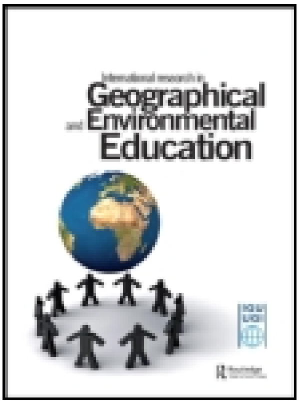

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Designing, implementing and evaluating a consultancy approach to teaching environmental management to undergraduates

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Designing, implementing and evaluating a consultancy approach to teaching environmental management to undergraduates

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What are the benefits of engaging undergraduate students with authentic, inquiry-based curricula that develop transdisciplinary research skills? Internationally, many educators believe that research-active curricula help students better understand how scientific and technological concepts underlie the complexities of our world, especially in the context of natural resource management and sustainability. This paper describes the outcomes of a "consultancy approach" (CA) to teaching an undergraduate water resources management course in an Australian university over the past 10 years. Using the documented experiences of staff, students and clients, this paper demonstrates how this research-based curriculum has engaged students in authentic field-based research in ways that are student-centred, address diverse learning motivations and demonstrate the realities of being a practising professional. In addition, by providing environmental managers with a depth of research knowledge applicable to decision-making at individual sites that they would otherwise be unlikely, even unable, to acquire, the CA to teaching addresses the ongoing need in Australian communities for reliable scientific and environmental data on which to base complex land management decisions.

Keywords: environmental management; research-active curricula; undergraduate research; water resources management; authentic learning; service learning

Introduction

A key issue for tertiary environmental educators internationally is the adequacy of curricula for preparing our future policy-makers. Currently, as Labov and Huddlestone note, even those "steeped in the content of a particular science discipline . . . may not have been asked to understand or explore deeply the processes, nature, and limits of science in decision-making" (2008, p. 347). It is vital, therefore, that environmental management courses help their students engage with the socio-political, as well as the scientific, context of the data that researchers collect and present, not least because experiential learning and appropriate "meaning-making" can improve students' understanding of problem-solving and decision-making (Millenbah & Millspaugh, 2003).

In water resources management (WRM), trustworthy local and regional data are crucial for effective decision-making. However, most communities around the world have insufficient numbers of researchers to collect that data, let alone the funds to pay them. In the US, Soni, Selna, Maguin and Haworth (2007) argue that there is an urgent need to introduce innovative WRM education programmes at senior secondary and tertiary levels to counter

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the upcoming, and crucial, shortage of water quality workers, occurring as "baby boomer" professionals retire, as infrastructure ages and as regulatory frameworks become more demanding. With similar situations throughout the developed world, and even more demand anticipated as developing countries upgrade their WRM needs and standards, ensuring that environmental management students are taught appropriate knowledge and skills relevant to sustainable water management is of global concern.

As tertiary educators in the fields of environmental management and sustainability education in a research-intensive university in Australia, we have been highly motivated by both the issue of authenticity in teaching (Donovan, Bransford, & Pellegrino, 1999) and the perceived needs of sustainable communities. We believe that our "consultancy approach" (CA) to undergraduate teaching in WRM successfully combines these elements. Introduced by Dr Beavis at the Australian National University (ANU) in 2000, this approach has evolved over the past 10 years into a consistent design that merges the needs of third-(final) year undergraduate students (the "consultants") and a range of community-based land and water management agencies (the "clients/stakeholders"), with academic researchers taking the role of "research advisors".

In this paper, we explore the rationale for this approach to undergraduate teaching in environmental management and its outcomes over 10 years of implementation. We describe the three key factors that have influenced the development of this model, namely (i) the increasing diversity of student backgrounds and associated motivations to study environmental management; (ii) the recognised pedagogical benefits of student-centred approaches to learning (Ramsden, 2003), including fieldwork (Dunphy & Spellman, 2009; Foskett, 1999); and (iii) a growing emphasis on the value of exposing undergraduates to inquiry-based learning through authentic research experiences (Healey, 2005; Healy & Jenkins, 2009). We describe the kinds of environmental settings where our CA has been applied and explore the outcomes, based on the documented experiences of staff, students and clients over multiple iterations of the course. Overall, we show that this approach not only gives students authentic and rewarding research and learning opportunities but also, and importantly in our view as concerned citizens, has significant social benefits by providing community-based environmental managers with a depth of research knowledge relevant to decision-making that they are otherwise unlikely to have the resources to acquire.

Motivations for studying water management are diverse

As elsewhere, student cohorts on Australia's campuses have changed markedly in recent years: a larger proportion of school leavers, mature-age students and international students are entering degree programmes, more courses include vocational aspects and more students must balance family and work commitments with study (Australian Government, Department of Education, Science and Training, 2002; James, Bexley, Devlin, & Marginson, 2007; Krause, Hartley, James & McInnes, 2005). These changes are reflected in an increasing diversity in undergraduates' backgrounds, abilities, interests, motivations and expectations.

Moreover, increasing flexibility in defining undergraduate programmes means that students who choose to enrol in a course on water management often include those majoring in psychology, engineering, law, development studies or the arts, as well as those from a range of pure and applied science backgrounds. Career motivations and aspirations are also highly divergent: while some students may be aiming to do scientific research in water or soil sciences, or to become environmental managers, others may simply be interested in understanding the broader issues related to water and sustainability that impact on our communities. Importantly in terms of course design, these variations in motivation and interest often parallel differences in students' background knowledge and existing laboratory or field skills.

Teaching such diverse groups of students about the complexities of WRM in Australia within a strictly scientific and experimental paradigm is thus potentially complex and challenging. In addition, the multiplicity of valid perspectives on the management of Australia's land and water systems (e.g. Crase, 2008; Hussey & Dovers, 2007) means that it is essential that a broader understanding of environmental management be encompassed in any curriculum on offer.

Student-centred learning is a focus

The increasing diversity in the student body has mirrored welcome changes in the approach to curriculum and educational design: the greater focus on student-centred learning, rather than on traditional transmission processes, is exemplified by efforts to support the constructive alignment of learning outcomes, teaching activities and assessment (Biggs, 1999; Marton, Hounsell, & Entwistle, 1997; Marton & Saljo, 1976; Prosser & Trigwell, 1998). As teachers as well as scientists, we recognise the importance of providing educational environments that are conducive to a "deep approach" to learning, in which students can relate the overarching ideas, themes and principles of new learning to their existing knowledge, rather than simply engaging in memorisation, non-analytical description or "pass the test" learning (Biggs, 1999; Marton & Booth, 1997; Ramsden, 2003, p. 47).

Empirical research suggests that fostering deep approaches to learning provides clear benefits to students: they reach higher levels of personal and intellectual development, have more positive attitudes towards the acquisition of new knowledge and skills and are more likely to see the challenges they overcome as moments of exhilaration (e.g. Laird, Shoup, Kuh, & Schwarz, 2008; Ramsden, 2003). All of these are valuable attributes for future environmental management researchers and practitioners. In addition, research on study orchestration suggests that students adapt their approaches to learning according to their perception of what is demanded of them (Eley, 1992; Meyer, 1991). Focusing on active research activities thus helps students take a deeper approach to their learning: as they engage in meaningful tasks, they gain first-hand understanding of how they can build on their existing or discovered knowledge.

Developing the relationship between teaching and research

The potential benefits of developing research-active curricula for undergraduates – and ideally not just for those in experimental or practical fields – have been the subject of much discussion internationally in recent years (e.g. Bakker, 1995; Barnett, 2005; Boyer Commission, 1998; Clark, 1997; Healey, 2005; Jenkins, 2004; Jenkins, Breen, Lindsay, & Brew, 2003; Kreber, 2006; Willison & O'Regan, 2007; Zamorski, 2000), including in Australia (e.g. Wilson, Howitt, & Wilson, 2007; Zubrick, Reid, & Rossiter, 2001). Involving undergraduates with the realities of science research is thus an important goal for many tertiary educators, and the concept of these students becoming "active stakeholders in a research community" was recently addressed in significant depth by Healey and Jenkins (2009). Their analysis of much of the international literature described above, and more, suggests that it is highly desirable for all undergraduate students to "experience learning through, and about, research and inquiry ... in ways that come as close as possible to the experience of academic staff carrying out their disciplinary research" (2009, p. 3).

According to Ramsden, this approach requires curricula that are "transdisciplinary, ... extend students to their limits, ... develop skills of inquiry and research and are imbued with international perspectives" (2008, p. 10).

Developing a student-centred, research-active curriculum in environmental management

Although fieldwork is characteristically included as a student-centred learning experience in many environmental management courses, Dunphy and Spellman argue that fieldwork must be constantly re-evaluated as a teaching method to ensure it remains a "valued and inclusive experience that produces balanced learners with enthusiasm for their subject" (2009, p. 27). Introducing our CA into the semester-long (13-week) course *ENVS3005 Water Resource Management* at the ANU was an attempt to address the above issues: that is, to encourage deep approaches to learning within highly diverse and differently motivated student cohorts, while meeting the goals of a research-active curriculum. The four key steps in developing the CA were (i) identifying relevant, appropriate and authentic science-based issues and opportunities; (ii) constructing research consultancy topics that incorporated disciplinary and contextual diversity; (iii) identifying the skill sets (and hence the learning activities) necessary to conduct and complete the research and (iv) incorporating all these aspects into the educational design, especially in the assessment tasks, with a particular focus on the self-paced constructivist learning typical of research experiences.

The consultancy approach: its design and implementation

Elements of the consultancy approach

Our consultancy approach (CA) involved:

- developing a cross-disciplinary curriculum and aligned assessment package, with scaffolding built into the learning and assessment activities (the latter comprising a literature review, content-based examination and the consultancy report);
- identifying "clients" (land/water managers) with real research needs;
- briefing students on these needs and helping them develop appropriate research questions in small (4–6 persons) research teams;
- providing the students with learning activities and resources (e.g. lectures, readings, discussions, practicals) to enable them to engage with the relevant concepts and knowledge, and to prepare a methodology for the collection of field data;
- taking students into the field for an intense period (5–7 days) of data collection, including accessing existing databases and, especially for those with a social science component to their research question, interviewing stakeholders such as community representatives and local professionals[1];
- supporting students through data analysis and reporting processes, including giving constructive feedback on laboratory work, collation and interpretation of results, and report writing;
- setting up a symposium for student teams to present their data to one another in order to facilitate and model cross-referencing and interdisciplinary thinking; and
- providing final documentation from each research team to the client as consultancy reports.

The course was delivered annually in this format from 2000 to 2007 and in 2009.[2] Throughout each course, a balance was maintained between "teaching" the students and allowing them to construct their own learning based on their research experiences. Feedback on ideas and specialist help with developing skills were freely available at all times.

Choosing a study site and relevant research questions

All study sites were in regions of New South Wales and the Australian Capital Territory within a reasonable distance (travel by road of minimum 20 minutes, maximum one day) of the ANU campus in Canberra. Given the research expertise of the course lecturer (e.g. Beavis, 2003; Beavis et al., 2006) and her existing contacts within state water and land management agencies, the selected area was usually a coastal floodplain characterised by acid sulfate soils and the risk of flooding.[3] However, over the decade of teaching, study sites also included a rural residential development, a rapidly expanding coastal settlement experiencing unregulated development and constructed wetlands within an urban catchment.

Well before each iteration of the course, Dr Beavis would initiate consultation with the land/water management stakeholders, which included state agencies and local governments (e.g. NSW Department of Environment, Climate Change and Water; NSW Department of Education; NSW Department of Agriculture; NSW Department of Primary Industries; and Kempsey Shire Council) as well as members of local land trusts (e.g. Hunter Wetlands Centre Australia), community activists (e.g. Macleay Acid Sulfate Soils Local Action Group [MASSLAG] and Burra Landcare Group) and water utilities (e.g. ACTEW, the water and electricity utility company in the Australian Capital Territory). In the ensuing discussions between academic and client/stakeholder professionals, the two key questions were: "What are the crucial gaps in our knowledge of water resource issues in this locality?" and "If professional consultants were available, what would they be asked to do?" Each discussion thus generated a set of salient research questions.

Given that the selection of a study site and the development of suitable research topics had to occur well in advance of student enrolment, the range of potential learning opportunities each time had to be broad enough to cater for the previously described diversity of student interest, background and motivation. Including topics that ranged across disciplines in both the biophysical and the social sciences (Table 1) was not only an authentic reflection of modern environmental management but also allowed students to choose either to consolidate knowledge in their major field of interest or to go outside those boundaries and expand their skills in new directions.

Course implementation

At the beginning of each course, students were told that they would essentially become real research consultants for the relevant client, that their major assessment task would be a professional standard consultancy report and that academic and professional integrity was essential. An initial assessment task required each student to research the study site's key environmental drivers on a systems scale (e.g. acid sulfate soils, coastal or peri-urban development, catastrophic bushfire). This background work ensured that by the time the students went into the field, they all had comparable understandings of the local environment and relevant management issues, and also compelled students to move out of their disciplinary "comfort zone": engaging with the full range of issues required students

Table 1. Examples of student research topics generated by consultation with stakeholders 2002–2009.

• The effect of permanent ponding on soil and surface water acidity in an acid sulfate soil environment.
• The biophysical and social implications of remediating wetlands of high ecological, cultural or aesthetic value.
• Environmental history of sites undergoing rapid change.
• The effectiveness of environmental instruments (such as state environmental policies and plans) in protecting the environment.
• Assessment of soil and water quality, riparian vegetation and macroinvertebrate biodiversity in a range of modified landscapes.
• Biophysical audits of wetlands, mangroves and saltmarsh located adjacent to newly zoned urban and peri-urban areas.
• Impacts of floodgate management (saltwater flushing) on productive and/or degraded areas.
• Viability of pasture under different field treatments.
• Geomorphological and hydrological assessments of stream systems draining multi-use catchments.
• Geochemical assessments of on-farm rubbish dumps.
• The efficacy of community-driven environmental management programmes.
• Pressures of recreational use on water supply dams.
• Mapping development of policy/legislation relating to specific issues and associated socio-economic implications.

to become familiar with the basic principles of all the various disciplines underpinning environmental management. Students thus learned about aspects of demography, sociology, law and policy, and economics relevant to the study site, as well as the more expected aspects of geoscience, hydrology, chemistry, physics and ecology.

With their background knowledge developing, each student chose a research question of primary interest (within the scope of those previously identified as being of interest to the client) and was teamed with others who shared that interest. Each team then planned its research and fieldwork by:

- formulating key research questions and objectives;
- developing a research design and methodology, including sampling strategies;
- undertaking background research about the field site;
- identifying and compiling relevant resources for fieldwork, including baseline data from existing databases and literature;
- preliminary liaison with key stakeholders; and
- developing strategies to optimise the evolution of a functional team by identifying, and working with, the strengths and weaknesses of each team member.

Issues of equity

To ensure equity in participation, which is a university and legal requirement, the course design catered as far as practicable to students' personal needs and economic status. For example, the field trip involved costs for travel, food and accommodation, none of which could be stinted if occupational health and safety measures were to be met.[4] From 2000 to 2007, financial and in-kind support from some clients[5] subsidised these costs to students. The proportion of students unable to participate in the field trip itself varied from year to year, but tended to average 5% of enrolments, and because the focus was on the research project (for which the field trip provided sets of specific data), all students felt part of a learning and research team at all times.

Students with health, disability or cultural issues that precluded or restricted physically demanding fieldwork were offered a less demanding component within a township local to the study site (e.g. a community survey of perceptions and attitudes towards a relevant issue, or library search through locally held historical resources). The few students unable to travel to the field at all (e.g. because of paid work commitments or carer responsibilities) were either able to conduct comparative field studies at a local site (e.g. an urban wetland, waterway or water supply system) or, more usually, given research-based desktop studies within their team's project (e.g. critical analysis of existing data, generation of maps from Geographical Information Systems or critical evaluation of the literature to answer specific questions posed by clients). In all cases, the learning objectives and outcomes were the same for all students, as the focus was on authentic research activities rather than on fieldwork per se.

The field trip and its aftermath

The five- to seven-day field trip was run during the mid-semester break (about 7 weeks into the 13-week course). After reconnoitring the area and speaking with key stakeholders, the student teams would begin their specific field activities. On-ground training in basic surveying, sampling and field-testing was delivered by accompanying "research advisors" (ANU academic staff and postgraduate students with disciplinary expertise and research interests relevant to the site, some of whom had been guest lecturers in the course). An effective fieldwork ratio (from five to 10 students per supervisor when possible) assured students of high-level support in their specific topics, and also allowed them to gain insights from specialists in diverse fields (reflecting the interdisciplinarity of professional WRM). This allowed questions to be answered quickly and helped students ensure they were "on track and avoiding tangents" (comment in student field learning journal, 2009). Throughout each field trip, there was also ongoing contact with, and support from, the relevant client and other stakeholders, allowing students to hear from, and question, state agency and local government land managers, private landholders, local community groups, aquaculturalists, agriculturalists, local historians, professional consultants and local journalists, as relevant to the study site.

On return from the field trip, each team completed their planned laboratory analyses of soil, water or biota samples. Under supervision, and again with access to regular feedback and support, each team would then set about writing a consultancy report on the basis of the team's own field and laboratory results. The potential problems of group work (such as free riding) are recognised and carefully addressed: the lecturer holds regular, compulsory meetings with all members of each group, at which contributions and updates on progress are presented by each individual and discussed by the group. All data were placed online so that all group members had access, preventing any competitive withholding of information. Part-way through report development, a semi-formal symposium presentation allowed the sharing and discussion of results across groups – reflecting the interdisciplinary relevance of data – so that teams could incorporate the relevant findings of others before finalising their own report and submitting it to the lecturer for assessment. The final report includes a table that identifies the contributions by each member, signed off by everyone in the group.

The course lecturer provided students with feedback on their work, and provided quality assurance processes before any reports were forwarded to clients. The "tyranny of distance" has meant that only rarely has it been possible to achieve the ideal of students formally presenting clients/stakeholders with reports and then having roundtable discussions, with the more usual outcome being a compilation of reports delivered in hardcopy or digital format.

The consultancy approach: outcomes 2002–2009

Sources of data and evaluation methodology

From the start, course design was subject to a continuous improvement cycle, based on formative evaluation and sustained, incremental innovation (Bessant & Caffyn, 1996). Since 2002, this process has included summative evaluation through the university's standardised, anonymous and independent course evaluation mechanisms, which included both numerical ratings and qualitative feedback. Improvements suggested directly or anonymously by students, staff or stakeholders have been incorporated as appropriate. In 2009, additional qualitative feedback was sought from that year's cohort to broaden our understanding of the students' experiences.

To describe and assess the outcomes of the CA, we have used three sources of data: quantitative evaluation metrics derived from the university's standardised evaluations since their introduction in 2002, qualitative feedback from clients and qualitative data collected from the 2009 field trip cohort in students' responses to open-ended questions in pre- and post-fieldwork surveys ($N = 22$ and 17, respectively). For the latter, following an informed consent data collection process approved by ANU Human Research Ethics Protocol 2009/129, students completed written questionnaires with simple open-ended questions immediately before the field trip (i.e. about halfway through the course) and in the final week of classes (i.e. about two weeks before the final reports were due). Students were also invited to maintain fieldwork learning journals to provide additional feedback. To ensure professional and academic integrity, these qualitative data were collected by Dr Beckmann and not discussed with course lecturer Dr Beavis until the course results had been publicly released.

To help analyse the qualitative feedback, we used the framework derived by Hunter, Laursen and Seymour (2006), which identifies six primary categories of student-reported benefits of undergraduate research experiences – personal/professional gains; "thinking and working like a scientist"; gains in specific skills; clarification/confirmation of career plans, including further study; enhanced career/graduate school preparation; and shifts in attitudes to learning and working as a researcher. [6]

Evaluation metrics 2002–2009

The standardised evaluations for the course's eight iterations consistently showed overall mean ratings in the "very good" to "excellent" categories (Figure 1).

Client perspectives 2002–2009

Throughout the years that the CA has been used, students in the course have created very favourable impressions with the various clients:

> . . . respectful and attentive, very co-operative, happy to take instruction and follow direction . . . obviously well-briefed and had planned their field-work well. (Project Officer, NSW Department of Agriculture, personal communication, 11 December 2009, referring to courses from 2002 to 2007 inclusive)

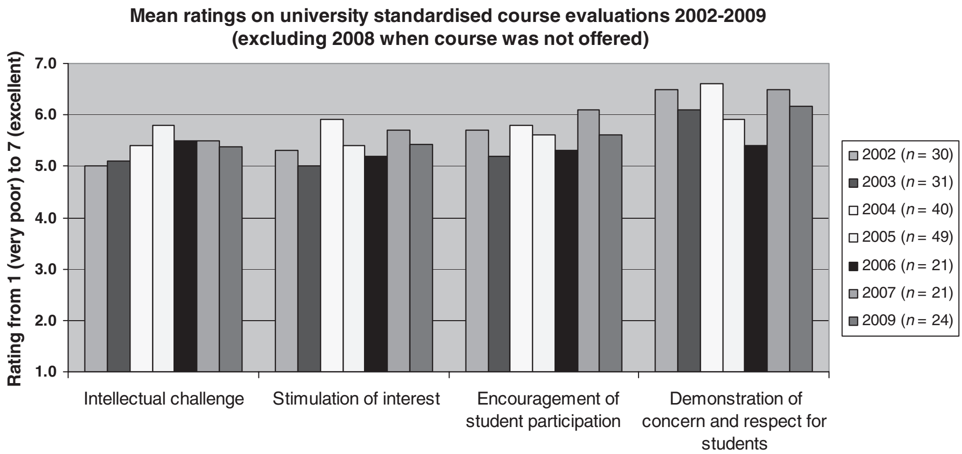

Figure 1. Mean course evaluation ratings 2002–2009.

> ... professional and courteous ... very interested ... keen to demonstrate that they could achieve, and indeed excel, at their task. (Environmental Manager, Kempsey Shire Council, personal communication, 1 December 2009, referring to courses from 2002 to 2007 inclusive)

> Very responsive ... ready to interact with presenters, inquisitive and confident ... mature, directed and very self-driven. They may not be working for a salary but they certainly applied themselves. (Education Officer, Hunter Wetlands Centre, personal communication, 20 November 2009, referring to course in 2009)

Case study: the 2009 course

In 2009, the study site was the Hunter Wetlands Centre Australia, near Newcastle, New South Wales: a "vibrant wetland ecosystem bursting with life", which had been a wasteland until a mid-1980s rescue by a community group (Hunter Wetlands Centre Australia, 2009). On their way to this site, the students were asked to reflect on their experiences in the course to date and their expectations for the fieldwork through three open-ended questions:

- To structure your learning in this course, you have been asked to function very much as a professional in researching, collecting data and reporting. How do you feel about this approach?
- Thinking about the actual activities and work you'll be doing during the fieldwork, what do you expect will be your main areas of learning? (These could be specific concepts, skills or experiences)
- Now that you have had the projects explained to you, what concerns, if any, do you have about gaps in your knowledge with regard to the fieldwork, or with regard to the use of technology to record data?

Almost all respondents reported that the teaching and learning activities experienced thus far had met their expectations ("learnt heaps in this course [already] through the way we approach problems").

Asked how they felt about being asked to function as professionals in researching, collecting data and reporting, all students responded positively. Their comments often referred to perceived future career benefits, with this approach providing “a useful insight into the professional world of consultancy”, making it “easier to understand what is needed in a professional situation” and giving them “an idea of how we would collaborate with others”. Overall, students were highly appreciative of the opportunities: “a very effective approach to learning, because it will compel me to research, analyse and report research to what I think is a professional standard”. The few concerns voiced were mainly related to the reliance on teamwork – “I am comfortable with this as an individual [although] I am not yet confident of our team doing this well together” – and the importance of high-quality feedback – “practical and useful, as long as there is lots of feedback, constructive criticism”.

The students had been well-briefed on the kinds of data collection activities available to them during the field trip, and each team had planned a methodology based on pre-visit research. As students physically approached the study site, we asked what they expect to be their main areas of learning in terms of specific concepts, skills or experiences. Many mentioned teamwork and data collection – “working as a team on a professional document”, “to measure pH of water and soil, take samples and get them uncontaminated”. Some students included more structurally complex responses, relating the data collection to its interpretation – “developing skills at taking samples, gathering data and interpreting it”, “testing water in holes over a large area and finding relationships”. Some students clearly demonstrated an understanding of the complexities and multifaceted nature of scientific research:

> [I will learn] What does and doesn’t work in the team I’m in, e.g. communication techniques and about one another. About governance and management that applies [at the study site] and how this influences people. To see and smell it (first-hand experience, not book learning). Research techniques, i.e. what’s effective and new ones. Knowledge about the sub-catchment and the wetlands first hand.

Although this is a third-year course, the diversity of student backgrounds and academic career paths previously described means that knowledge of research skills cannot be assumed. A key component of the course therefore occurs in the weeks before the field trip itself, when students are trained in both relevant theory and research methods, including field and laboratory techniques, through weekly lecture and practical classes. The pragmatic decision, given limited pre-visit laboratory time, to teach the more detailed data collection skills on site at the beginning of the field trip can risk creating apprehension: one student approaching the study site was honest enough to note: “I don’t feel I know enough about collecting data and I’m freaked out about the report write-up”.

However, for the great majority of students, the “just-in-time” approach worked very well. This was clearly shown at the end of the course when students were asked what had been their main areas of learning in the period *after* the field trip. As expected, practical skills, teamwork and report writing featured heavily in responses. However, the references to new skills – “how to use equipment”, “sampling, measurement”, “group work, communication and group facilitation” – were often included in responses that were not only far more complex than those given prior to fieldwork but also described cognitive and affective learning outcomes in more holistic, relational terms: “the spatial variability of water bodies”, “experience of being in control of investigation” and “access to ‘values’ of [land management] staff, . . . team-building, knowledge of peers, site-specific knowledge”.

Fuller, Edmondson, France, Higgitt, and Ratinen (2006) describe the experiential learning benefits of field trips associated with undergraduate environmental education: being away from the classroom or laboratory provides novel learning opportunities and facilitates a contemporaneous mix of observational, cognitive, psychomotor and affective learning. This was neatly summarised by one of the 2009 students: “experiences are priceless – teamwork skills, communication skills, fieldwork conditions, learning methods of study”. While the CA could be argued to be no different from a conventional field trip in providing such opportunities for experiential learning, we believe that the underlying thrust of the students’ “professional” roles on site enhanced their capacity to learn across the whole spectrum of domains. The depth of these learning experiences is illustrated by extracts from the reflective journals of two students, which document the more intangible benefits of collaborative learning (see Table 2 below). The natural settings also provided opportunities for personal reflection, which gave students another dimension of learning: “stepping out of the comfort zone once in a while will do you good”. These kinds of affective learning outcomes are a bonus to caring academics and scientists, and provide students with insights into the intangible benefits of working in careers in environmental management.

The consultancy approach: discussion and appraisal

Using students as researchers for community projects is not novel (e.g. Hughes, Blair, Clear-Hill, & Halewood, 2001), especially at the postgraduate level and in “market-related” disciplines. In Australia, for example, Douglas (2007) describes a postgraduate elective at the University of Technology Sydney (UTS) that results in “consultancy reports” being delivered to indigenous, advocacy, educational and charitable organizations, while Healey and Jenkins refer to a final-year capstone course at the University of Queensland that uses team-based problem-based learning “to give students experience of research-based consultancy” (2009, p. 30).

Our approach, however, takes the CA into a field-based experimental and interdisciplinary environmental management setting and allows undergraduates to engage more directly with both the research interests of the teaching academics and the research needs of the community. Like Douglas, we have found that “the community contribution . . . gives [students] a purpose beyond the assessment process, and helps to generate positive student engagement”, but we have also recognised more direct benefits to the wider community in the nature of the environmental research being accomplished (2007, p. 31).

Benefits to students

Ramsden (2003) has argued that a deep approach to learning is fostered through an active engagement with cognitive and affective knowledge, facilitated by learning activities that encourage development of analytical, generative, reflective and evaluative skills alongside practices that allow students to synthesise ideas to mesh with their previous learning. Our students identified many of these features in their feedback: their reported learning covered not only the practical data collection skills vital to a professional environmental researcher, but also the more complex skills of being able to analyse, interpret and communicate data as a team. We saw a more holistic understanding of the concepts of research and researchers developing among students in this course, with students’ feedback falling into all categories identified by Hunter et al. (2006) as tangible and intangible benefits of undergraduate research (Table 2). These findings suggested that the CA did indeed encourage deeper approaches to learning.

Table 2. Illustrative examples of student benefits from undergraduate research (Hunter et al., 2006) taken from course feedback (2009 *Water Resources Management* cohort).

Category of student benefit and descriptive elements from undergraduate research as identified by Hunter et al. (2006)	Quotes from student responses to course feedback that illustrate this benefit	Illustrative student responses from this study (from student learning journals produced in 2009)
Thinking and working like a scientist Apply knowledge and skills: understanding science research through hands-on experience. . .; understanding nature of scientific knowledge (open-ended, constantly constructed); understanding how to approach research problems/design. Increased knowledge and understanding of science and research work (theory, concepts, connections between/within sciences). Transfer between research and courses; increased relevance of coursework.	• "How to test groundwater quality. Understanding factors that influence groundwater quality and interconnectivity. Discover current groundwater issues and state of knowledge through background reading". • "[Learned] how to analyse materials collected in the field and realise who we need to send samples to, and how we go about understanding our results". • "Research into the findings . . . we must have knowledge of background material in order to interpret the results and to start forming relationships between different data obtained". • "What all the data means – how to relate it back to scope of study". • "How to better record data to avoid confusion". • "Analysing, conceptual thinking, being logical and identifying sequences/relationships".	• "It was great fun trudging around in the mud with gumboots and taking samples and measurements. I learned how to read the pH of the soil. It was a real practical experience where we as a team had to make all the decisions. It was challenging to get some samples". • "Especially seeing the geography around the site, and travelling [to and] from it, pushed home an appreciation of different plants, fauna, geography, hydrology, land uses, etc, that I'd not got from desk top study . . . Similarly, getting a sense of the industrial history of the area is deeper than reading Australian Bureau of Statistics information. . .". • "We thought we had found acid sulfate soils since it smelt lots and the ground was yellow. So we got samples – but later we found it was actually alkaline!"
Becoming a scientist Demonstrated gains in behaviours and attitudes necessary to becoming a researcher (student takes "ownership" of project; shows responsibility, intellectual engagement, initiative; creative and independent approach in decision-making). Greater understanding of nature of research work and professional practice.	• "The pairing of the field trip with the report writing skills have been really great in preparing me for writing and collating a professional report. The practical skills in the field and becoming familiar with equipment was great!" • "It was interesting how the [course] started off with the physical and chemical aspects of chemistry and how it moved towards more serious social, ethical management problems related to water".	• "[Wednesday] Just had talks from [two key informants on site] – learnt a lot more from these than web-based and National Library of Australia research. . . . [Friday] An interview today revealed more data. Some of it was sensitive and unlikely to have been put into writing . . . not in any of the annual reports I've read".

(Continued on next page)

Table 2. Illustrative examples of student benefits from undergraduate research (Hunter et al., 2006) taken from course feedback (2009 *Water Resources Management* cohort). *(Continued)*

Category of student benefit and descriptive elements from undergraduate research as identified by Hunter et al. (2006)	Quotes from student responses to course feedback that illustrate this benefit	Illustrative student responses from this study (from student learning journals produced in 2009)
Personal-professional Increased confidence in ability to do research, contribute to science, present/defend research, and in "feeling like a scientist". Establishing collegial, working relationships with faculty advisor and peers.	• "Tying together library research and on the ground interviews . . . with academic viewpoints". • "This is a good approach. It increases motivation and pride in our work". • "I feel that there is quite a lot of pressure to do well and being fairly inexperienced in writing major reports, it is slightly daunting. However, I think it pushes us to strive for a very good outcome, where we otherwise may have produced a report of lesser quality".	• "I got insights on the people who work and volunteer at the centre, how the site has "evolved", and stakeholder values that now shape how I consider the research question. This is because human (in)actions and anthropogenic changes have a large influence on the constraints, opportunities and history of water resource management on the site and in the region". • ". . . trip in a canoe for our water samples . . . was great! . . . It was a challenge to steer through the maze. We paddled to the extremities of the canoe trail and tested the water. . . . There were mangroves everywhere but mainly the roots, not many full trees. . . . We got to the other end . . . and spotted some frogs. After swapping positions, we paddled back . . . having discussions . . .".
Clarification, confirmation and refinement of career/education paths Increased interest/enthusiasm for field; validation of disciplinary interests. . .; greater knowledge of career/education options; clarification of which field to study; introduced to new field of study.	• "This course has given me a keen interest in water management". • "[Water] is a big issue. Everyone needs water, without it we have no life. It is a precious resource. Developing countries have poor access to water and often poor sanitation. I'd like to contribute to make a better world".	
Enhanced career/graduate school preparation Real-world work experience (students); . . . opportunities for collaboration/networking with faculty, peers, other scientists; new professional experiences; resume enhanced.	• "Water is always going to be an issue for people/communities and I would love to be able to help people learn how to better manage/use this resource". • "Have always wanted to get into groundwater work projects which will enable the Third World to have fresh drinking water".	

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Table 2. Illustrative examples of student benefits from undergraduate research (Hunter et al., 2006) taken from course feedback (2009 *Water Resources Management* cohort). *(Continued)*

Category of student benefit and descriptive elements from undergraduate research as identified by Hunter et al. (2006)	Quotes from student responses to course feedback that illustrate this benefit	Illustrative student responses from this study (from student learning journals produced in 2009)
	• "I would like to be involved in international development projects in future and WRM may be an aspect of this". • "I feel led to work with developing countries in getting access to fresh water and sanitation management". • "As a final year student, it makes me feel well prepared for some jobs that I will by applying for. The feedback will be very useful for determining how well developed these skills are and what I need to work on".	
Skills Communication skills: presentation/oral argument; some writing/editing; laboratory/field techniques; work organization; computer; reading comprehension; working collaboratively; information retrieval.	• "Skills in writing a consultancy report which is absolutely useful . . . [my] first time writing such a report". • "Ability to communicate during interviews and the importance of establishing a good rapport". • "Managing/coordinating a group project – learning to guide team members to stay within the scope of the project". • "Difficulty and importance of compiling information and working as a group to a deadline that reduces stress".	• "Working together in a cabin is conducive to team building, e.g., we share food, take turns, have a chat, get to know one another. This is at a deeper level than seeing people just at team meetings. One realises how much we can have in common! [Our] group cohesion increased, as there was one-on-one contact. I learnt more about the strengths of group members that can be drawn on in the report". • "I'd had fun teaching a campfire song while doing the sampling and it was good building relationships. The team worked together well. . . . I will definitely treasure the memories . . . learning back [on campus] will be a lot [more fun] knowing all the class better now". • "I'd already searched in academic literature, [on the Internet], . . . and the Australian National Library. The library here had more! (So I feel happy and optimistic.) . . . It's easier doing this here as you can pass a book to the person next to you at the library table and ask 'real-time' questions or discuss issues face to face . . . I much prefer this!"

To what extent does this evidence validate our curriculum as an emulation of a "professional consultancy" role? Students' feedback on learning activities and their formal assessment tasks show that they gained, or were working towards, many of the professional competencies identified by Toohey (2002) as essential for consultants in agriculture and natural resource management (Table 3). Moreover, although students' final reports were central to course assessment, and the students obviously wanted to do well in the course, it

Table 3. Example of key competencies for advisors and consultants in agriculture, natural resource management and related sectors (Toohey, 2002).

Competency area	Specific skills typical of this competency (Toohey, 2002)	Evidence that students gained these through the consultancy model √ Significant evidence (√) Circumstantial evidence × No evidence
Communication skills	Group facilitation	(√)
	Conflict resolution	(√)
	Aural, writing and public presentation skills	√
	Interpersonal skills	√
	Negotiation skills	(√)
	Court room (expert witness) skills networking	×
	Mentoring	×
	Media skills	√
	Leadership and team skills	(√)
	Learning skills	√
Natural resource management	*Generic*	
	Long-term perspective	(√)
	Holistic view of systems (financial, ecological, social)	√
	Impact assessment	√
	Environmental protection	√
	Regulatory framework	√
	Documentation (records)	(√)
	Biodiversity and ecosystem services	√
	Specific to role: e.g.	
	Surface and groundwater management	√
	Off-site impacts	(√)
	Salinity and acidity	√
	Soil health	√
Applied sciences	Knowledge/understanding of plant biology and soil science	√
Social issues	Neighbour interactions	(√)
Regulation components	Industry-specific regulations and policy	(√)
	Chemical registration	×
Business skills	Operation of own business	×
	Understanding client needs	(√)
Risk management and assessment	For finance, climate, production and environmental management, occupational health and safety, strategic planning	(√)
Professional ethics	Roles/responsibilities, adherence to a code of ethics	(√)

appeared that assessment became almost incidental for many students. Rather, they valued their contribution to "real" research, with reports given to community clients for their professional use, and hence open to legitimate citation in *curricula vitae* as research outputs. This can be a significant advantage for those students seeking to enter the highly competitive fields of academia or government service, and some teams were nominated for externally funded awards on the basis of their research outputs in this course.

Although we have not yet formally surveyed past students, unsolicited feedback from individual students has catalogued the impact of the course on their lives, exemplified by these two comments:

> [Before] this course, my studies had focused on social geography and economics. I discovered a passion for science, particularly in the field of water resources, during this course.

> After completing [this course], I was inspired to pursue a career in water resources research which later developed into a specialisation in Hydrogeology.

Benefits to clients and stakeholders

The study sites were characteristically places where changes in the scientific knowledge underpinning land management and in local development pressures and regulatory frameworks, coupled with funding constraints on local research, have led to mismatched levels of knowledge and trust among stakeholders. Typically, such circumstances lead to conflict at individual, group and inter-generational scales (Dyball, Beavis, & Kaufmann, 2004). It was therefore vitally important for many of these clients to be able to access scientific data that described their sites, and the students' work was crucial in this regard. If undergraduates are to be involved in authentic research, quality assurance is vital. The clients/stakeholders have certainly trusted and valued the students' final reports sufficiently highly to use them in management and decision-making. Clients' unstintingly positive feedback on the quality of students' work showed the level of professionalism that can be achieved even by undergraduates:

> Based on my experience with [commissioned] work ... by junior consultants, the efforts and outcomes derived by the students compared very favourably, particularly in regard to on-ground fieldwork. ... I place a great deal of trust in the reports, [which are] developed, researched and referenced in a professional manner. (Environmental Manager, Kempsey Shire Council, personal communication in response to survey, 1 December 2009)

> We regard the reports .... as a higher level product. (Education Officer, Hunter Wetlands Centre, personal communication in response to survey, 20 November 2009)

Stakeholders have reported that data from rapid appraisal projects have been used in management plans and internal reports, while findings from other projects have helped identify the efficacy of current practices at site-specific scales or been used in the "development, implementation and monitoring of specific environmental rehabilitation projects' (Stakeholder, personal communication in response to survey, 1 December 2009).

Other stakeholders' feedback on the value of data is also reassuring of the value of work done by the students:

> A very useful document ... I am surprised by the invertebrate data. It will help us track biodiversity, water quality, etc. at all three sites.

> To come up with suggested remediation shows that you appreciate the need to review urban structures throughout their lives. ACT Roads will find the section on repair and remediation very useful.

> I will really value having access to this [report] when I have to discuss the condition of the catchment. You have let me know very clearly what is above [named] Road. This will make a very useful baseline in the future.

All projects have the potential to raise new research questions, thus driving the process of knowledge-building. Stakeholders have played a key role in identifying future projects from the outcomes of past ones:

> It has been so interesting to see things through their eyes . . . [the health project] fits into . . . the Ramsar work I am doing. (Education Officer, Hunter Wetland Centre, personal communication, 15 September 2009)

> A valuable resource for the local community . . . to highlight areas that need more research. (Project Officer, NSW Department of Agriculture, personal communication, 11 December 2009)

This involvement represents an integral part of the collaborative process, since the student projects are designed specifically to help stakeholders fill gaps in knowledge or to support management planning and implementation. However, the reality is that many environmental research tasks in Australia derive from legal challenges, which militates against the status of student research, however excellent, even though clients recognise a much broader impact that is hard to document and quantify:

> Undergraduate research results would not stand up in court and it is a reality that you may have to present at court on consultancy reports . . . the most valuable [outcome] was the students' engagement with the local community . . . it gave the locals a big boost to self-esteem and a confirmation they were contributing to sustainable management. (Project Officer, NSW Department of Agriculture, personal communication, 11 December 2009)

Benefits to academics

Biggs (1999) argues that optimising conditions for a deep approach to learning requires course design that (i) minimises anxiety and creates a high expectation of success; (ii) provides time to engage in tasks emphasising depth, rather than breadth, of learning; and (iii) teaches and assesses in a way that stimulates critical thinking and multi-structural thinking. The evidence presented in this paper demonstrates how the CA meets these conditions and has enabled the course lecturer and collaborating academics to enjoy the fruits of successful and effective teaching experiences. In addition, the more intensive and interactive teaching relationship with students has provided good opportunities to recognise their particular strengths and skills, which has allowed for more meaningful references for individual students and "talent spotting' for students capable of further research (some of whom lacked the confidence to consider such a path without the lecturer's support). Academics' own research has also benefitted from the greater exposure to thinking and data collection at relevant study sites, especially when specialists in different disciplines gathered for field trips.

Benefits to society and service learning

Students report that the CA allowed them to gain authentic and professional skills relevant to future careers in WRM and other forms of environmental management: "helps … prepare [us] for real job circumstances and situations". A less visible but equally important benefit is the focus on providing real research for real clients. Effective environmental decision-making requires rich data sets informed by a realistic approach to engaging with the costs and benefits of decisions, which in turn requires a detailed understanding of the complex dynamic processes occurring in the environment. As noted earlier, policy-makers at all levels need knowledge of environmental management in all its interdisciplinary glory. This teaching model allows students to appreciate how environmental researchers support their communities by providing crucial data and interpretation. Regardless of the students' ultimate career direction, this experience allows them to understand the socio-political context in which much scientific research is used and hence to explore at first hand their "roles and responsibilities as citizens of their local community, their nation, and an increasingly interconnected, interdependent, and scientifically driven world" (Labov & Huddleston, 2008, p. 347).

The CA thus provides not only a research-led focus but also a distinct form of "service learning", defined as experiential education that provides reciprocity of learning, where both providers and recipients of service benefit (Sigmon, 1979). With graduation just six months away for most students in the 2009 course, about half reported that they were considering working in WRM, with most indicating they were strongly motivated by a commitment to "service" (see Table 3 for examples). The CA could also provide an option for natural resource management educators in developing countries, given the need to enhance professional education in these areas (Setha & Mund, 2008).

Effort and costs

Without doubt this model of teaching takes more effort at all stages of design, implementation and follow-up than a traditional lecture–practical format. The set-up "costs" of time and effort – contacting clients, reconnoitring study sites and developing feasible projects – are matched by the input required for the successful management of field trips, which must take into account the need for sometimes complex travel, accommodation and food arrangements; occupational health and safety issues (including risks from venomous snakes at most of our sites); and on-site supervision and teaching in often difficult environmental and climatic conditions. Stakeholders have recognised these costs, and have thus often provided supplementary field equipment, field supervision and in-kind support, such as personal introductions to interviewees or landholders. One must also acknowledge the high level of input required from the academic staff to ensure the quality of data collection, analysis and reporting by students. To what extent this effort is offset by the benefits to students and communities is a question that individual academics must answer for themselves, but our experiences, as both environmental scientists and educators, have been very positive and make the effort more than worthwhile.

Conclusion: a model of authentic learning

Given the chronic underfunding of environmental appraisal and assessment work in Australia, the research done by undergraduate students during this course since 2000 often comprises the sole set of scientific data at the relevant study sites. By providing real research questions that address the "on-the-ground" decision-making needs of real stakeholders and maintaining a strict control on quality assurance and academic integrity, we have been able to take undergraduates from a purely academic and assessment-focussed learning environment to one that is authentic, practical and challenging.

In this way, we have met Barnett's challenge to "adopt teaching approaches that are likely to foster student experiences that mirror the lecturers' experiences as researchers" (2000, p. 163). Students, academics, environmental managers and local communities are all demonstrated beneficiaries of the CA:

> The other great outcome is the interaction with the community and the relationships that develop in a very short period. I am sure in the Macleay there are many doors now open and respect for staff and students from ANU. (Project Officer, NSW Department of Agriculture, personal communication, 11 December, 2009)

Not only does this model indeed make undergraduate students the "active stakeholders in a research community" sought by Healey and Jenkins (2009), but we believe it is also creating a tiny ripple of change in our future:

> [This course] had an enormously positive impact on my academic and professional development . . . encouraged intellectual curiosity, academic rigour, camaraderie between students, and genuine engagement and empathy with stakeholders. [It gives me] a grounded hopefulness . . . that we can successfully address environmental challenges when we take the time to scientifically understand them and engage on the ground with all those involved and impacted. (Unsolicited feedback from past student)

Notes

1. Although formal ethics approval is not required for undergraduate courses, potential interviewees are identified and contacted by stakeholders and the lecturer before the field trip, and the projects, their purpose and their outcomes/outputs are discussed in detail before stakeholders are asked to consent to be interviewed. Additional interviewees identified during the field trip are also asked to consent before being interviewed. Protocols of confidentiality are strictly followed, and all interviewees are given access to copies of the final reports.
2. In 2008, Dr Beavis was on sabbatical, and the course was presented in a different format.
3. Acid sulfate soils (ASS) occur naturally in both coastal (tidal) and inland (freshwater) settings. Undisturbed, these soils present no problem, but excavation or drainage allows sulphides in the soil to react with the oxygen in the air, forming sulphuric acid. The latter can kill plants and animals, contaminate drinking water and aquaculture, and corrode concrete and steel. Locating areas where ASS could become a problem is crucial to ensure identification of areas where development should be avoided or special treatment is required. Draining flood-prone areas, even temporarily, provides ideal conditions for oxidation of ASS, so today's land managers must engage with problems associated with the flood mitigation practices previously imposed for decades on Australian east coast landholders. Many costly mistakes in ASS management have already occurred in New South Wales, Queensland and South Australia, involving considerable damage to land, buildings and waterways (Beavis et al., 2006).
4. When students are spending their days working in ASS environments, the accommodation is often, of necessity, some distance from the actual field site and must include adequate daily washing facilities, which generally precludes cheaper camping options.
5. Kempsey Shire Council, NSW Acid Sulfate Soils Program, and the NSW Department of Agriculture.
6. All unattributed quotes are taken from written feedback from students in the 2009 cohort, primarily from the responses to the questions asked in pre-and post-fieldwork surveys, but also from unsolicited emails from past students.

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