

PREPARING STUDENTS FOR CAREER IN SCIENTIFIC RESEARCH: EDUCATING THE NEXT GENERATION OF IN-VIVO SCIENTISTS

Dave I. Lewis, Institute of Membrane & Systems Biology, Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JT.

Background

This case study describes one biomedical sciences lecturer's vision to provide an innovative, research-led education in integrative physiology and pharmacology for the next generation of in-vivo scientists.

Over the last twenty years, the development of powerful molecular biological techniques and technologies has led to a marked reduction in the use of animals in scientific and medical research in the United Kingdom (Home Office, 2011). However, studies at the molecular and cellular levels do not allow us to fully understand how individual organs function or interact with other body systems, and therefore, the use of research animals continues to be essential for scientific progress. However, the increasing adoption of reductionist approaches by the scientific community has resulted in a global shortage of individuals with the knowledge, skills and expertise to be able to undertake whole animal or in-vivo research (APBI, 2008). Universities therefore have a responsibility to meet the needs of industry and academia by educating the next generation of in-vivo scientists; to provide a select cohort of undergraduate students with the knowledge, expertise and skills to be able to undertake integrative physiology and pharmacology investigations.

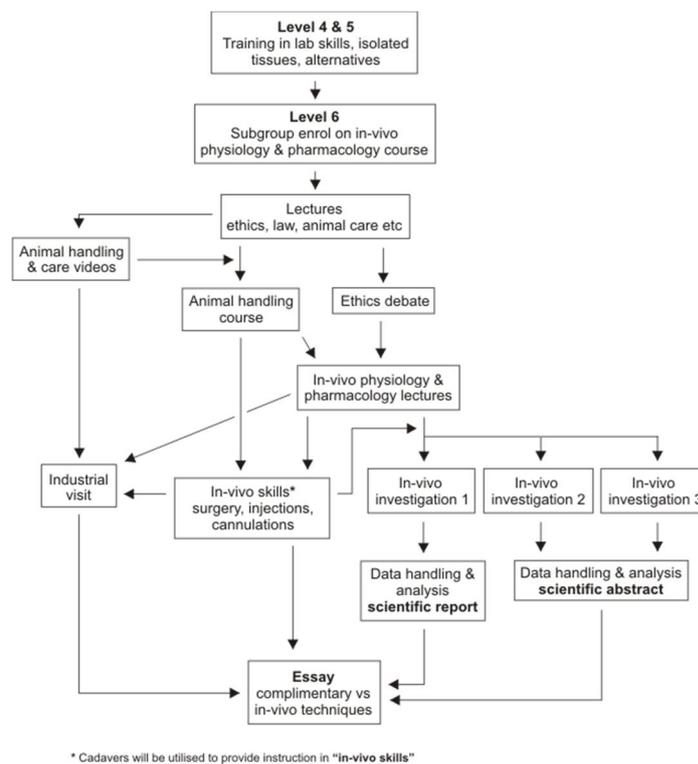


Figure 1: Schematic of Level 6 module which provides an education and training in integrative physiology and pharmacology

The lecturer's vision is to build on the knowledge and skills gained at Levels 4 and 5, particularly in cell culture, isolated tissues and other reductionist techniques, to provide a restricted cohort of Level 6 students who wish to go onto research careers, either in academia or industry with experiential learning in whole animal physiology and pharmacology (Figure 1). Future in-vivo scientists require more than practical training, they need a much broader education in the discipline and therefore, in addition to hands-on experience of integrative techniques and preparations, students are provided with lectures on animal welfare, ethics and law, and the use of in-vivo techniques and models in specific areas of research delivered by in-vivo experts in those fields (Lewis, 2012). A site visit provides knowledge and understanding of the use of research animals in Industry whilst the ethics debate enables students to better understand the arguments for and against animal experimentation. Each educational activity links with, and builds on, knowledge gained and skills learnt in earlier sessions, for example, students are provided with lectures in animal handling, husbandry and welfare before undertaking an animal handling course. This knowledge

and skills is reinforced by lectures on behavioural pharmacology which students then utilise in psychopharmacological experimental studies. Self managed learning, group learning and reflective practice are key features of the module. Students design and then undertake their own experimental studies; they have a free choice on the topic/research area of their end of module essay in which they discuss the role of in-vivo versus complimentary experimental techniques in their selected research area (self-managed learning). This essay is incorporated so that students can integrate all they have learnt to better understand the role of in-vivo studies in modern biomedical research. The majority of activities are group activities. Students enrolled on the module come from four different degree programmes; many have completed an Industrial Placement year. The intentional switching of students between groups for different activities means that a learning community develops. Students benefit from their peers different skills and knowledge, thus enhancing their own learning experience and facilitating deeper learning. Students have their own personal blogs on the modules Virtual Learning Environment pages where they are required to reflect on their thoughts on animal experimentation prior to and following the debate; they are also strongly encouraged to reflect on their learning and opinions throughout the module. The assessments for the module are designed to develop key scientific transferable skills such as critical reviews of the literature, scientific abstract and report writing, oral communications and the public communication of science.

Reason for introducing this teaching method

The 2008 ABPI report highlighted the chronic shortage of trained in-vivo physiologist and pharmacologists within the UK at all levels (less than 120 undergraduates per year receive training in this area) to the extent that survey respondents were concerned about the future of these disciplines. Appointment as a Programme Manager provided the opportunity for the Lecturer to develop a module which provided an education in in-vivo sciences for a restricted cohort of students at his Institution who wish to go onto careers in scientific research. The module was designed, not only to provide hands-on training in experimental techniques, but a much broader education in in-vivo sciences, to move away from passive lectures and practicals to a more engaging, enquiry-based experiential learning, which harnesses student enthusiasm and gives them ownership of their learning. On ensure that it met the needs of Industry, it was developed and is co-taught in partnership with colleagues from Industry. The recommendations of the ABPI and Biosciences Federation in-vivo science report (2007) was also utilised to inform the content of the module.

Lecturer perspective

The lecturer had a desire to share his passion for in-vivo sciences with his students. To develop a module which, whilst it would not make his students fully trained in-vivo scientists, would provide them with a greater knowledge and understanding of the role of in-vivo sciences in modern biomedical research, would engender in them the same enthusiasm for the subject as he has and a desire to undertake a research career in this area. Achievement of these objectives is reflected by the considerable demand for places (typically 3-4x oversubscribed), the exceptional student feedback received and the significant impact the module has on the employability of its graduates. The success of the module is undoubtedly due to the equal partnership that develops between staff and students. The intensive nature of the teaching combined with group working which results in the development of a real learning community; students are prepared to go the extra mile.

“Even though I could complain about the very early starts for the practicals/industry visit, I feel that I really can't because the experience I got from these and all other aspects of the module were so enjoyable, that any start, no matter how early, would have been worth it”

The small number of staff who contribute to the module share the Lecturer's vision and have a similar desire to impart their knowledge and passion for the subject to their students. There is clearly a social dimension to learning on this module.

All parties are committed to continually improving and developing the module. Staff and student reflections, and feedback from students, funding providers, Industry and other external parties is utilised to inform these improvements, with our experiences disseminated and shared with colleagues. This dissemination has led to animal rights activists now contributing to the education of students on the module through the provision of a seminar on the ethics of animal experimentation.

Student perspective

This was collected through anonymous feedback forums on the module's virtual learning environment pages, student completion of our sponsors feedback forms and end of module surveys. The data presented is a mean of the seven years this module has been running.

Students appreciate the lecturer's dedication, enthusiasm and willingness to adopt a range of different teaching methods in order to provide an excellent education and training in in-vivo sciences. Their feedback on the content, structure and learning experience provided by this module is exceptional. When asked "How interesting was this module compared to other modules on your course", virtually all students thought it was the most interesting module that they had enrolled on throughout their time at Leeds (mean score = 4.88/5), with comments such as the following commonplace:

"This module is unique, challenging and the best module I have attended at Leeds so far because each element of the course forces you to think and act like a scientist as opposed to a student"

"It is by far the best module I have done during my three years at university. It was the only module where I feel we learnt the theory and then were able to apply it within practical situations"

Students were particularly appreciative of the experiential learning provided by the module, the integration of theory with "hands-on" practical experience and how the module, as a whole, raised knowledge and understanding of the role of in-vivo studies in modern biomedical research (score = 4.80/5)

"It has been incredibly educational and useful, giving me an insight into in vivo techniques, as well as improving many skills of my own"

"What I have learnt since the beginning of this course, I cannot find out from reading any textbook or scientific report"

"The nature of this module, spending so much time in a lab with the researchers allowed a much better way to learn. Demonstrations and lectures are good but when you are able to fully investigate a problem alongside a researcher the depth of understanding achieved is far greater"

They recognised the high quality of teaching and learning provided (mean score = 4.75/5), the commitment of staff, and how this led to the creation of a learning community

"The lecturers were passionate about what they were teaching which always comes across".

"Everyone who gave us a lecture or practical helped us hugely and taught us a lot that we had not learnt before"

"It has felt for the first time I can communicate with staff about work and work together with others which I have not been able to do on any other module"

Students also recognised how the module had led to them exploring career options they didn't even know existed before enrolment on it, the applicability of the knowledge and skills (both scientific and generic) they had gained to their future research careers (mean = 4.81/5), and the impact of these on their employability.

"The chance to receive training in advanced in-vivo techniques as part of our degree – invaluable"

"It has given me an exceptional view on in vivo research, and the skills that I obtained from the module are paramount to my application for future research positions."

As such, virtually all students would strongly recommend the module to their peers (mean = 4.93/5)

"I feel privileged to have been able to take part in this module and I would recommend it to anyone with an interest in research"

"I genuinely have no ways in which this module could be improved... except maybe increase the no of places available so more people can have the opportunity to experience it!"

Issues

Providing an education or modules in in-vivo sciences is expensive, requiring considerable staff and financial resource. Enrolment on these modules is normally limited to a restricted cohort of students within individual programmes, with provision often only possible with financial support from Industry. In designing the module content, module leaders have to weigh up the benefits of students obtaining personal licences under the Animals (Scientific Procedures) Act thereby enabling them to gain direct, "hands-on", personal experience of in-vivo studies or for students not to obtain licences, but to participate in such studies, as in this case study, via "delegated authority" (i.e. assist by undertaking tasks, such a placement of animals in experimental arenas, which require minimal expertise or training). The latter provides significant time and cost-savings; it also enables student exposure to, and participation in, more

complex experimental studies. The use of research animals in education is controversial. Use of delegated authorities and restricting module enrolment to students who intend to use this education in their future careers ameliorates these ethical implications. Finally, many Institutions may not have the staff to provide an education in in-vivo sciences. There is a severe shortage of experienced teachers with the requisite skills and expertise; the 2007 ABPI and Biosciences Federation in-vivo sciences report highlighting that 25% of these academics were due to retire within 10 years.

Benefits

The benefits are both short and long-term. The experiential, self-managed learning and other approaches utilised in this case study have a significant impact on student academic achievement; the mean module mark for this teaching is, on average, 10% higher than other Level 6 taught modules. Graduates will also be well educated in in-vivo sciences, able to identify and solve problems of anaesthesia, homeostasis and drug responses in whole systems and thereby avoid wasting or inflicting avoidable suffering to animals in their future careers through ill-considered, inexpertly designed or poorly conducted experiments. They will have the knowledge and understanding to see the place of in-vivo studies in modern biomedical research and how such studies integrate with alternative but complimentary techniques. This education will also substantially increase their employability. Despite the shortage of trained in-vivo scientists, less than 120 UK undergraduates per year receive training in this area (ABPI & Biosciences Federation, 2007). Students who are exposed to in-vivo studies during their undergraduate studies are highly sought after by both academia and Industry. Each year, between 50-80% of students who enrol on the module will go onto PhD studies, usually in in-vivo sciences, on graduation. Within Industry, positions in in-vivo sciences are only offered to applicants who have received training in this area, either during their undergraduate studies or at postgraduate level. Despite the high cost of providing an education and training in in-vivo sciences, modules such as this should be viewed as "Flagship" modules; modules which make individual programmes distinct from those offered by competitor Institutions and significantly increase the employability of students enrolled on them.

Reflections

The success of the activities described in this case study have come from the development of strong partnerships between students and staff, working collaboratively to provide an exceptional student learning experience. The teaching and learning practices described could easily be adopted by other Institutions. The successes of the work have been widely shared and disseminated through publications (articles, book chapters, development of collections of open educational resources (e.g. Lewis 2009; 2011; 2012)), invitations to speak at national and international conferences and to run professional development events/training courses. On a personal level, the lecturer has been invited to Chair national and international initiatives in education and training in in-vivo sciences (British Pharmacological Society In-vivo training Committee, IUPHAR Integrative & Organ Systems Pharmacology Initiative), and to contribute to the development and accreditation (e.g. Society of Biology) of degree and other training programmes in in-vivo sciences. This sharing of knowledge and expertise will lead to improvements in the education and training of future in-vivo scientists, animal welfare, and therefore scientific studies, globally.

References

- Association of the British Pharmaceutical Industry (2008). Skills needed for Biomedical Research. Available at: <http://www.abpi.org.uk/our-work/library/industry/Pages/skills-biomedical-research.aspx>
- Association of the British Pharmaceutical Industry and Biosciences Federation (2007). In-vivo sciences in the UK: Sustaining the supply of skills in the 21st Century. Available at: <http://www.abpi.org.uk/our-work/library/industry/Pages/in-vivo-report.aspx>
- Lewis D.I. (2009). Animal Welfare, Ethics and the 3Rs. Training materials and resources. Available at: <http://www.lasa.co.uk/3Rs%20resource%20e-version%20Dec09s.pdf>
- Lewis, D. I. (2011). In vivo Work. In *Effective Learning in the Life Sciences: How Students can Achieve their Full Potential* (ed. D. J. Adams), John Wiley & Sons, Ltd, Chichester, UK.
- Lewis D.I. (2012). Educating the next generation of in-vivo scientists. Meeting the needs of Industry and Academia. *Altex: Alternatives to Animal experimentation* 29 (In press)