Sciences this is steadily growing in number (7% of students) although in other areas, for example, Subjects Allied To Medicine, the popularity is declining (1.7% of students) (HESA 2020a and HESA 2020b). More male students undertake placements than female students. There is no disaggregated data on ethnicity. The impact of Covid-19 on sandwich placements is as yet unknown, but it is estimated that 26% of final year students have lost internships in 2020 (Greaves 2020).

Gaining work experience during undergraduate study is an important differentiator to students entering the bioscience job market. Graduates who have undertaken a placement can realise advantages of a higher degree award outcome (rise of at least one grade boundary) and a positive impact on their full-time employment prospects (students surveyed were twice as likely to be in full-time work and less likely to be working part time or volunteering) (Brooks and Youngson 2014).

This paper focuses on how the pandemic and other political and global factors may lead to necessary alterations in bioscience curricula and ways of working, and whether there are opportunities to enhance student practical and placement activities to redress changing employer needs, and prepare *all* bioscience students for a post-Covid-19 world.

The changing bioscience landscape

Bioscience sector needs

The Association of the British Pharmaceutical Industry (ABPI), in their latest skills-gap analysis, highlight the need for graduates and postgraduates to develop knowledge in the areas of genomics and immunology for the biological sciences, and also computational, mathematical and statistical disciplines (ABPI 2019). The report outlines emerging disciplines such as bioinformatics, biomedical imaging, automation and physiological modeling, which could be better served through revising bioscience curricula for online learning rather than needing to be in a physical laboratory.

Sector considerations post-COVID-19 and post-Brexit

There are emerging opportunities for scientists post-Covid-19 to work in government and policy (RSB 2020a), and those having a global and entrepreneurial outlook will be important contributors to the growth of the UK's Life Sciences sector. McKee (2020), Minister for Trade, Investment and Innovation in Scotland, in a report on innovation in life sciences and the response to Covid-19, emphasised that the sector would require specialists who are able to think creatively about solving problems, and who are adaptable leaders (McKee 2020). It is suggested that there will also be the need for more regulatory affairs professionals in the post-Brexit era, to support innovation and commercial growth in medicines, foods and therapeutics (ABPI 2019), and graduates with commercial experience will be desirable to support business growth (Science Industry Partnership 2020).

Therefore, undergraduate bioscience programmes could consider opportunities to enhance curricula with perspectives on policy, globalisation, commerce, regulatory affairs and entrepreneurship, potentially also providing alternatives to laboratory practical teaching. These suggestions could be explored through discussions with employers and industry, and also university regulators.

Growth in remote working

Up to 49.5% of UK employees were remote working during the height of the pandemic (ONS 2020), and in response to staff and environmental benefits, several large employers are making permanent changes to enable their staff to work from home either partially or fully (BBC News 2020; Ralph et al. 2020). Universities therefore could consider integrating 'on-campus' and 'on-line' student learning and teaching to equip students with the skills to thrive when remote working becomes mainstream in some work areas. This will need to include training on mental and physical wellbeing, with the added pressures of integrating work and home life (Bevan, Mason, and Bajorek 2020). Specific problems occurring during the pandemic include rises in musculo-skeletal complaints, poor sleep and mental health problems, and the long-term impact of remote working on people's health remains to be seen (Bevan, Mason, and Bajorek 2020). This suggests that wellbeing education should become more integrated into University curricula, and even better, at school.

Equitable opportunities

Strategies to support student education through Covid-19 and beyond need to be carefully considered so as not to widen the attainment gaps between different student groups. These are well recognised and have only marginally improved in recent years (a 22% point difference between ethnic minority students and their counterparts in terms of upper second class and first class degree outcomes, HEFCE 2018). The pandemic has exposed inequalities in early years education in differences in parental engagement in the home and differencing levels of access to a learning environment (Montacute 2020). Inequalities within higher education may arise from lack of access to technology tools, and reduced opportunities for some students to develop peer networks (Raaper and Brown 2020). Addressing inequality was one area where work placements made a difference and students from disadvantaged groups who undertook them achieved higher qualification outcomes (Moores, Birdi, and Higson 2017). It is already suggested that Higher Education needs to work harder to create an "inclusive and transformative system" that is open to all who wish to engage in it (Ashwin 2020), and maintaining activities such as placements that can support disadvantaged students during the

pandemic is challenging. Leicester University has guidance for those working in student employability and placements on equal opportunities that is relevant in the present context (Leicester 2020). Other organisations have established virtual work experience programmes that connects school and college students with employers, where online working has provided added flexibility in selecting dates and also times to interact (Bell 2020).

Solutions for Campus Laboratory Practicals and Projects

There are potential solutions that could replace current teaching methods with online alternatives, to accommodate the Covid-19 crisis and also weave in some of the ambitions above. Many lecturers have found creative solutions to run practicals and projects online, but maybe some could be replaced with a 'capstone' activity. There might be opportunities to 'kill two birds with one stone'.

Laboratory teaching comprises practical sessions that rise in complexity through levels of study, through to independent or group final year projects. The evergreen challenge facing practicals is how to support student transition from schools into university labs, coping with growing class sizes, covering the cost of consumables and how to enthuse students in practicals in areas where science is perceived as being boring or tedious (Wilson 2008). Final year projects are a further opportunity for students to gain a taste of working independently and developing their problem solving.

Use of Virtual Labs

There are numerous examples of the use of virtual laboratories to support student transition to University and their development in laboratory skills through all levels of study. Laboratory skill open educational resources (OER) created for the 2009 Virtual Analytical Laboratory Project at De Montfort University were designed to support student transition into labs, and was used at the start of semester 1 in a remote fashion; students had access to laboratory skills videos, problem solving and test exercises (Rolfe 2012). (Open educational resources or open content refers to any resource made available under the terms of a Creative Commons license for reuse and often adaptation and repurposing (UNESCO 2020)). In other examples, the use of virtual laboratories enhanced students' confidence before going into the lab and operating equipment, and they were able to engage in higher level discussions with staff (Dyrberg et al. 2017). Virtual laboratories can be designed for group learning, and also still permit doctoral and postdoctoral researchers to gain valuable teaching experience in supervising on-line classes (Vasiliadou 2020).

The use of openly available content such as the Open University's 'Open Science Laboratory' provides off-the-shelf tools and practical simulations that can be embedded into curricula, including a virtual histology microscope (Open University 2020). The use of laboratory simulations specifically for neuroscience and anatomy teaching were found to benefit student learning, although it may be that some subjects are more visual and lend themselves better to this form of teaching (Bish and Schleidt 2008; Ferrer-Torregrosa et al. 2016). Student learning of physiology practical skills was enhanced using video guides that were both accessed before the class as well as during the timetabled session (Crocker, Andersson, Lush, Prince & Gomez (2010). Virtual labs also allow for self-paced learning of chemistry techniques such as chromatography and high performance liquid chromatography, and could be used for home learning (Stone 2007).

The use of augmented reality laboratory classes offer additional dimensions using mobile devices to scan over bar codes to access multimedia resources; these technologies lessen the reliance on the teaching staff so could be easily used in a socially distanced lab, or used as resource to be used at home providing the students had access to a smart phone (Akçayır et al, 2016). The use of commercially available laboratory simulations such as Labster® offer a means of boosting student confidence and their acquisition of basic skills and knowledge such as laboratory health and safety, although licensing would need to allow access from a remote setting (Coleman and Smith 2019).

Bioinformatics and data work within the curriculum

To address emerging industry needs and to provide further alternatives for remote study, the use of bioinformatics and data analysis may offer a solution. The use of bioinformatics resources are often well integrated into molecular biology curricula, although in a survey of 16 universities, was found to be used in a complementary manner and not a replacement for the wet laboratory experience (Coward and Gray 2014). In light of the rising sector need for data-literate students, and increasing automation of many laboratory procedures in professional labs, one might argue there is flexibility to remove some wet practicals in favour of these skills.

The use of open datasets are used to support biological, earth, and environmental science teaching, and greatly improved data literacy, conceptual understanding of large datasets and problem solving with data (O'Reilly et al. 2017). In other examples, the use of bioinformatics tools are also integrated into the curriculum including BLAST, a National Center for Biotechnology Information (NCBI) tool; students learnt valuable skills effectively through the

teaching, and were challenged and enthused by it (Makarevitch, Frechette, and Wiatros 2015). Further ideas for data harvesting projects, or those that use previously collected research data are available (Elmer & Durocher 2020). Accessing publically available health data for example from the UK Data Archive which requires a simple registration could be useful for a practical or project (Essex University 2021).

Alternatives to final year laboratory projects

Perhaps the most pivotal time for a bioscience student to gain laboratory experience is as part of their final year project. Final year projects and dissertations should be a motivating and empowering experience for students (Healey et al. 2013). As the authors describe, there is often the assumption that students actually want to undertake wet laboratory projects, and in one initiative at Durham University students selected between a lab project, a business activity or education and communications activities. This flexibility isn't afforded to those professionally accredited programmes in which defined laboratory hours need to be achieved, but it could be argued with rising automation and changing work environments, these requirements could be challenged.

Capstone projects are more common in the US and Australia, and comprise a final year 'venture' in which the student may devise activities to contribute to their own professional portfolio. These projects can be done in conjunction with local communities and businesses (Healey et al. 2013). Three-way partnerships between students, universities and partners also benefits staff through building networks and gaining business insights for their teaching and research (Derounian 2007).

A list of diverse capstone project ideas from the Royal Society of Biology are a useful starting point, and attempt to avoid the project slipping into just a literature review (RSB 2020b). Lewis (2020) also described several capstone options for final year projects for bioscience students, including projects suitable for remote working or that were team-based (Lewis 2020).

In providing projects that utilise a wider range of research methods, staff can better support the interests and career aspirations of the students. The present authors have both carried out systematic reviews with undergraduate students, which offer relevant skills for those wishing to enter healthcare professions. The pros and cons of doing a mini-review for a project are discussed, including the unexpected workload from retrieving and evaluating a large number of publications, plus limitations of the process which should ideally involve multiple authors (Wissinger 2018). With an enthusiastic student and careful supervision, a systematic review project can produce publishable data (Walker and Adukwu 2020).

Another fulfilling and popular type of project is undertaking an audit or questionnaire. Those bioscience students who may be studying professional courses such as Healthcare Science or Biomedical Science may have the opportunity to carry out an audit of their laboratory or clinical environment (Tor, Steketee, and Mak 2016).

There are other ways in which final year projects could be diversified to remove the pressure of using the lab, provide relevant knowledge and skills for the sector, and be carried out in what might increasingly be a remote working scenario. Work would need to be done to deliver a robust experience with possibly some element of pair and group working, important transferable skills desired by employers.

Solutions for Placements

There are 5,870 Life Science small, medium and large enterprises in the UK (Science Industry Partnership 2020). Students traditionally gain in-work experience during year-long placements or holiday internships. Given the low uptake of students on sandwich placements despite the opportunities afforded (HESA 2020b), shorter experiences such as a ten week summer internships are a good compromise to enable the student to develop commercial awareness and entrepreneurial skills with less disruption to their study.

With the advent of more remote working post-Covid-19, universities and partners could consider how to facilitate students gaining these opportunities, particularly given the benefits they can create for disadvantaged student groups (Moores, Birdi, and Higson 2017). The pandemic also provides an avenue for businesses to explore how to support internships, work experience and placements to address some of their emergent needs.

Embedding Entrepreneurship

A logical starting point is increasing student awareness of the benefits of work experience, and gaining their enthusiasm for it. Universities such as Loughborough and Nottingham Trent provide entrepreneurship facilities and ecosystems to support student training and networking on campus (Loughborough 2020, NTU 2020). At Manchester Metropolitan University, in the Department of Health Professions, a senior lecturer in nutrition established the award-winning social enterprise MetMunch, and embeds entrepreneurial opportunities for students within the nutrition curriculum (MetMunch 2020). At Staffordshire University, one initiative was based upon a two-way collaboration with local private industry in the design and mentoring of its business start-up programme. External collaborations help to develop staff expertise and enrich

the student experience. Additional activities include guest lectures, placements and internships and collaborative projects (Clements 2011).

Whilst many of these examples are large-scale initiatives built over time, universities and staff can start dialogue with local companies to secure opportunities for students. At Pukka Herbs, we carry out a range of 'taster' activities such as sponsoring practicals to carry out a relevant piece of research, providing student seminars and guest lectures, sponsoring undergraduate projects, and providing internships and placements. Each activity raises awareness of different business-related career opportunities available to science students, and facilitates dialogue between university staff and an industry partner. This has led to many entrepreneurial activities with local university bioscience departments, and the authors of this paper have worked together on collaborative internships that have resulted in publication (Poswal et al, 2019).

Remote Internships

The idea of a remote summer placement or internship is limited in that it does not provide a fully immersive business or industry experience, but it can be argued that it provides a relevant experience that may reflect some of the working practices of the future. Remote projects can be fruitful and mutually beneficial to all parties. Carrying out desk-based projects can provide a variety of opportunities for the students such as developing skills in new research methods that they wouldn't otherwise experience at University (questionnaires, scoping reviews, systematic reviews, data-based projects). Employers and Universities can tailor desk-based projects to meet some of the expectations of industry experience with scheduled client meetings, report writing and dissemination of results.

The authors of the present paper have worked with students on four summer internships, and the most recent involves a student based at his home in Vietnam. Research supervision at a distance presents particular issues and challenges, including the use of synchronous and asynchronous IT, negotiating ways of working possibly across time-zones, and does require an increased levels of motivation by the learner (Zaheer and Munir 2020). There is increasing focus on understanding student wellness needs, and aspects of physical, social, intellectual, occupational, spiritual and emotional dimensions of wellness were used as a framework for ensuring students were adequately supported when learning at a distance (Wong and Wong 2020). More research needs to be done to understand student and staff perspectives on these ways of working.

Summary

Table 1. Remote learning solutions for bioscience education

Laboratory Practicals and Projects
Use of Virtual Labs <ul style="list-style-type: none">• Open educational resources as virtual labs (Rolfe 2012)• Multimedia resources as virtual labs (Dryberg et al, 2017; Open University 2020)• Augmented reality (Akçayır et al, 2016)• Laboratory simulation (Coleman and Smith 2019)
Bioinformatics and data work within the curriculum <ul style="list-style-type: none">• Open datasets / data projects (O'Reilly et al, 2017)• Bioinformatic tools (Makarevitch, Frechette, and Wiatros 2015)• Assorted data projects – data mining, using existing data (Elmer and Durocher 2020)
Alternatives to final year laboratory projects <ul style="list-style-type: none">• Capstone projects (Healey et al, 2013, RSB 2020b, Lewis 2020)• Systematic review (Wissinger 2018; Walker and Adukwu 2020)• Audits and surveys (Tor, Steketee, and Mak 2016)
Placements <ul style="list-style-type: none">• Embedding entrepreneurship within curriculum (Loughborough 2020; NTU 2020; MetMunch 2020)• Remote internships and placements (Zaheer and Munir 2020)• Wellbeing framework (Wong and Wong 2020)

University laboratory teaching is in a challenging situation due to the Covid-19 pandemic with universities in the UK and around the globe teaching remotely or in a blended manner, and returns to campus facilities likely to be unpredictable through 2021. Employers are also considering remote working either partially or fully, and some on a permanent basis, so this requires changes to be made to the delivery student practicals, projects and placements, to provide students with relevant experiences of these changing conditions.

The authors acknowledge these are challenging times, but there maybe an opportunity to take a longer-term view on the changing external environment. This may also help address some of the problems traditionally associated with practicals and lab-based undergraduate projects.

Also it may be possible to reflect upon the pharmaceutical and other life science sectors that are seeking computational, graphical, regulatory and desk-based knowledge and skills, that could take the strain off the need to be in the lab and on-campus. The Quality Assurance Agency subject benchmark are supportive of digital approaches to replace practicals and the use of other research methods such as surveys to support student learning (QAA 2021). Admittedly, in professional accredited courses that may have more stringent laboratory requirements, the flexibility and pace of change may be more restricted.

For placements and work experience, university careers teams and academic teams could consider a wider range of employment-relevant activities, partnering more closely with local business and industry to enrich curricula and provide students with developmental opportunities. Also considering other project methodologies such as questionnaire design and systematic reviews could also provide transferable skills.

The intention of this article was to identify tools and approaches that academic teams might be interested in using and adapting to support remote teaching, with emphasis on practicals, projects and placements. Its limitation is that it has not focused on student assessment and feedback that would also need to be successfully executed remotely. Some suggestions to face-to-face assessment and practical considerations for implementing them are available (Brown and Sambell 2020).

There is no doubt that university staff and students have had a tumultuous year. Front of mind should be the wellbeing of all involved, and new strategies should also be considered through the lens of equality to ensure that those disadvantaged on campus are not equally disadvantaged through remote teaching and working. Given the transformations to bioscience teaching that have been made over the course of the pandemic, opportunities should be made to support staff to share their practices through publishing case studies and evaluations for the benefit of the wider community.

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