Biological Fieldwork in Australian Higher Education: Is The Cost Worth The Effort?

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Abstract

Student engagement in fieldwork and other field-based activities are crucial elements of an undergraduate biology degree. Fieldwork and other field-based activities, however, are under threat as funding declines and regulations and approval processes in Australian universities increase. The consequence of this is that in some universities, field work has disappeared from the curriculum. The reasons for the decline in field work include an increasing number of student enrolments and the high cost of running field-based activities. Students are very often attracted to programs because of the fieldwork element. Additionally, student evaluations from units with field work repeatedly report fieldwork and field activities are their favorite components of the course, and moreover, of their undergraduate experience. Re-engaging universities administrators with the value of field work may take some creative thinking. This review reports on the current state of fieldwork and field-based learning activities within tertiary biology education in Australia. It investigates reasons for the decline of fieldwork, provides ways to integrated fieldwork into the curriculum, including assessment, and examines the future role of fieldwork in higher education.

Introduction

Fieldwork provides biology students with authentic, interactive experiences which have been shown to increase student interest and enhance learning (Kern & Carpenter, 1984; Hefferan, Heywood & Ritter 2002; Simmons, Wu, Knight & Lopez 2008). Yet field work is under threat, as universities, under pressure to reduce costs, cut field work (both the total number of field trips and the total hours of practical work) from the tertiary biology curriculum. Fieldwork in biology provides one of the few places in tertiary biology education where students observe nature first hand through the use of scientific inquiry. Scientific inquiry provides students with opportunities to test ideas and concepts learnt in lectures in the real world. First-hand experiences, removed from the confines of the classroom, also allow for creative thinking and problem solving (Lonergan & Andresen, 1988). Field work provides opportunities for students to improve their observation and data collection skills through dynamic interaction between staff and peers. Several studies have demonstrated the effectiveness of fieldwork. Hart and Nolan (1999) found that field work had a positive effect on student knowledge gain, attitude and behavior. Rickinson (2001) and Dillon, Rickinson, Teamey, Morris, Young Choi, Sanders and Benefield (2006) found substantial evidence that fieldwork developed the knowledge and skills of students in ways that was not possible through classroom experiences. Eaton (2000) and Butler (2008) found that outdoor learning experiences developed student cognitive skills. These studies, however, have been almost exclusively on school-aged children rather than university students.

First hand experiences in the natural environment are widely regarded as an essential part of the undergraduate curriculum particularly in the tertiary teaching of biology. Both lecturers and students generally agree that practicals and fieldwork are one of the most effective and enjoyable forms of teaching and learning (Spicer & Stratford, 2001). Learning can be maximised if fieldwork has a clearly stated purpose in the curriculum, and it should evolve appropriately to include innovations in teaching and learning and advancements within the discipline.

The aim of this study is to review the role of fieldwork in biology in universities in Australia and to highlight problems and issues for the future to stimulate debate. In addition, this review provides an overview of good practice in fieldwork.

Field work under threat

Given the value of field work and the support from academics and students, it is alarming that as early as the 1980's, field work and field based activities have been under threat of being removed from university curricula (Berliner & Pinero, 1985). More recent faculty budget cuts (Salter, 2001); increasing student numbers, particularly at first year level and increased regulatory safety requirements have combined to make the logistics of organising field work more difficult.

Biology is not the only science discipline to recognise the value of fieldwork. In geography and geology, fieldwork has been an essential component of undergraduate tertiary education (Nairn, Higgit, Vanneste, & Leuven 2000; Kent Gilbertson & Hunt 1997). Despite the importance of fieldwork, few departments mandate fieldwork at an undergraduate level (Higgitt, 1993).

If we are to promote and maintain field work in the curriculum it is important to provide evidence of its value in learning. To date, evaluations on the impact of field work on student learning in tertiary biology education have been considered inadequate (Leeming Dwyer, Porter & Cobern 1993) as they are mainly in the form of student surveys and questionnaires about their enjoyment of the activities. Recent research reviews on the broader value of environmental education have also not found sufficient evidence that fieldwork aids student learning (Hart & Nolan, 1999; Rickinson, 2001).

Such shortage of evidence increase concerns about the lack of justification for fieldwork in biology curricula. Reviews by Smith (2004) and Boyle, Maquire, Martin, Milsom, Nash, Rawlinson, Turner, Sheena, Wurthmann and Conchie (2007) and discussions with academics across Australia (pers. comm.) have identified the following issues which remain a threat to fieldwork in tertiary biology curriculum:

1. The cost of field work is greater than lecture-based courses but not as great as many biomedical based practicals which require expensive reagents and enzymes. Many universities have introduced requirements for students in courses with fieldwork to cover some aspects of the cost whether it is food, transportation, or accommodation. This is in contrast to non-fieldwork laboratory–based practicals, which require no extra costs.
2. More time and effort is required by academics to ensure that OH&S regulations have been met. This includes employing staff with current first aid certificates.

3. Class sizes have increased, especially in first year, making field-work logistically more difficult and the potential for damage to the environment greater.
4. Increases in animal welfare and ethics regulations and approval processes, which include student training in basic animal handling such as trapping, and observing behavior, have also increased logistics.
5. The number of and expense of approval processes and permits for working in national parks have increased. This includes public liability insurance in areas such as land holding agencies.
6. Students are shifting interests from whole organism field-based degrees to lab-based biomedical degrees.
7. Academic staff have less expertise in fieldwork than they did previously.
8. University students now spend less time on campus and more time in part-time job work. Field work which once occurred on weekends or were week-long experiences cannot be as easily scheduled because of student work responsibilities.

The diverse nature of the discipline of biology may also partly explain the decline in fieldwork as many biologists do laboratory or computer based research and never spend time in the field. Reports from the UK have shown that there is a critical shortage of academic biologists who have the professional skills needed to support field work in conservation and environmental biology (e.g. Heywood, 1995; House of Lords, 2002). Ironically, these lack of skills coincide with a time when environmental issues are a global concern. As contact with nature affects student's attitudes towards the environment and future decision making (Smith, 2004) it is important that all students in Biology become better acquainted with nature.

A broad review of field-based activities in Biology at Australian Universities

There has been an increase in the number of students enrolled in a biology degree (Smith 2004). To determine whether fieldwork was a component in these biology degrees, a course profile analysis was done by reviewing the websites and course handbook entries of Australian biology courses and degree programs for all universities in Australia.

Courses included in the analysis were from all biology sub-disciplines, but excluded medical sciences and biochemistry. A total of 1003 biology courses were found in 35 universities. Twenty-five percent (254 courses) of biology courses had fieldwork components embedded in their curriculum. A fieldwork component was present significantly in the sub-disciplines of ecology, conservation, marine biology and botany. Fieldwork components were not found in genetics or microbiology courses. The university with the maximum number of field courses was James Cook University with 26 courses followed by Edith Cowan University which had the greatest proportion of courses with fieldwork (see Appendix 1).

An overview of first year Biology courses in Australia by Burke da Silva, Young, Familari, Rayner and Blanksby (2013) found that 13% of first year courses had at least a small component of fieldwork, but none were solely field based. Most fieldwork activities within biology were found in second or third year level courses. At these levels, activities ranged from walks around the university campus as part of a single laboratory session to activities which were intensive and spanned 1-2 weeks, typically being held out of semester and often away from university campus.

On-campus activities within scheduled laboratory sessions can be valuable, especially at the introductory level, but vary enormously among institutions, and are dependent on whether the university is rural or urban. Even within an urban environment, however, there are still activities which can be field based and observational such as bird watching or monitoring plants on campus. Weekend excursions which are off campus can be difficult for the reasons described above, but these are the most likely to provide students, especially those from urban universities, with exposure to the natural environment.

Several universities have field stations that are owned by the university being based far away from university campuses. University owned field stations are advantageous because they are well established, have often been under operation for decades and have occupational health and safety requirements organized. Although the accommodation costs associated with running courses at field stations can be quite large, they provide better alternatives to camping where adverse weather conditions can bring field trip to premature end.

Some examples of field work in remote locations away from university campuses include:

- Weekend field trip to Kioloa (Australian National University, Invertebrate Zoology)
- 11 days of intensive field work from Alice Springs to Darwin (Charles Darwin University, Field Studies in Tropical and Desert Landscapes)
- Five x 12-hour field work per study period (La Trobe University, Zoology A)
- 2 day fieldtrip (University of Melbourne, Vegetation Management and Conservation)
- 1 week at Hideaway Island, Vanuatu (University of Newcastle, Coral Reef Biology and Ecology)
- Small research project over a weekend (University of Queensland, Animal Ecophysiology)
- Two week field trip to Port Lincoln Marine Station (Flinders University, Marine Ecology)

It is critical that the learning outcomes of fieldwork are clearly identified to increase the probability that students maximize benefits. Objectives of fieldwork, as found in the literature (for review see: Kent, Gilbertsone & Hunt, 1997), include key features that should be considered when planning a field course. These include presentation of materials at the appropriate level and complementing other teaching methods as well as the content and ethos of the rest of the course, and the degree program. Providing students with an opportunity to engage with real life settings, with organism in context can be highly stimulating and if students are guided in their inquiry they can gain maximal learning.

The application of theoretical models in the field is the main basis of course learning outcomes on the web sites of several Australian universities. A list of specific course learning outcomes for field work as stated in course handbooks on websites at Australian universities are found in Table 1.

Table 1. Course learning Outcomes for Field work in course handbooks at Australian universities.

• Learn field techniques and apply your understanding of ecological theory (Charles Darwin University, Introductory Ecology)
• Gain hands-on experience in tropical research (James Cook University, Population and Community Ecology)
• Field trips are used to reinforce lecture topics, to expose students to scientific research methods, and to introduce students to sight and sound techniques of bird identification (Macquarie University, Birds of Australia)
• To provide students with an opportunity to engage in an authentic experience of the entire process of scientific research (University of Melbourne, Field Biology of Australian Wildlife)

The claim that fieldwork is an effective method for teaching and learning in Biology has received little empirical evidence in the literature. Currently there is little evidence of any benefit and much of what exists is anecdotal (Hall et al. 2004). How effective fieldwork is as a teaching method will depend on the learning aims, the learning design and the type of assessment and feedback.

The pedagogical value of fieldwork

Fieldwork offers an opportunity for academics to integrate theoretical and practical concepts (Kern & Carpenter, 1984, 1986; Lonergan & Andreson, 1988; Gold & Haigh, 1992; McEwen, 1996). Introducing fieldwork early in a degree may help students to engage with the course, and could provide an important element to aid in transition to university study, as students have shown high levels of enjoyment and interest in field-based learning (Boyle et al. 2007). Orion and Hofstein (1994) found that the educational effectiveness of a field trip is maximised if it occurs early in the semester, and if it is preceded by a short preparatory session that aids in familiarising students with the different learning environment of fieldwork. In their study of school-aged students' perceptions of nature-based excursions, Ballantyne and Packer (2002) found that students enjoyed novel fieldwork and suggested that revisiting a single site may decrease student-learning outcomes.

Alignment with course materials

Similar to laboratory-based instruction, fieldwork is most effective when it is aligned with other activities in the course or degree program (Duncan & Hmelo-Silver 2009). Nairn et al., (2000) noted when fieldwork is delivered as a discrete unit as a single field trip component (as found within Australian universities) it often lacked alignment with the curriculum. By using fieldwork as an opportunity to investigate concepts covered in the theoretical part of the course, students engage with the course content and "deep" learning occurs. (Ramsden, 1988; Higgitt, 1996). Providing opportunities for deeper learning experiences, in which students are building upon a foundation of previously acquired knowledge, is a very effective approach for learning (Biggs, 2003). Project-based fieldwork may therefore be seen as 'deep-learning', while observational activities are more 'shallow' in learning outcomes.

Observational approach

In Australian university course profiles, the most commonly cited purpose of fieldwork, was to provide students with time to observe the natural world. As shown by the work of Darwin and Wallace, observations can produce insights into the natural world. Observation, whether

in the field or within the laboratory, is the first step in the process of science and can be a highly stimulating approach for some students. Although Kent et al. (1997) found that observation can be effective in introducing students to new environments, it may be less effective than a hands on approach. Gold (1991) found that fieldwork that takes an observational approach is more meaningful to students if they have conversations with academic staff. Contact with experienced academics and tutors in less structured environments can remove the hierarchical element from teaching and learning, and students gain confidence through interactions with staff members.

When designing fieldwork programs attention to the ways students learn most effectively may aid in understanding. Often academic staff decide on the project and activities are assigned to students (Cloke et al., 1981). Although this method provides students with results which can be easily interpreted, this hand-held approach limits the level of engagement and learning opportunities for students. It is most effective as an introduction to fieldwork and it is a fairly common format for first year courses. This format is also typical of fieldwork that supports a laboratory-based course, where students take samples in the field which are analysed later during the laboratory session (Mellor, 1991). To be most effective an observational study needs to be connected with more inquiry field-work based activities.

Inquiry Approach

The transition from an observational to an inquiry-based approach to fieldwork allows students to develop skills in project design, organization, leadership and group work (Pawson, Fournier, Haigh, Muniz, Trafford and Vajoczki 2006; Houser, Brannstrom, Quiring and Lemmons 2011). A multitude of studies have found that inquiry approaches allow students to take ownership of their work (Savery & Duffy, 1995) and even lead to an undergraduate research publication (Burke da Silva, 2012). Kern and Carpenter (1986) found that students in the field exhibited increased levels of higher-order thinking compared with students in other learning environments. Field work offers an authentic experience which provides a natural problem-solving context and enhances scientific thinking (Lee and Butler 2003). Fieldwork provides a multitude of opportunities for students to design their own experiments; consider the role of controls and variables; collect their own data and improve their technical skills. Such opportunities provide students with insights into how scientific research is done, which can be highly motivating for young hopeful scientists.

Fieldwork is often 'student centered' with the academic staff being a mentor rather than a lecturer (Gold, 1991; Gibbs & Jenkins, 1992). There is, however, little empirical evidence that 'student-centered' learning in fieldwork is effective and most evidence is about perceptions of effectiveness rather than learning performance. Studies used to determine whether students understand concepts better through this approach will provide evidence to help maintain it in the curriculum.

An international review of fieldwork in coastal management programs by Scott et al., (2006) found that both academic staff and students held positive views on the effectiveness of fieldwork as a teaching methodology, but this was outweighed by negative aspects of costs and coordination. There have been some drawbacks to fieldwork reported. Fletcher and Dodds (2004) found that students experience trepidation about academic staff expectations of field-based learning and had concerns about time away from university campuses. Similarly, Boyle et al., (2007) found that students from seven different UK universities experienced anxiety prior to off campus field work, when in the field, however, these concerns were alleviated and student confidence increased. It is likely that as urbanisation increases students

will have limited experience of the natural world and fieldwork will become a place where students gain excellent learning outcomes, albeit following some trepidation.

Fieldwork locations need not be exotic to result in effective learning (Kern & Carpenter 1984). Learning can be enhanced even through local, small trips. For example, Pawson and Teather (2002) found the effectiveness of fieldwork increased when students were given local fieldwork opportunities. Students perceived their work more positively, and content knowledge and practical skills improved.

Virtual Fieldwork

In the increasingly technological on-line world, the use of virtual fieldwork is increasing. Spicer and Stratford (2001) examined student perceptions of virtual field trips. While students were extremely positive about virtual field work and indicated that they provided valuable learning experiences, almost all students were resoundingly opposed to them if it meant they replaced real fieldwork. Similar to most e-learning tools, virtual field trips may be best used in preparation or in conjunction with real field trips. Using them as a replacement is likely to reduce student enjoyment and decrease student opportunity for high quality learning experiences. Virtual field work cannot replace the full and often unpredictable nature of fieldwork which includes smells, weather, and other irregularities or vagaries of the natural world. There is also a danger of removing fieldwork form the undergraduate curriculum and the lack of preparation of students for the real world of postgraduate research that requires fieldwork.

Assessment of Fieldwork

The assessment of fieldwork is not always straightforward and although it can be qualitative, has been mostly quantitative in biology (Kastens, Manduca, Cervato, Frodeman, Goodwin, Liben, Mogk, Spangler, Stillings and Titus 2009; Orion & Hofstein, 1994). Although fieldwork provides academic staff with many opportunities to link fieldwork with a wide range of knowledge and skills (Lonergan & Andresen, 1988; Kneale, 1996; McEwen & Harris, 1996), the most common form of assessment of fieldwork found in this review is the written scientific report followed closely by an oral presentation as a result of group work (Kent et al. 1997). The oral presentation of results during a field course can help students to organise their ideas in preparation for their written report. The most difficult part of a fieldwork report for many students is the interpretation of their own results (Haigh & Gold, 1993). Students often lack the confidence they need to analyse and interpret their data especially if it involves statistics. Discussion of the results with other classmates and teaching staff may help alleviate these concerns. It is common for students to present basic results, but many students have difficulty interpreting results adequately. The intervention of academic and other teaching staff may assist students toward higher levels of interpretation and may prove to be valuable.

Organisational group work skills may also be assessed as part of fieldwork and an effective strategy is through peer assessment (Wheater & Dunleavy, 1995). Assessment of group work skills in a field situation has been found to be controversial (Habeshaw et al., 1992) and more difficult to assess than laboratory based group work. The literature available on the effectiveness of assessment of group work in other contexts may not necessarily be relevant. Fieldwork, however, provides one of the best opportunities for students to demonstrate leadership skills and gain teamwork experience and if assessment is made clear in advance, taking into consideration the different roles of team members, can be a highly rewarding undertaking.

> *"The UQ course that I most enjoyed was Australia's Terrestrial Environment. It covered the unique flora and fauna found in Australia, with the added excitement of frequent animal visitors appearing in class...yes, even a crocodile! The outstanding feature of this course has to be the field trip to Fraser Island, a highlight of my year in Australia, and led by lecturers clearly passionate in their field of study. This is one course not to be missed!" Sophie Le Butt (United Kingdom)" (website reference XXX)*

Feedback

Feedback is an often neglected component of the fieldwork learning experience, (Gibbs & Jenkins 1992). Fieldwork is ideally placed to help students gain understanding through reflection (Kolb 1984). Studies have found that students who experienced fieldwork integrated vertically throughout the curriculum had increased knowledge and understanding of the importance of fieldwork (Dunphy & Spellman 2009). Unlike other traditional aspects of learning, where feedback is delivered at the end of an assessment experience, fieldwork provides opportunities for feedback to be provided to students throughout the assessment process. Feedback can also be an effective means of integrating the concepts and skills learned in the field with the other course learning outcomes.

Fieldwork is complex and time-consuming which results in academics providing insufficient time for discussing outcomes or interpreting and relating findings to theoretical concepts learned in the classroom/lecture theatre (Lonergan & Andresen, 1988). Sessions to discuss fieldwork findings therefore should be incorporated as part of the teaching time. They should be held as soon as possible after the field experience, and should highlight critical events or pull together the bigger picture, which might not have been clear to the students while they focused on finer details associated with assessment. Staff can usefully highlight important concepts that were noted by students but not regarded as critical, and bring elements of the field trip into alignment with theoretical concepts (Lonergan & Andresen, 1988).

Conclusion

Fieldwork education within the biological sciences is expensive and logistically difficult but remains highly regarded by both teaching staff and students. The student-centered approach is clearly an engaging and effective means to maximize student learning outcomes and deep learning. Fieldwork remains part of the Australian higher education biology curriculum, but because of logistical issues is often found in second and third year level courses and restricted to students enrolled in the sub disciplines of ecology and marine/terrestrial biology. The ultimate goal of fieldwork, other than to generate knowledge and produce skills, is to develop students' awareness and understanding of the natural world, and the current problems facing biodiversity and the planet. With this in mind, fieldwork should be considered as part of the first year experience so that a much larger number and greater variety of students can benefit from it. Students who have direct experiences with nature are more likely to have an enhanced environmental awareness which ultimately will affect their attitude in this area and produces a more literate student body. (Hungerford & Volk 1990).

This review has summarised much of the relevant literature on fieldwork and has found relatively little information exists in the biology discipline with substantially more work in the disciplines of environmental education, geology and geography. This review has also suggested ideas for best practice and highlighted the lack of empirical evidence on the achievement of learning outcomes for students who do fieldwork in biology at Australian universities. Although much evidence exists on the perception of effectiveness of fieldwork,

especially to engage students, there is little information on how to best evaluate the effectiveness of fieldwork or the need for fieldwork in biology. Fieldwork will continue to be threatened by the demands for efficiency and cost reduction across the higher education sector. Fieldwork like other expensive learning experiences must be justified using evidence of effectiveness as a learning experience which leads to higher cognitive and affective gains if it is to satisfy administrators of the value for money.

Research is particularly needed on the longer-term impacts of fieldwork and the effectiveness in preparing students for the workplace or for careers in research.

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Appendix 1: List of Australian Universities, the number of Biology courses (total and 1st year) at each institution and the number of Biology courses (total and 1st year) with a field work component.

University	No. Biol. Courses	No. Biol. Courses With Fieldwork	No. 1st Yr. Biol. Courses	No. 1st Yr. Biol. Courses With Fieldwork
Australian National University	36	4	4	1
Central Queensland University	13	1	3	1
Charles Darwin University	16	3	1	0
Charles Sturt University	17	1	6	1
Curtin University	19	7	6	0
Deakin University	15	3	3	0
Edith Cowan University	24	15	3	1
Flinders University	46	14	10	3
Griffith University	12	2	2	0
James Cook University	55	26	7	1
La Trobe University	30	4	8	1
Macquarie University	39	11	6	1
Monash University	25	3	3	0
Murdoch University	25	5	5	2
Queensland University of Technology	25	15	3	1
RMIT University	22	2	3	0
Southern Cross University	20	5	4	1
Swinburne University of Technology	4	0	2	0
University of Adelaide	62	10	10	1
University of Canberra	6	1	2	0
University of Melbourne	54	11	8	0
University of New England	49	11	6	1
University of New South Wales	35	10	5	1
University of Newcastle	38	13	5	1
University of Queensland	51	9	3	1
University of South Australia	27	4	10	1
University of Southern Queensland	11	0	3	0
University of Sydney	22	5	5	0
University of Tasmania	44	14	10	1
University of Technology Sydney	26	8	2	0
University of the Sunshine Coast	20	6	2	0
University of Western Australia	45	15	4	1
University of Western Sydney	30	8	6	1
University of Wollongong	21	3	4	0
Victoria University	19	5	4	1
TOTAL	**1003**	**254**	**168**	**24**