Science under siege: necessity driving the teaching-research nexus

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ABSTRACT

In recent decades there has been a major shift in Australian government policies associated with universities. These reforms have been focused largely on reducing the economic dependence of universities on government. In parallel with these reforms, there has been increasing pressure on universities to lift their performance in both teaching and research and there has been much talk of the research-teaching nexus. In this chapter we provide a case study as an example of how the authors have moved to integrate teaching and research in the face of fiscal adversity. We conclude that the outcomes were positive to all involved and provided an enhanced student learning and experience, while supporting the integration of teaching and learning for the academics involved. This integration of the twin activities of teaching and research provided academic staff with opportunities to develop their research initiatives beyond what would have otherwise been possible within the same timeframe if their research and teaching had not been entwined. However, we reflect that if science were not under siege there may not have been the incentive to change the *status quo* and drive the research-teaching nexus.

Key words: education reforms, teaching and research integration, student learning outcomes, undergraduate teaching innovation

Introduction

A major shift in direction for the higher education system in Australia was introduced with the reforms spearheaded by John Dawkins, Minister for Employment, Education and Training (see Dawkins 1987, 1988). His plan envisaged a 30% increase in enrolments across the University sector. A major driver for the reforms was to reduce government funding to the higher education sector by increasing efficiencies (Gupta 1990). This was achieved primarily by enforcing greater economies of scale through the amalgamation of Australian tertiary education institutions to form fewer, larger multi-campus universities (Abbott and Doucouliagos 2003). For example, in 1989 the three Colleges of Advanced Education situated in Western Sydney combined to become the University of Western Sydney (UWS undated).

In parallel with the perceived benefits of the economies of scale provided by the amalgamations, the reforms also focused on reducing the economic dependence of universities on government (Dawkins 1987, 1988). As a consequence there has been a 'very limited' increase in government funding since that time (Smart 1991; Gillespie *et al.* 2001; Abbott and Doucouliagos 2003). For example, there was a projected shortfall of approximately $1 billion/annum between the introduction of the reforms in 1989 and 2001. It was envisaged that this shortfall would be made up from private sources and productivity improvements (Smart 1991). The restrictions on government funding have not changed substantially over time. For example, Bradley *et al.* (2008, pp. xii) commented that there was 'abundant evidence that government provision of funds for underlying infrastructure to support research in universities is significantly below the real costs'. This expert team also went on to suggest that there was 'substantial' cross-subsidy to research from teaching funds.

Even among established universities the focus on research within universities is a relatively new phenomenon. Gibbons (1997) suggested that such focus has been greatest since the 1940s, and became one of the core values of universities only 'recently'. He suggested that this increased emphasis on university based research had driven the disciplinary structure within universities. In turn this structure organised teaching through the provision of a framework for the undergraduate curriculum. Subsequently, the synergy between teaching and research has been described by Hattie and Marsh (1996, pp. 507) as 'incontrovertible to many', although they went on to demonstrate that the overall relationship between the quality of both teaching and research was only 'slightly positive'. However, the Australian government is committed to developing the teaching-research nexus. For example, Bradley *et al.* (2008, pp. xxi) recommended that there should be 'more rigorous criteria for accrediting universities and other higher education providers based around strengthening the link between teaching and research as a defining characteristic of university accreditation and reaccreditation'. The Bradley

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expert panel also recommended that there was a need to 'strengthen requirements for universities to carry out research in the fields in which they teach so that they can contribute fully to the knowledge economy and produce graduates who embody the distinctive value of teaching that is informed by research (Bradley *et al.* 2008, pp. xx).

In 22 years the University of Western Sydney has evolved from three independent teaching-based colleges with a tolerance for research to what the University Admissions Centre (UAC 2010) described as 'a large research-led and comprehensive university' with more than 36,000 students. Staff are encouraged to develop a nexus between their teaching and research (e.g., UWS 2009), and the Australian Universities Quality Agency recognised that students at the University are provided with innovative and flexible teaching programs (Scott 2007). One such approach to innovation that we have included in our curriculum in the final year of the undergraduate degree is research-based student learning.

For the mutual benefit of students and academics, we have sought to improve the nexus between research and teaching in the delivery of zoology. Our on-going aim is to enhance student learning by seeking opportunities for students to move beyond the 'talk and chalk' of the classroom. One approach we have adopted is to expose students to research during their undergraduate years. In addition to providing opportunities to be involved in integrating the theory taught in classes with examples in the field, it also provides students with opportunities to experience research, test and/or develop their research skills, provide hands-on learning experience that combines theory with practice, and enhance their 'career ready' opportunities. A spin-off for us is to cross-subsidize our research with teaching. For example:

1. Procured equipment for undergraduate teaching that may be used for field research;
2. Access technical support in setting up field experiments that would not otherwise be available to research;
3. Obtain willing field support; and
4. Allows us to test ideas and undertake pilot studies as the basis for developing projects.

It also develops students' academic networks, maximizes opportunities for staff to interact with students and expose them to research, and identify and encourage students to consider Honours and postgraduate research opportunities.

Developing such engaged teaching and research opportunities for students with small groups, or one-on-one is relatively simple, but it is much more difficult to have meaningful outcomes for students and staff with large third year classes. In this paper we present a case study that describes one outdoor laboratory activity that enabled us to integrate research and teaching with 75 students in a third year subject that included substantial numbers of non-environmental science majors. The project described formed a segment of a larger on-going research program that is investigating the impact on biodiversity in wetlands used to store treated sewage effluent and stormwater. The segment of the study that we developed to involve undergraduate students investigated the emergence of species that have a larval stage in aquatic systems. Our null hypothesis was that there was no significant difference in the diversity and abundance of invertebrates that emerged from the polluted (treated sewage and stormwater effluents) and artificial wetlands that were not exposed to these pollutants. The student project involved:

- Comparison of two types of traps, commonly used in orchards to trap invertebrate pests of fruit trees, for their efficiency to trap invertebrates with an aquatic larval stage;
- Investigation of the most appropriate spatial placement of traps in the wetland;
- Preliminary determination of differences in diversity and abundance of invertebrates among wetland types; and
- Investigation of the sex ratio in chironomids as an indicator of pollution.

Case study

Site description

The Hawkesbury campus of the University of Western Sydney was originally excised from the Ham Common in 1891 to develop the Hawkesbury Agricultural College to train students in the practice and theory of agriculture. The farm-lands of the campus have remained outdoor agricultural teaching facilities, although since the early 1900s the remnant bushland has been intermittently used as outdoor laboratories and for research. Over 30 farm dams have been developed over the history of the College. More recently, a major water reuse facility has been developed that takes treated sewage effluent and stormwater from the local township of Richmond. This effluent is housed in purpose built wetlands (e.g., Figure 1) for use as non-potable water and to contribute to environmental flows in Rickabys Creek, a tributary of the Hawkesbury – Nepean River (Burgin, 2010, pers. obs.).

Sampling was undertaken at nine dams: three that were used to store treated sewage effluent, three that stored stormwater, and three dams that did not receive supplementation from either of these pollution sources.

Figure 1. An example of a purpose-built, turkey nest dam used to store effluent on the Hawkesbury campus of the University of Western Sydney, and used as one of the replicates for the stormwater treatment (photograph: Michael Dingley).

Overview of sampling design and materials

Two types of sticky traps were sourced: yellow coloured traps that were designed to trap 'aphid, whitefly and other flying insects' and blue coloured traps that were designed to trap 'thrips and other flying insects' (Bugs for Bugs, http://www.bugsforbugs.com.au/index.php). These 17 x 10 cm traps are supplied with a grid printed under the sticky adhesive surface of the trap to assist in the monitoring of the catch. The traps are also manufactured with a hole punched in the top so that they can be hung in or around plants in an orchard. Using a paper punch an additional two holes were punched near the bottom so that these holes could be used to secure the traps in the field in a specific orientation. An additional hole was placed to one side on the centre of the trap as a marker for orientation with the wetland. When ready for use the sticky traps were peeled open and reverse-folded to expose the sticky surface of the trap. This allowed for both exposed sides of the trap to operate as a sticky trap.

Deployment and collection of traps

A trapping unit consisted of a pair of star pickets with six sticky traps strung between them (Figures 2, 3). The two star pickets were placed approximately 5 m apart and driven into the soil at a distance of 30 – 50 cm from the edge of the water. Two lengths of heavy duty (30 kg) fishing line were strained (hand-tight) between the two pickets. These horizontal fishing lines parallel, and were initially approximately 50 cm apart. The six sticky traps (3 yellow, 3 blue) were attached to these lines at approximately 700 mm intervals. To secure the traps plastic coated wire twists were threaded through the three holes (top and bottom) of the sticky traps and tied off to the fishing line. The tying off of traps further increased the tension of the fishing lines (by drawing the lines closer together) thereby supporting the traps and maintaining their orientation (see Figure 4). Where there was vegetation under (or near) the trap that had the potential to become attached to the sticky traps (e.g., *Paspalum* sp. seed heads), it was clipped away.

Four of these trapping units (4 x 6 sticky traps in total) were placed at the edge of each wetland, one trapping unit on each of the four cardinal compass points (Figure 3). The traps were always placed with the central hole in the same position to identify the orientation of the trap after they had been removed from the trapping station and sampled in the laboratory component of the student project.

Traps were surveyed regularly to ensure that an 'appropriate' number of invertebrates had been trapped (i.e., sufficient to make the laboratory phase interesting but not to overwhelm the students). It was deemed that there were sufficient individuals trapped after one week. Sticky traps were subsequently collected in the reverse order to which they had been set. Each trap was cut free from the trapping unit and placed in a zip lock plastic bag (Figure 5), appropriately labelled to identify its placement in the field. Throughout the fieldwork phase of the project a time sheet was maintained so that students that were not involved as volunteers were able to gain an appreciation of the time involved in this aspect of the project.

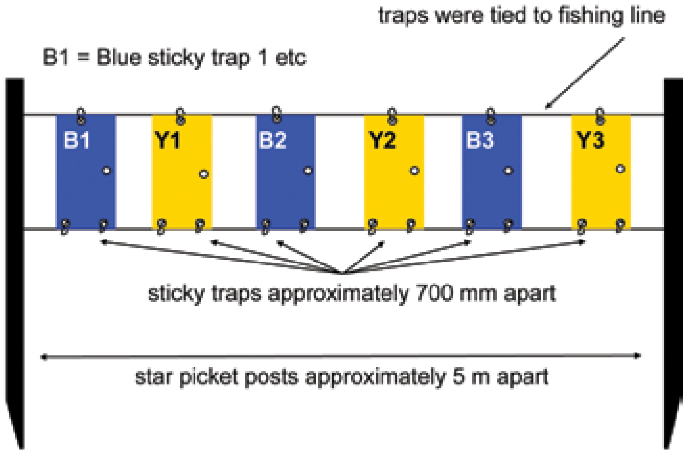

Figure 2. Sticky trap arrangement in a 'trapping unit' as viewed from the bank or wall of wetland. The orientation of the single hole at the mid-line of the trap was placed to the right. Photo, M. Dingley.

Figure 3. Three trapping units on the edge of a farm dam used in the invertebrate student research experience showing three of the four trapping stations set at the cardinal points of the compass. Photo, A. Renshaw.

Figure 4. Sticky traps collection from a trapping unit by Liz Baily, Ian Wright and Michael. Dingley Photo, A. Renshaw.

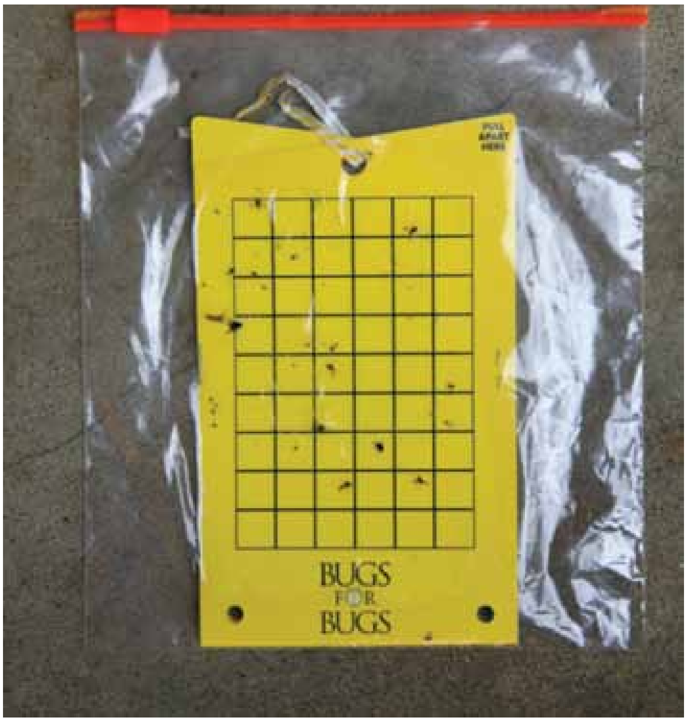

Figure 5. Yellow sticky trap showing grid, placement in plastic zip lock bag, and an example of the catch (since this was a 'prototype' there is no hole at the centre right for orientation.) Photo, M. Dingley.

Student laboratory exercise

Over the semester the students were provided with an overview of the objectives of the broader research project, together with discussion around the segment of the project they were involved with. In addition, they were given lectures on the theoretical and applied underpinnings of the project to support the curriculum requirements of the subject. This included lectures on invertebrate biology, pollution dynamics, biodiversity, experimental design, and statistical analysis.

Because each trap had been placed in a clear plastic zip lock bag, the traps did not have to be handled directly in the laboratory. This avoided students coming in contact with the adhesives on the traps, and also minimised damage to the specimens. The invertebrates were therefore sampled *in situ* within the plastic bags. This approach overcame problems that we have previously encountered of 'accidental' loss of invertebrates during the laboratory or mixing samples, and allowed for 'recycling' of the traps for experienced entomologists to use as the basis for future sampling from the traps. To further support student learning, additional staff associated with the broader 'Dams project' but not allocated to the class willingly gave their time in the laboratory. This ensured a much higher student – staff ratio than was normally provided to students in the laboratory classes.

Working in pairs in the laboratory students were supported with sub-sampling the traps, identification of invertebrates, and recording of their data. In a subsequent laboratory the students analysed the pooled class data as the basis of a written report on their preferred research question. Researchers were able to review the student data as preliminary analysis for their further study of the raw data.

Student feedback on the initiative

At the University of Western Sydney students are encouraged to take the opportunity to provide feedback on their learning experience within a subject in various ways. In this subject there was a discussion group scheduled to debrief at the end of the exercise. Students are also formally and anonymously surveyed by the University on their learning in each subject at the end of each teaching semester. This questionnaire has questions based on their level of agreement on a 5-point Lickert Scale, and there are open ended questions that ask for their views on different aspects of the subject (e.g., worst/best activities; their view on staff knowledge of the subject matter, assessment relevance). Informally, students also make unsolicited comment in writing directly to staff involved in the subject or to others as they see appropriate (e.g., Program Leader, Head of School).

In discussion groups at the completion of the exercise all students agreed that the exercise was a positive learning experience, and this satisfaction was reflected in formal surveys. Many students also expressed surprise and a new found appreciation for the amount of time involved in research, particularly compared to the typical three-hour practical that they experience in other subjects. Despite the perception that additional work was required there were no complaints about the workload imposed on them. Students appreciated being exposed and involved in all aspects of the project. A typical response to this involvement was that it 'gave me a deeper understanding of what research is and can be'. Another student wrote of the training provided in developing 'logic and reasoning'. Several students commented that the discussions of the experimental methodology were the 'most important learning outcome'. Asking a research question is one thing but 'how you go about answering it is another' was what one student called 'the creative part', and another was excited about doing 'real science'. In addition, students expressed appreciation of the value of the use of spreadsheets for both data management and analysis primarily because of the size of the 'real' dataset that they had generated, and the feeling they had that 'the numbers meant something'. One student has since written to the Subject Coordinator to thank him for the experience and commented in his email that he 'believed that the research exercise was the very reason ... [he had] been employed in .... [his] new job'. He claimed he was appointed because he had had 'experience in handling a large dataset'.

In the open ended section of a student survey of this subject many students were complimentary about the laboratory exercise that offered them an opportunity to engage with research as part of their required learning. Most of the students indicated that they enjoyed the experience and many students reported that they considered that the exercise was valuable. For example, typical comments were that the best aspects of the subject were the 'practicals and the hands-on experience'; 'being involved in research', or experiencing the 'linkage between practical and theoretical/ statistical learning'.

All of the staff involved, including those who were not employed to demonstrate in the subject, were equally positive about the experience and indicated that they would be keen to support this activity in the future.

Outcomes for research

The exercise had broader outcomes than the students' positive learning outcomes. It provided:

1. The opportunity to pilot the project and refine it as the basis of more intensive sampling across time. For example, it confirmed that the traps developed to capture a very different suite of species (i.e., pest species in orchids) also captured a diversity of species that spend their larval stage in freshwater wetlands.
2. As a result of this laboratory exercise, funding has become available to extend the research.
3. It was the catalyst for a least four students to undertake Honours within the wetland project, one directly in the research area. Two of these students have now progressed from Honours to PhD.
4. While the data obtained from a single field survey was not deemed sufficient to write up as a manuscript, there are papers in development from subsequent research.
5. It provided a model within the School for others to follow in their teaching, and has acted as an impetus for staff research efforts.

Conclusion

The two major activities of academics are teaching and research (Marsh and Hattie 2002). However, it is widely perceived that there is a disjunction between the two activities, and it is commonly considered that there is an 'urgent' need to strengthen the nexus between them (Zubrick *et al.* 2001). We consider that driving the teaching-research nexus is an excellent method of providing enhanced student learning, enjoyment, and it also provides students with opportunities to involve themselves in research that may not otherwise be available. Integrating the twin activities also provided academic staff with opportunities to develop their research initiatives beyond what would have otherwise been possible within the same timeframe if their research and teaching had not been entwined. The project also enhanced the teaching experience for students and staff alike.

If science were not under siege we may not have identified the necessity to seek to drive our personal teaching-research nexus. All of those who were involved, students and staff, would have missed the learning opportunity.

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References

Abbott, M. and Doucouliagos, C. 2003. The efficiency of Australian universities: a data development analysis. *Economics of Education Review* **22**: 89-97.

Bradley, D., Noonan, P. Nugent, H. and Scales, B. 2008. *Review of Australian higher education. Final Report*. Department of Education, Employment and Workplace Relations, Canberra.

Burgin, S. 2010. A natural history of the Ham Common, the lands sandwiched between Richmond and Windsor – two of Governor Macquarie's five towns, Pp. 263-276 in *A Natural History of Sydney*, edited by D. Lunney et al. Royal Zoological Society of New South Wales, Mosman.

Dawkins, J.S. 1987. *Higher Education: A Policy Discussion Paper*. Department of Employment, Education and Training, Canberra.

Dawkins, J.S. 1988. *Higher Education: A Policy Statement*. Department of Employment, Education and Training, Canberra.

Gibbons, M. 1997. *What kind of University? Research and Teaching in the 21st Century*. 1997 Beanland Lecture, Victoria University of Technology, Melbourne. http://www.griffith.edu.au/vc/ate/pdf/gibbons.pdf [Viewed 2 February, 2010].

Gillespie, N.A., Walsh, M. Winefields, A.H., Dua, J. and Stough, C. 2001. Occupational stress in universities: staff perceptions of the causes, consequences and moderators of stress. *Work and Stress* **15**: 53-72.

Gupta, D. 1990. The Dawkins higher education plan: its rationale and implications. *Higher Education Quarterly* **44**: 155-162.

Hattie, J. and Marsh, H.W. 1996. The relationship between research and teaching: a meta-analysis. *Review of Educational Research* **66**: 507-542.

Marsh, H.W. and Hattie, J. 2002. The relation between research productivity and teaching effectiveness: complementary, antagonistic, or independent constructs? *The Journal of Higher Education* **73**: 603-641.

Scott, G. (2007). *Audit of the University by the Australian Universities Quality Agency.* University of Western Sydney, South Penrith. http://www.uws.edu.au/__data/assets/pdf_file/0003/7338/Summary_AUQA_Outcomes.pdf [Viewed 2 February, 2010].

Smart, D. 1991. Higher education policy in Australia: corporate or coercive federalism? *Journal of Education Policy* **6**: 97-100.

UAC. 2010. *University of Western Sydney (UWS)*. University Admissions Centre, Silverwater. http://www.uac.edu.au/undergraduate/institutions/uws.shtml [Viewed 2 February, 2010].

UWS. 1990. *UWS Latest News: Outstanding UWS staff rewarded with prestigious national teaching and learning awards*. http://pubapps.uws.edu.au/news/index.php?act=view&story_id=2511 [Viewed 8 February, 2010].

UWS, undated. *UWS History*. http://www.uws.edu.au/rams/archives/uws_history [Viewed 2 February, 2010].

Zubrick, A., Reid, I. and Rossiter, P. 2001. *Strengthening the Nexus Between Teaching and Research*. No. 6499. DETYA No. 6499 HERC00A, Department of Education, Employment and Workplace Relations, Canberra.