Embedding research ethics and integrity into undergraduate practical classes




Karena L Waller[A], *Daniel P Barr*[B], *Paul M Taylor*[C] *and Odilia L Wijburg*[D]

[A]Department of Microbiology and Immunology, The University of Melbourne, at The Peter Doherty Institute for Infection and Immunity, Melbourne, Vic. 3000, Australia. Tel: +61 3 8344 0045, Email: klwaller@unimelb.edu.au

[B]Office for Research Ethics and Integrity, Research Innovation and Commercialisation, The University of Melbourne, Melbourne, Vic. 3010, Australia. Tel: +61 3 9035 4170, Email: dpbarr@unimelb.edu.au

[C]Office for Research Ethics and Integrity, Research Innovation and Commercialisation, The University of Melbourne, Melbourne, Vic. 3010, Australia. Tel: +61 3 8344 2047, Email: pmt@unimelb.edu.au

[D]Department of Microbiology and Immunology, The University of Melbourne, at The Peter Doherty Institute for Infection and Immunity, Melbourne, Vic. 3000, Australia. Tel: +61 3 8344 9919, Email: odilia@unimelb.edu.au

The core principles of research ethics and integrity that underpin the responsible conduct of research are critical to the design and performance of high quality research that generates excellent research data and outcomes that can be confidently trusted. Although many senior researchers have gained an in-depth appreciation and understanding of the importance of research ethics and integrity in the responsible conduct of research, many undergraduate students in science and technology disciplines do not obtain a basic, working knowledge of relevant research ethics and integrity principles as part of their degree. Here, we describe the introduction of a research ethics and integrity curriculum component into our third year practical classes, and the beneficial outcomes that we observed.

Research ethics and integrity in the responsible conduct of research

The requirement for the responsible conduct of research (RCR) is increasingly gaining attention within the broader scientific community. Guidelines for RCR are provided by research institutes, universities and governments around the world. The 'Australian Code for the Responsible Conduct of Research' provides guidelines on key areas to promote scientific integrity and best practise in research and emphasizes the need for training in RCR[1]. Importantly, 'The Code' also addresses community expectations of researchers. Numerous scientific publications, some of which are published in high profile seminal journals like *Nature* and *Science*, have sought to bring greater awareness to the scientific community of what constitutes RCR, and what researchers and research institutes (including universities) can and should be doing to achieve it[2,3]. This increased attention, coupled with RCR being an integral component of all disciplines within the Science, Technology, Engineering and Mathematics (STEM) umbrella, has led to an increased awareness of the need for appropriate education in RCR[4–7] during tertiary education, and for research higher degree (RHD) students[8]. Yet despite this, the teaching and learning of the core principles of research ethics and integrity that underpin RCR for undergraduate university students is very often implicit rather than explicit. Indeed, many undergraduate students at the conclusion of their three year Degree possess a poor understanding of what constitutes RCR, or more bluntly, *why things need to be done a certain way*

in research[8–10]. An earlier survey of American undergraduate Biology courses highlighted this issue, finding none of the 104 courses reviewed included a required (compulsory) curriculum component on ethics[11]. Thus, it is perhaps not surprising that many undergraduate students lack this knowledge at the conclusion of their three year undergraduate Degree.

To overcome this, many academics are now calling for earlier inclusion of some basic training on RCR in the undergraduate curricula of STEM disciplines[9,12–14] rather than its more usual introduction when undergraduate students undertake an intense research-based learning experience (such as an optional senior Honours year). Unfortunately, not all undergraduate students undertake such an intense research experience, and so many students graduate from their degrees and go on to seek future employment in STEM disciplines without a basic, requisite working knowledge of relevant research ethics and integrity. To directly redress this issue for graduates of Microbiology and Immunology majors at The University of Melbourne, we recently introduced into the curricula of our third year practical subjects a component on research ethics and integrity that directly links to the in-class critical dissection of a primary research article in journal club sessions.

The students and subjects

The students undertaking our third year practical subjects in Microbiology (MIIM30016 Techniques in Microbiology) and Immunology (MIIM30015 Techniques in Immunology) are drawn almost exclusively from the Bachelor of Science (BSc) and Bachelor of Biomedicine (BBiomed) Degrees. Each of these practical subjects consists of 1x 3 hours (h) of practical per week, plus 2x 1h of lecture or tutorial sessions per week. The practical topics in both subjects were specifically designed to provide a 'research-type' learning experience for the students focusing on different aspects of Microbiology and Immunology. Additionally, in each of these subjects the majority of the practical sessions were 'wet' practicals performed in a certified Physical Containment Level 2 (PC2) laboratory, while a minority were 'dry' practical sessions predominantly focusing on bioinformatics, analysis of flow cytometry data and Journal Club sessions (enabling the critical review of a recent discipline-specific primary research article). Both of these subjects were first deployed in 2014, and included a curriculum component devoted to research ethics and integrity. These sessions typically comprised a 1h general introduction to research ethics and integrity followed by a 1h interactive workshop. These sessions were prepared and delivered by Dr Daniel Barr (Associate Director) and Dr Paul Taylor (Director) from the Office for Research Ethics and Integrity (OREI) at The University of Melbourne and were facilitated by Dr Karena Waller and/or Dr Odilia Wijburg. The introductory session focused on the principles of research ethics and integrity most obviously connected to research in Microbiology and Immunology. The idea of the connectedness of one piece of research to another, and the iterative but sometimes paradigm-shifting nature of research, were explored with the analysis of case studies. Areas of research practice that are of immediate relevance to student researchers, such as: research data and records management and navigating authorship; the objectives of animal and human research ethics; and the impact of research misconduct, were explored in more detail. The latter interactive workshop was specifically designed to stimulate students to answer questions about research ethics and integrity and also required them to apply their newly acquired knowledge of RCR (gained from the introductory sessions) in the context of the Journal Club paper. Although students had previously dissected and evaluated the structure and scientific content of the Journal Club paper in a separate class, the workshop session required them to review the paper again, but this time from the perspective of research ethics and integrity by asking the question 'what is it about the paper that makes you trust the findings?' At the end of each teaching semester in each subject, we administered a voluntary, anonymous questionnaire (Table 1) to students requesting responses to Likert-items (on a scale of strongly disagree to strongly agree) and written comment to open-ended questions regarding their thoughts on the utility of the research ethics and integrity sessions. Although the questionnaire used in 2014 contained just two questions regarding research ethics and integrity (Table 1), in 2015 to probe what the students thought about the utility of these sessions in greater detail, we expanded the number of questions in the questionnaire to six.

Quantitative analysis of the Likert-item responses and the qualitative analysis of the open-ended responses revealed some interesting trends. Across both years and both subjects, students overwhelmingly agreed (including the cumulative agreed and strongly agreed responses) that they found the research ethics and integrity sessions useful (2014: 47.9% agreed compared with 39.7% neutral and 12.3% disagreed and strongly disagreed; 2015: 52.8% agreed, compared with 38.5% neutral and 8.8% disagreed and strongly disagreed; Figure 1). Additionally, in 2015 when we probed the students in greater detail about their thoughts on the utility of the sessions, the students again overwhelmingly agreed (including the cumulative agreed and strongly agreed responses) that these sessions provided them with:

1. a better understanding of why they were required to follow certain practices in the subject such as completing a Lab Notebook (57.8%);
2. a better understanding of the importance of research ethics and integrity in RCR (58.4%);

Table 1. Questions included in the voluntary, anonymous questionnaires deployed in 2014 and 2015.

Year	Question Number	Question	Type of Student Response
2014	Q1	I attended the Research Ethics and Integrity sessions and found them useful[A]	Desired response (on a scale of strongly disagree to strongly agree) selected on a computer scannable response sheet
2015	Q1	I attended the Research Ethics and Integrity sessions and found them useful*	As above
	Q2	After attending the Research Ethics and Integrity sessions I feel I now have a better understanding of why I am required to follow certain practices in the subject (such as completing a Lab Notebook)	As above
	Q3	After attending the Research Ethics and Integrity sessions I feel I now have a better understanding of their importance in conducting responsible research	As above
	Q4	After attending the Research Ethics and Integrity sessions I feel I now have a better understanding of what constitutes responsible research	As above
	Q5	After attending the Research Ethics and Integrity sessions I feel I now have a better understanding of who I can speak to if I have concerns about the responsible conduct of research	As above
2014 and 2015	Q6	If you attended the Research Ethics and Integrity Sessions, did you find them useful and interesting? Please comment.....	Written response required in the space provided on the questionnaire

[A]The wording of Q1 in the 2014 and 2015 MIIM30016 questionnaires is as shown, however the wording of Q1 in the 2014 and 2015 MIIM30015 questionnaires was: I found the research ethics and integrity session(s) useful.

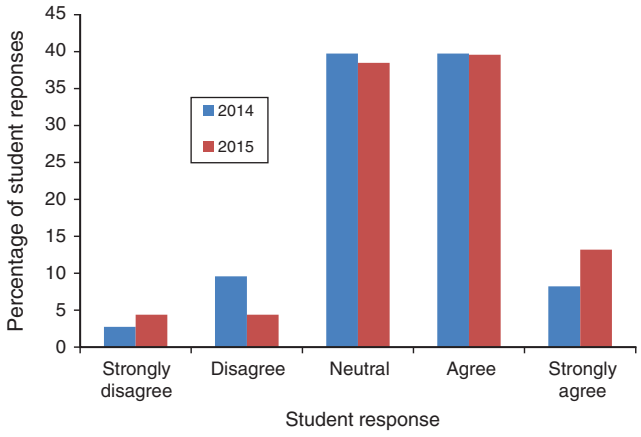

Figure 1. Graphical representation of the student responses (on a scale of strongly disagree to strongly agree) to Q1 of the 2014 and 2015 questionnaires in both MIIM30015 and MIIM30016. Across both subjects, 73 out of 96 students responded to Q1 in 2014 (overall response rate 76%) and 91 out of 140 students responded to Q1 in 2015 (overall response rate 65.0%). Students overwhelmingly agreed (including the cumulative agreed and strongly agreed responses) that they found the research ethics and integrity sessions useful (2014: 47.9% agreed; 2015: 52.8% agreed).

3. a better understanding of what constitutes responsible research (59.1%); and
4. a better understanding of who they could speak to if they had concerns about the responsible conduct of research (59.7%; Figure 2).

A review of the written comments (cumulative from both years and both subjects) returned by students in response to Question 6 (Table 1) also revealed many positive comments regarding the utility and interest-value of the sessions. Some of these comments have been supplied below:

- *Yes, it gave a good 'heads up' for things to be considered in future research tasks* – 2014, MIIM30016
- *Yes, topic was interesting. Hadn't* [sic] *it been for this session, I wouldn't have thought of the issues* – 2014, MIIM30016
- *Yes. They were useful and interesting. Learned many things that I wasn't aware of* – 2015, MIIM30016
- *I found them interesting because I hadn't learned it before* – 2015, MIIM30016

However, like most questionnaires, a few comments returned by the students indicated that some students had not appreciated the utility of these sessions, as demonstrated by:

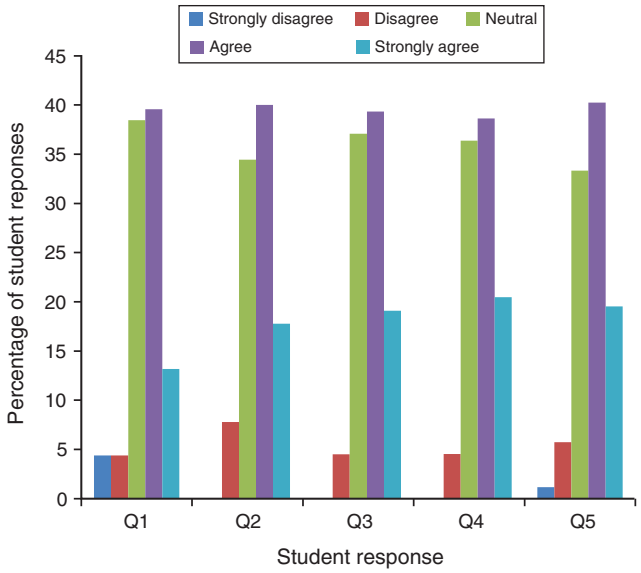

Figure 2. Graphical representation of the student responses (on a scale of strongly disagree to strongly agree) to the expanded question set used in the 2015 questionnaire. In 2015, a minimum of 87 students (maximum 92) out of 140 students across MIIM30015 and MIIM30016 responded to each question, equating to an overall response rate of 62.1%-65.7% (min-max.) per question. Students overwhelmingly agreed (including the cumulative agreed and strongly agreed responses) that these sessions provided them with: a better understanding of why they were required to follow certain practices in the subject such as completing a Lab Notebook (Q2, 57.8%); a better understanding of the importance of research ethics and integrity in RCR (Q3, 58.4%); a better understanding of what constitutes responsible research (Q4, 59.1%); and, a better understanding of who they could speak to if they had concerns about the responsible conduct of research (Q5, 59.7%).

- *...pointless* – 2015, MIIM30016
- *Not particularly useful as we are not researchers yet* – 2015, MIIM30016

These latter comments are particularly interesting (and troubling) to us as educators as they seem to highlight the fact that some students did not see the applicability of the information to them. Perhaps this is because, as third-year undergraduate students, they were not currently conducting or contributing to primary research, and/or most were not likely to be currently engaged or employed in STEM disciplines. Disappointingly though, such comments may also indicate that some students could not foresee the future applicability or utility of this knowledge to their potential employment in STEM disciplines (and perhaps even employment more broadly). To address this issue of applicability and relevance in future iterations of these subjects, greater emphasis will be placed on reminding the students that a basic, working knowledge of research ethics and integrity is extremely beneficial for the whole of their trajectory through STEM disciplines, from the educational to the vocational. And, for those students who choose to move away from STEM disciplines after graduation, a basic, working knowledge of research ethics and integrity and its importance in RCR is still highly beneficial in terms of producing more well-rounded graduates who can contribute to building a better informed general public.

Concluding remarks

In summary, the data herein demonstrate that the majority of students found the research ethics and integrity sessions useful, and that following these sessions, they had a greater appreciation and understanding of the responsible conduct of research and the importance for it. Although there is obvious room for improvement in the deployment of these sessions in future iterations of the subjects, overall we feel the incorporation of these sessions into our third year practical subjects has directly redressed a curriculum gap and yielded beneficial outcomes to many of our undergraduate students. Ultimately, it would be highly desirable if all undergraduate tertiary degrees in STEM disciplines included a curriculum component on relevant research ethics and integrity to provide an opportunity for students to attain a basic, requisite working knowledge prior to graduation.

Human ethics approval

This study was conducted under the approval of Human Ethics Application 1646306.1 at The University of Melbourne.

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Biographies

Dr Karena Waller is a Senior Lecturer in the Department of Microbiology and Immunology at The University of Melbourne and Chair of the ASM VIC Branch. Karena completed her PhD and subsequent post-doctoral and fellowship positions in malaria research at Monash University and Albert Einstein College of Medicine (New York, USA) before taking up an Academic Teaching-focused position at The University of Melbourne in 2010. Karena was the recipient of an ASM Teachers Travel Award (2010) and a Melbourne Medical School Early Career Development Teaching Award (2014).

Dr Daniel Barr is the Associate Director of the Office for Research Ethics and Integrity at The University of Melbourne. Dan graduated with a PhD in immunology from The University of Melbourne. Dan educates students, researchers and administrators, and manages processes and provides advice for research misconduct investigations. He is passionate about research integrity and research about research, particularly understanding the role of policy and cultures of research integrity.

Dr Paul Taylor is the Director of the Office for Research Ethics and Integrity at The University of Melbourne. Paul graduated with a PhD in microbiology from The University of Melbourne and has been working in research management for 13 years. At OREI, Paul leads the development and implementation of research ethics and integrity policy, education and training and support.

Dr Odilia Wijburg is a Senior Lecturer in the Department of Microbiology and Immunology at The University of Melbourne. She is an internationally recognised expert on the immunobiology of mucosal bacterial infections and has over 15 years' experience as a senior research fellow. She changed careers in 2013 when she was appointed as Academic Teaching-focused senior lecturer and was the recipient of Melbourne Medical School 2014 Teaching Award.