For enthusing students about soil science through a focus on discovery, critical environmental issues and the application of contemporary teaching and learning principles

OVERVIEW: SUMMARY OF CONTRIBUTION AND CONTEXT

Is soil science relevant, interesting or useful? Since joining James Cook University (JCU) in 2004 I have developed a soil science curriculum through which students are motivated, inspired and equipped for work in environmental science and other diverse fields. The effectiveness of my approach is demonstrated by an exponential increase in student enrolments and outstanding feedback from students and peers. My teaching has seen a three-fold rise in enrolment in the main subject ('EA2007 Applied Soil Science') despite the national stagnation in tertiary science enrolments, and well above-average student evaluations of teaching and the subject.

I embrace the challenges of teaching science to diverse students in a regional setting, across campuses. Students I teach differ widely in age, experience, educational and cultural backgrounds, and are enrolled in Bachelors of Science, Planning, Arts, or Sustainability. In the 1st year environmental earth science subject I introduce soils and explore their intimate links with the rise and fall of societies, global cycles and climate change. Enthused by the experience of my teaching in this 1st year subject, students now increasingly enrol in the 2nd year non-core subject 'Applied Soil Science', which is the key focus of this nomination. 'Applied Soil Science' engages students in active enquiry of key soil properties and processes in a curriculum that I developed in the *absence* of "discipline-specific teaching principles" for soil science (Field et al. 2011, p 9).

> *Paul is an excellent teacher, he is passionate about the subject, (has) broad knowledge, made an otherwise dull subject very interesting and I look forward to pursuing in my career (Student feedback, 2010).*
> *This was a brilliant subject. The enthusiasm of the lecturer was passed onto the students. It was good to meet a lecturer that still has passion about their subject. The subject matter was extremely well thought out and expertly delivered. I learned a lot and would now like to take more soil and science subjects. Thank you (Student feedback, 2011).*

I aim to motivate and inspire diverse and sometimes underprepared students through a values-based curriculum and a range of teaching strategies. We discuss authentic and relevant problems, including how soil properties and management are linked to pollution, poverty, wealth, health and the water and carbon cycles. Discovery through hands-on learning in the field and laboratory is a critical motivator. One example is a sculpture competition in which students feel and learn about the importance of soil texture. In another exercise, students are astounded when they see the huge variations in the rate at which water disappears into the soil depending on vegetation type. Relevance of the subject is emphasised by active involvement of industry professionals. I facilitate discussions that engage students in contemplating their own values, raising their critical thinking skills and motivating them to pursue independent inquiry. In addition to considering ecological, agricultural and engineering perspectives and viewpoints, we engage with local Indigenous knowledge of the natural environment.

Making a difference: Australian tertiary science education and James Cook University's mission, values and priorities. This nomination addresses serious national concerns about science education. The Office of the Chief Scientist (2012a) pointed out an urgent need to improve tertiary science education to ensure future prosperity, demonstrating that Australia is currently lagging behind other countries. In the period 2002 to 2010, national tertiary domestic enrolments in the science disciplines were generally stagnant (Office of the Chief Scientist, 2012b).

In class I bring the University Plan (2011-2015) into action by tackling many of the critical challenges facing the tropics worldwide, especially rural and remote areas, as well as the wider global community. The learning program is enriched by our research and that of others, and closely engages industry, communities and government. The focus is on fostering intellectual curiosity and developing analytical skills, while inspiring passion through enthusiastic involvement. Accessibility and flexibility of learning is maximised by using multiple contact modes, while maintaining personal contact and hands-on work in the wonderful natural laboratory surrounding us. Finally, the approach and content are woven within the principles of environmental and social sustainability.

CRITERION 1: APPROACHES TO THE SUPPORT OF LEARNING AND TEACHING THAT INFLUENCE, MOTIVATE AND INSPIRE STUDENTS TO LEARN

My teaching approach is rooted in my passion and belief that soil, the thin skin of the earth, is one of the most important and fascinating topics we can study. I aim to infect the students with enthusiasm and wonder through a focus on discovery and relevance to diverse fields of interest. I also encourage critical thinking, peer learning and goal-setting to instil motivation (Kember et al., 2010).

Peer learning, critical thinking skills and deep learning are stimulated and exercised through active learning strategies. For example, our discussions of topical and controversial issues within lecture periods are initiated by directing carefully prepared questions or propositions to the whole class, giving them a few minutes to think, then eliciting responses from selected students. This invariably kicks off a good discussion. For example, on the topic 'Should soil carbon be included in Australia's carbon trading scheme?', I ask their response to a recent quote from a more-or-less well-informed politician or industry figure (there have been plenty of these over recent years). This active learning approach helps maintain attention and invites students to engage with their peers to bring greater life and interactivity to lectures, rather than relying on the traditional one-way traffic of information from lecturer to students. The discussions recognise, and indeed benefit from, the students' diverse backgrounds, which is particularly important for engaging students in science disciplines (Rice et al., 2009).

I encourage curiosity and empower students to consider future areas of discovery by highlighting the unknown; for example, the complex interactions that are not yet understood and the notion that soil is the last frontier of biological discovery, with millions of species yet to be discovered. Current research is truly exciting.

Students tell me they are inspired and motivated when they see how relevant soil science is to their field of interest. I identify their interests through a survey at the start of 'Applied Soil Science', asking their degree, major, background and aspirations. The students come from a diverse range of backgrounds in terms of culture, study experiences, skill levels and professional experience. Similarly, they hold a diverse range of aspirations and goals. I reach *all* students by exploring how an understanding of soil properties and processes can improve peoples' lives and our management of the environment across a range of contemporary issues, and by providing a rich array of learning experiences. Students' interest is further stimulated by engaging private and government sector environmental professionals in the teaching team. For example, a farmer digs backhoe pits to show students his different soils and explains how they influence productivity; an engineer explains control of erosion on an urban development site; and a government officer demonstrates an electromagnetic induction meter, which the students then use in a soil salinity survey. This direct contact with practitioners and professionals fosters learning, but also plays a crucial role in helping students set career goals, giving meaning and motivation to excel in their current studies.

> *The hands on laboratories and field trips were excellent. … "Fieldwork was brilliant - thanks for all the field trips which allowed us to ask questions to professionals in the field. Paul Nelson is a very approachable lecturer who provides clear, well delivered lectures and practicals. He is very organised with providing subject materials and great communication skills. One of the best lecturers I have had so far in my degree (Student feedback, 2011).*
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> *I appreciated the expectations that Paul set for us from the beginning. The assessment structure (fortnightly prac reports, short answer tests spread throughout the semester, interactive lectures) was outstanding and extensive feedback was given for all assessment pieces. I think this structure helped to confirm the concepts of the course and I feel confident with the information that was taught (Student feedback, 2011).*
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> *Paul was approachable, friendly and genuinely interested in our success in this subject. I think he could teach a few of the other lecturers a thing or two about how to relate to students and how to give decent and constructive feedback (Student feedback, 2011).*

I have developed a curriculum integrated across all levels of study, constructively aligned to ensure effective learning (Biggs 2003). The program is designed not to produce soil scientists, but to engage and influence a diverse range of people and equip them for work in diverse fields. In 1st year, I focus on stimulating students to think about soils; most students come to university with little or no appreciation of their environmental significance. In 2nd year the bulk of the learning about soil properties and processes occurs. In 3rd year, the class concentrates on applied knowledge and skills that will translate well into the workplace.

We begin each soil science teaching block by discussing the question 'What is soil?' This definition informs the pedagogic basis for all my teaching. Soil can be defined as the part of the earth where the atmosphere, water, minerals and living things all interact to their maximum extent. Furthermore, it is the part of the earth that affects humans the most and is most impacted by us. The subject is therefore interdisciplinary and value-driven. The most pressing environmental issues facing humans are closely linked to the nature and management of soil: food security, supplies of energy, water and nutrients, climate change, waste management, and loss of biodiversity. This broad applicability is the hook by which students become engaged.

In lectures, I deliberately stray from the standard western approach to soil science, using my experience in Melanesia, Asia and Indigenous Australia. As far as I am aware, I am the first person to use local Indigenous (Yidinyi) soil classification concepts in a soil science course. In keeping with JCU's commitment to working together with Indigenous communities, Bill Ellwood, a student of Yidinyi heritage, and I developed the content; with Bill researching soil-related terms and concepts

from his language group. I find that highlighting linkages between different knowledge, approaches and values is a good way of breathing life into what can easily become a dusty or muddy topic, while contributing to formation of desired graduate attributes related to critical thinking and understanding Indigenous Australian cultures.

My teaching is research-led, bringing in an element of discovery that students find exhilarating. Lectures and online resources are interspersed with references to exciting advances in our understanding of this complex, opaque medium, driven by techniques such as electromagnetic sensing across the spectrum and spatial scales, molecular biology, isotopic analysis and by theoretical advances in understanding complexity (eg. non-linear systems) and diverse inter-disciplinary approaches. I give examples from my own research in Queensland, Papua New Guinea and Indonesia, as well as recent examples from other regions. I draw heavily on my pre-academic background in industry, giving examples and teaching skills that are relevant to land and water management. This, combined with an emphasis on current research questions, helps students develop an enquiring approach.

Practical exercises are critical to the student experience. I have designed practical exercises (in the field and the laboratory) and field trips that make maximum use of our location. We are fortunate to have a huge variety of land management issues and soil types within an hour's drive of Cairns and Townsville. Good practicals give clear demonstrations of important concepts while teaching valuable practical skills. I have developed simple methods with minimal methodological clutter, and maximum visual or tactile impact. A lack of high quality practical work in 1st year has been identified as one of the major impediments to students becoming engaged and motivated in tertiary science education (Rice et al., 2009). I address this by linking soil properties with global cycles of water and carbon through some hands-on laboratory experimentation and a walk through a creek, looking at vegetation, hydrology and soil profiles exposed in the bank. Practical work is carried out in groups, employing formative team-building exercises and frequent meetings to enhance learning effectiveness (Lizzio & Wilson, 2007). The free sculpture competition is a highlight.

This subject was ***so well planned and run!!! All lecturers should try to make their subjects so user friendly.*** *Paul made sure that not only the podcasts but videolink lectures were available to revise or listen to if you missed a lecture.* ***The practicals were so well organised and really put everything into focus.*** *Paul is amazing in what he knows and how he references everything and knows so much (Student feedback, 2010).*
Lecturer is very organized. The ***best I have experienced on JCU in regards to lecture notes, additional info for subject, field trips, essay and tests*** *announcements and IMPORTANTLY he gave feedback of tests and essays! Good field trips, and well organized. He makes very good use of Learn JCU with extra surveys and topics. Well done and an example for other lecturers in JCU (Student feedback, 2011).*

I keep things interesting by employing a rich array of visual and online resources in addition to the lecture recordings and podcasts. These include recent videos about salinity, land degradation and organic agriculture. One resource the students find inspiring and provides a sense of belonging to a global community of soil carers is 'Dirt – the Movie' (2009). Other media includes the excellent interactive 'OzSoils' program. I keep the lectures and discussions updated with recent media articles relating to soil.

Assessment items are designed to encourage learning. For example, regular quizzes are based on *threshold concepts* given in lectures, ensuring that students have an explicit guide as to what must be understood. These concepts are specifically reviewed in lectures. For all assessment tasks, including essays and practical reports, I make my expectations clear, recognising the importance to the student experience of matching expectations with reality in terms of the structure, content and assessment they encounter. I make a point of providing prompt individualised feedback on assessment to build confidence and engagement within a diverse student cohort and maximising teaching-learning effectiveness (Kift & Moody 2009).

Again, I developed these principles of curriculum design in the absence of soil science-specific literature (Field et al. 2011).

EVIDENCE OF RECOGNITION

My sustained commitment to improving student learning is demonstrated by an exponential increase in student enrolments in the main subject (Applied Soil Science), from 23 in 2004 to 63 in 2011 (Fig. 1). Enrolments in the other subjects into which I teach have also risen, with the latest enrolment figures being 382 for 'Environmental Processes and Global Change' in 2012 and 24 for 'Field Studies in Tropical Soil and Water Science' in 2011. Student grades have also trended upwards over this period (Fig. 1), which I believe is attributable largely to improvements in my teaching approach.

Students have reported very positive learning experiences in my classes. For example, the student feedback satisfaction score (94%) and response rate (70%) for my main subject (Applied Soil Science, 2011) were well above Faculty of Science and Engineering targets (85% – satisfaction and 30% response rate). Scores have risen substantially above the JCU

average for virtually all criteria (Table 1). According to the 41 comments on the best aspects of the subject, students were most enthusiastic about the excellent organisation (16 comments), the interesting and useful nature of the practical exercises (16), the enthusiasm, approachability and quality of feedback provided by the lecturer (14), the nature of the assessment, especially the regular short quizzes (12) and the quality of the lectures and notes, including their accessibility online (11). It was also clear that the quality of the tutor in Townsville, Sue Berthelsen, was critical to the students' good experience (7 comments) and helped achieve my goal of maximising student engagement. Table 1 indicates the average student evaluation scores for 'Applied Soil Science' subject for the last 3 years, averaged across both campuses of delivery, compared to the University average. This demonstrates the very positive response from students to the teaching approach.

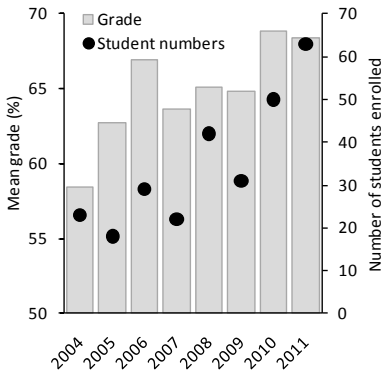
Table 1. Student feedback scores for 'Applied Soil Science' (1-5 Likert scale)

	2009		2010		2011	
	Subject	*JCU*	Subject	*JCU*	Subject	*JCU*
Response rate:	26%	*17%*	30%	*13%*	74%	*11%*
The teaching staff of this subject motivated me to do my best work	4.00	*3.91*	4.55	*3.90*	4.27	*3.91*
The teaching staff worked hard to make this subject interesting	4.34	*3.99*	4.64	*3.98*	4.53	*3.97*
My lecturers were extremely good at explaining things	4.09	*3.88*	4.89	*3.88*	4.30	*3.87*
The staff made a real effort to understand difficulties I might be having with my work	4.00	*3.82*	4.40	*3.77*	4.27	*3.80*
The teaching and learning experiences of this subject were well organised	4.34	*3.85*	4.58	*3.81*	4.68	*3.84*
Overall, I am satisfied with the quality of this subject	4.34	*3.87*	4.69	*3.81*	4.51	*3.82*

My contribution to student learning is well acknowledged by graduates, peers and external stakeholders. At the institutional level I received a JCU Faculty Citation for Outstanding Contribution to Student Learning in 2012. In addition, I was awarded the overall JCU 2012 Citation for Outstanding Contribution to Student Learning. Graduates acknowledge my contribution to their success, as noted in the following:

> *Paul Nelson's teaching of soil science inspired me to undertake Honours in soil science and has also led to my employment in the field. His clear passion for soil science, extensive knowledge of the subject material, and exceptional delivery of the course resonated with me, making my learning experience both enjoyable and thoroughly rewarding. I gained an invaluable understanding of not only the theoretical aspects of soil science but also the practical applications which I now find I am continually calling upon in my new position (Jack Koci, Technical Officer on Qld Dairy Farmer Organisation Project).*

Figure 1: Student enrolment numbers and mean grades in 'EA2007 Applied Soil Science' over time



The quality of my soil science teaching has been recognised by the broader community. Staff from the Qld. Dept. of Natural Resources and Mines, engineering/environmental consulting company Douglas Partners and commercial farmers have enthusiastically become involved, giving their time and expertise, as well as lending high value equipment that falls outside our research capability (geophysical survey equipment, rainfall simulator).

My contribution to the soil science community is acknowledged by Dr John Armour, Principal Scientist, Qld. Department of Natural Resources and Mines, and my reputation as an inspiring teacher results in requests by the Australian Society of Soil Science to present workshops, for example 'Understanding Soils Workshop' in Cairns in Nov 2009, and invitations to contribute to key forums, for example the 'Soil Science Core Body of Knowledge Forum' at the University of Sydney in December 2011. Comments arising from a recent external peer review of my teaching in 'Applied Soil Science' included:

> *I would have to state that student feedback, both quantitative and qualitative, on Paul's teaching and their learning is some of the best I have seen…I praise Paul for his efforts in developing field work teaching that enables the students to observe or engage with 'real world' problems, as this is identified as one of the single most important teaching experiences by students, graduates, and employers... the greatest praise of all is there are a number of (student) comments stating the need to develop a new course that can be taken in senior years so the students can continue learning in this area. This is high praise indeed (Dr Damien Field, Uni. Sydney, lead author of recent study on soil science teaching principles; Field et al. 2011, 2012).*

Most importantly, my engaging teaching is increasing numbers of students who are obtaining improved grades. I look forward to continuing this work of enthusing and inspiring students about the future of science.