Authentic, large-scale undergraduate research experiences (ALUREs) in physiology – development, implementation, evaluation and dissemination

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Calls for reform in science education (Bybee and Fuchs, 2006) and physiology education in particular (Michael, 2006), have long argued for an emphasis on the development of key scientific thinking skills that will prepare students for the complex, novel problems they will face in the 21st Century workplace. Developing practicals that incorporate physiological research can shift students from passive recipe-based practicals to active learning (Michael, 2006), improve student interest and enthusiasm and teach students important physiological concepts along with key skills in the critical evaluation of complex data (Zimbardi *et al.*, 2013; Luckie *et al.*, 2012). However, designing research experiences for large cohorts of students has many pitfalls that can result in students learning less rather than more (Kirschner, Sweller & Clark, 2006).

After a major review of the Bachelor of Science, we developed, implemented, and evaluated a series of five vertically integrated courses with inquiry-style laboratory practicals for undergraduate students specialising in physiology (Jones *et al.*, 2013). These practical curricula were designed so that students would work with increasing autonomy and ownership of their research projects to develop increasingly advanced scientific thinking and communication skills. We have analysed videos of students (n=22) in these classes developing hypotheses, designing experiments, conducting the experiments and analysing and interpreting their findings, and analysed their written reports (n=140). Students demonstrate significant learning gains in hypothesis formulation and experimental design during the early stages of the vertically-integrated curricula, and develop skills in the critical interpretation of their findings and relating these to the primary literature in the later stages of the course sequence (Zimbardi *et al.*, 2013; Bugarcic *et al.*, 2012). Throughout this series, students develop a deep understanding of scientific writing, evidence-based reasoning and the contestable nature of scientific knowledge.

Collaboration between clusters of bioscientists leading similar curricular reforms, has led to an OLT Leadership project which is supporting nation-wide uptake of this model of Authentic Large-Scale Undergraduate Research Experiences (ALUREs). We are now working with a large network of academics to provide the benefits of research experiences to thousands of undergraduate students in the biosciences. The evolution of our work from curricular renewal to expansive dissemination, has provided many important lessons and insights for how to, and how NOT to, design, implement, evaluate and disseminate ALUREs.

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