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A new model for training soil science students to compete in a global society

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Abstract

Without question, this is an exciting time for soil scientists and the discipline of soil science. Many of the grand challenges that we face globally, including climate change, environmental degradation and restoration, food security, population growth, and energy sustainability must involve soil scientists. With these challenges and the pending retirements of many soil scientists, particularly those of the baby boom generation, there are many opportunities for placement of well trained soil scientists in academe, government, and the private sector. This new generation of soil scientists must be globally engaged and experienced in operating in the international environment. To be competitive in securing jobs and to ensure a productive and satisfying career, our students must be trained in different ways than in previous periods. They must have: coursework and training in not only traditional areas but in engineering, social policy, business and economics, ethics, and public policy; transdisciplinary research opportunities that are multi-scale, internships in industry and government; international experiences; and training to enhance oral and written communications skills. These aspects of training will be discussed in the paper presentation.

Preparing professional pedologists through field practicums and career experience

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Abstract

Soil science programs at US colleges and universities, especially land grant institutions and other large state schools, have provided many of the trained pedologists working for local, state, and federal agencies, particularly the soil survey program of the USDA-Natural Resources Conservation Service (NRCS). It has been projected that almost half of the approximate 500 field soil scientists employed by the NRCS will be eligible for retirement over a five year period. While actual retirements will be less, it is imperative that a new generation of field soil scientist be trained in proper field and laboratory methods, as well as in advanced methods of geospatial analysis, to ensure that soil survey programs are able to provide valuable products that are adaptable to changing user needs and compatible with other spatial resource data. There are several ways that colleges and universities can engage with students and employers to develop the knowledge and skills that will enable graduates to become effective employees that are capable of working productively with other scientists, as well as with those who use, manage, or otherwise make decisions that incorporate the information collected, analyzed, and distributed by soil scientists. Two important activities available within college and university soil science programs that enhance student training are field practicums and career experience. This presentation will discuss the key courses that are or should be part of a comprehensive training in pedology, emphasizing the important field, laboratory, and computer skills that should be taught. We will also discuss US government programs that enable students to gain work experience that is complementary to the student's academic program and career goals. These programs include the Student Career Experience Program (SCEP) and the Student Temporary Employment Program (STEP).

Producing the thinking soil scientist

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Abstract

There is an increasing expectation that graduates in the discipline of soil science not only have a good grounding in existing knowledge, but the technical abilities and generic skills that enable them to use interdisciplinary approaches to solve real world problems. In doing so graduates have to be able to interact with members of the community at all levels and understand the social, economic and cultural elements that affect the adoption of the solutions they will provide. To develop graduates with such a holistic approach would require students, teachers and industry engaging with each other at appropriate times during the education process. To achieve this, and presented here for the first time, the evolution of a Teaching-Research-Industry-Learning (TRIL) educational framework is described and supported by educational theories. When illustrated using some of the current teaching and learning activities (e.g. practical classes or problem-based learning) used by soil science educators in Universities the theoretical framework may not be as foreign as it first appears. To evaluate the usefulness of TRIL five Australian Universities are working with agencies, accrediting bodies and industry to determine its use for producing a national soil science curriculum answering the need for work-ready graduates.

Key Words

Work ready, soil education, national curriculum.

Introduction

Today's graduates need to be adept problem solvers, use interdisciplinary approaches and be technically proficient. For example, Bouma (1997) states that modern approaches to identifying and solving key issues in agriculture requires representation from a broad spectrum of the community, including agricultural scientists, government agents, environmental groups, producers and consumers. The development of graduates with a holistic approach requires greater synergy between students, teachers and industry. Surveys of students often indicate that teaching approaches tend to be traditional and teacher led. Many disciplines are also remote from industry such that, even with the best intentions, the development of work-ready graduates is lacking with problem-solving abilities being a common deficiency (AC Nielsen Research Services 2000). The Australian Vice-Chancellors have recognised the value of industry involvement in higher education for the development of work-ready graduates and have advocated a national internship scheme for all students (Universities Australia 2008). A recent Australian Learning and Teaching Council (ALTC) report on work-integrated learning has shown the growing trend in industry involvement in higher education and the benefits to students, universities and employers (Patrick *et al.* 2008).

As noted by Smiles *et al.* (2000) much of this is relevant to the discipline of soil science. Quoting John Philip when reflecting on his degree from Melbourne University 'all things are understood and that all a young engineer needs to know is what handbook to use' with the further point that 'a suppression of curiosity and the removal of the intellectual challenge made the course utterly boring and its products brain-dead'. Inspired by this quote Smiles *et al.* (2000) believes the challenge for soil science education is to stimulate curiosity and innovation while providing the students with a good grounding in existing knowledge. This also requires that students recognise the need for a holistic approach to solve real problems, but maintain their objectivity in their technical advice. They must be understandable when they interact with society and bureaucracy and understand that the application of soil science to problems has social, economic and cultural elements that affect its adoption by the end-user. To achieve this, a soil science educational framework needs to be developed that facilitates the interaction between the students, teachers and relevant industry parties.

The teaching-research-industry-learning (TRIL) framework

To satisfy the need for producing the thinking soil scientist to meet the challenges of the modern world, the TRIL framework needs to be considered. This framework illustrated in Figure 1 shows that learning by students and academics in a university is a complex interrelationship of teaching, research and association with industry.

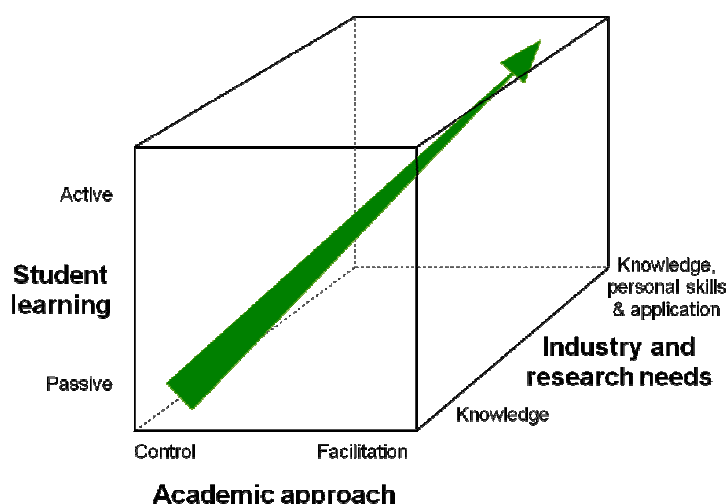


Figure 2. A further view of the Teaching-Research-Industry-Learning (TRIL) framework.

Learning is affected by the interaction between research and teaching and also by the impact industry has on them. Another view of the TRIL framework is given in Figure 2 and is concerned with the student, academic and industry with three axes that represent a continuum: student learning on a scale from passive to active; the academic teaching approach on a scale from controlling to facilitating; and the needs of industry, ranging from basic knowledge alone to knowledge, the application of knowledge, and the personal skills required to effectively perform in industry. The top right rear corner of the cube is where students are autonomous and independent learners enabled through academic facilitation to meet the needs of graduates for industry.

The theoretical justification for the relationship presented in Figure 2 begins with the concept that there is a need for a deep approach to learning so that students can relate theory and knowledge from different sources to construct a coherent whole. This is best achieved when students are active participants in their learning (Ramsden 2003) rather than passive recipients. This active learning needs to be supported by a teaching approach that relinquishes exclusive control by the teacher in favour of facilitation (Salmon 2003). Commonly, this often involves teaching and learning activities where the students interact with each other as well as the teacher. In particular, the students also have more choice in learning topics and assessment (Chickeing and Gamson 1991; McCombs and Lauer 1997; Boyer 1998; Duffy and Kirkley 2004). The intention is to focus on what the student does and promote student responsibility (Biggs 1999). Through this interaction it is also hoped, in addition to knowledge, that as graduates the students have acquired 'generic skills' or 'generic attributes' (Barrie 2004 2007). With these skills the graduates should have qualities such as adaptability, resourcefulness and flexibility to enable success in the workplace (Curtis and McKenzie 2001). This is best achieved by a closer liaison between employers and higher education when teaching and has been advocated for the mutual benefit of students and industry (Conner 2005). Furthermore, Garraway (2006) has noted that employers need to be part of the curriculum development process.

Looking at the teaching and learning activities that are currently used by soil science educators in Universities the TRIL theoretical framework may not be as foreign as it first appears. This can be illustrated by the following examples, all of which are satisfactory and relevant teaching and learning approaches used in soil science. If we consider the top left front corner of the framework, representing a controlled-active-knowledge building environment, this more than likely would represent many laboratory classes that students of soil science participate in throughout their degree.

Examples of soil science laboratory classes can be found that shift the activities towards the top right front corner where the teacher relinquishes control. In one such class the students negotiated with the teacher the theme of their study (e.g. heavy metal contamination or mineralogical characterisation of the profile). They then collected their own soil samples, were presented with a generic methods book, and had to write their findings for publication in the Australian Journal of Soil Research. The work was then assessed using the guidelines used by reviewers for accepting the paper for publication (Field and Gräfe 2007). The role of the instructors was to act as advisors as the expectation was the students would identify the appropriate; methods to use, data processing and manuscript preparation.

The controlled-active-application represented on the top left back corner of Figure 2 would describe case-based learning (CBL) commonly used not only in soil science but science in general (Smiles *et al.* 2000). In such an environment often students are presented with a problem and working with each other and the teacher acquire the knowledge and skills necessary to develop a solution. The key issue here is that the teacher has identified the problem and knows the answer to the problem that the student will finally present. More recently, an approach described as problem-based learning (PBL) is being used in the senior years at institutions that teach soil science (e.g. at The University of Sydney). The difference being that the students are put in contact with industry and work through a process to identify the problems and negotiate, with each other, industry and the teacher, which of these they are going to work through. The students are also expected to design the process and manage the problem, which they record and may be used in the assessment. As the problems are real the solution is not always known from the beginning, and as noted by Smiles *et al.* (2000), the solution has to take into consideration other factors such as economic constraints and/or government policy implications. Approaches such as PBL shift the learning to the top right far corner which should facilitate the development of the thinking soil scientist.

Researching for a curriculum

An additional challenge is the falling enrolments in sectors of the globe and the uneven distribution of academic expertise in institutions affecting the delivery of graduates with the required soil science expertise. This, in addition to the diversity of the Australian climate and landscape, has resulted in a partnership being formed between The University of Sydney and the universities of Melbourne, Adelaide, Queensland and Western Australia that will test the viability of the SAI framework to promote curriculum development. The key aim of this partnership is to involve industry more in student learning; establish shared and cooperative methods between universities to alleviate declining academic expertise in any one institution, and within the framework described above to develop learning and teaching processes to produce graduates with the knowledge and skills to meet the broad challenges facing the agricultural and environmental sectors. For this to occur representatives from other universities will be included as the project develops and a reference group includes representatives from: the Australian Council of Deans, the Australian Soil Science Society, Certified Professional Soil Scientists accreditation body, and industry partners. By looking at current teaching practices and canvassing the opinions of students, university staff and industry participants over a number of iterative action-cycles it is hoped that an overarching national soil science curriculum will start to emerge to address the key aims outlined.

Conclusions

This paper has highlighted the need for graduates who are work-ready and prepared to solve complex real world problems. Current thinking is that this is achieved through a strong engagement of the student, academics and industry in common teaching and learning environments. To support this a Teaching-Research-Industry-Learning (TRIL) framework has evolved and can accommodate the current teaching and learning practices already used in soil science, but also should prove useful when developing and mapping a curriculum that requires the input from students, teachers and industry.

References

- AC Neilsen Research Services (2000) 'Employer Satisfaction with Graduate Skills'. Research Report. Department of Education, Training and Youth Affairs.
- Biggs J (1999) 'Teaching for quality learning at university: What the student does'. (SHRE and Open University Press: Buckingham).
- Bouma J (2001) The new role of soil science in a network society. *Soil Science* **166**, 874–879.
- Boyer EL (1998) The Boyer Commission on Educating Undergraduates in a Research University. Reinventing undergraduate education: A blueprint for American research universities. <http://naples.cc.sunysb.edu/Pres/boyer.nsf/>
- Chickering AW, Cummings R (2007) 'New Directions for Teaching and Learning: Applying the Seven Principles for Good Practice in Undergraduate Education'. (Jossey-Bass Inc.: San Francisco).
- Curtis D, McKenzie P (2001) 'Employability skills for Australian Industry: literature review and framework development'. (DEST).
- Duffy TM, Kirkley JR (2004) Learner-centred theory and practice in distance education: Cases from higher education. (Lawrence Erlbaum Associates: Mahway, NJ).

- Field DJ, Gräf M (2007) From experimentation to publication: Challenging students perceptions of scientific research. In 'Proceedings of the International Society for the Scholarship of Teaching and Learning, Sydney, NSW'
- Garraway J (2006) Creating productive interactions between work and the academy. *Higher Education* **52**, 447-464.
- McCombs BL, Lauer PA (1997) Development and validation of the learner-centred battery: Self-assessment tools for teacher reflection and professional development. *The Professional Educator* **20**, 1-21
- Patrick C-j, Peach D, Pocknee C, Webb F, Fletcher M, Petro G (2008) 'The WIL [Work Integrated Learning] report: A national scoping study. Australian Learning and Teaching Council Final report'.
- Ramsden P (2003) 'Learning to teach in higher education. Second Edition, RoutledgeFalmer'. (Ilen and Unwin).
- Salmon G (2003) 'E-moderating: The Key to Teaching and Learning Online'. Second Edition. (RoutledgeFalmer: London, New York).
- Smiles DE, White I, Smith CJ (2000) Soil science education and society. *Soil Science* **165**, 87-97
- Universities Australia (2008) 'A National Internship Scheme: Enhancing the skills and work-readiness of Australian university graduates'. Position Paper No. 3/08, May 2008.

The challenge of soil science undergraduate education

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One of the not-so-delicious ironies of soil science undergraduate education in Australia, and probably most other parts of the world, is that the more ‘big ticket’ soil issues emerge and get airplay in the public domain, the fewer students seem to engage with degree courses containing significant components of soil science. Over the last five years, the demand from Australian employers for soil science graduates has outstripped supply from Australian universities. Globally, the interest in food, fuel and latterly climate change, has “...brought soils back onto the global research agenda” (Hartemink and McBratney 2008). Despite this, the discipline of soil science does still not appear strongly on the radar of school-leavers looking to make their mark in the world (Collins 2008). It would seem that as discipline-promoters, soil scientists make good soil scientists.

Putting aside the difficulties of undergraduate recruitment, however, there is a separate set of challenges that face soil science educators once a pedon of soil science students actually enrol. These challenges can be glibly encapsulated as ‘what and how do we teach them?’ Addressing first the ‘what’, over the last 20 or 30 years there are a number of developments in both university structures and the profession of soil science that have ‘changed the landscape’ of soil science education. As Collins (2008) points out, the majority of university soil science units are embedded in agriculture courses, but with declining enrolments in these courses, the number of soil science departments and indeed the faculties of agriculture that generally house them, have been gradually whittled away. Consequently, the number of individual units that any given faculty can offer in soil science, and the breadth and depth of teaching in soil science, has slowly been reduced also. Smiles *et al.* (2000) assert that “...in Australia, no school of soil science is big enough to offer a reasonable spectrum of skills required...”

Using my own experience as an example, when I undertook the introductory soil science unit (8 credit points) in the 2nd year of my agricultural science degree in the late 1980s, I endured 46 hours of lectures and approximately 60 hours of practical sessions, including two afternoon fieldtrips. The content included coverage of soil morphological properties, structure, soil strength, pore space relations, infiltration, the moisture characteristic, static columns, drainage models, irrigation models, clay mineralogy and structures, rocks and minerals, geology, soil thin sections, soil water extracts, EC, pH, OC, P, lime requirement, soils of New South Wales, district soils and climate, t-tests and ANOVAs. If we wind the clock forward twenty years to the present introductory soil science unit (6 credit points) at The University of Sydney, students are subjected to 36 hours of lectures and approximately 30 hours of practical session, including 1.5 days of fieldwork. Although there has been some (university-imposed) deflation in the number of contact hours per credit point (13 to 11), the bigger change has been in the amount of content covered. In today’s introductory unit we cover soil morphological properties, soil formation factors, structure, soil strength, pore space relations, infiltration, the moisture characteristic, clay mineralogy and structures, rocks and minerals, soil water extracts, EC, pH, OC, P, N and lime requirement. Some of the material covered in the introductory unit 20 years ago has now either been shuffled up into the intermediate or senior soil science units or omitted altogether. A similar story can be told for the content of intermediate and senior soil science units of yesteryear.

It can be argued, however, that the loss of some content from these soil science units is not necessarily a bad thing, as the expectations of students and of employers have also changed over the last 20 years. Rightly or wrongly, many of today’s undergraduates appear to believe that a university education is a transaction – money for knowledge. A perceived lack of ‘useful content’, or a perceived heavy workload, usually results in some punishing student evaluations of teaching; as student evaluations are routinely obtained for units of study, academics are acutely aware that evaluation results may be used outside the confines of the unit, such as by a panel deciding on a promotion case. Such tensions may not encourage innovative teaching practices or clear-headed reviews of content. Judging by the changing suite of employers of soil science graduates, the expectations of those employers must also have changed. A review of the employers of members of the Australian Society of Soil Science Inc. in 2008, 1998 and 1988 revealed some seismic shifts in where soil

scientists work. In 1988, around 140 ASSSI members worked for the research organisation CSIRO; by 2008, this number had dropped to around 40. A similar dramatic fall is evident for ASSSI members employed by government departments (250 in 1988, 125 in 2008), while the number of university employees (including postgraduate student members) belonging to ASSSI has been largely stable (around 150) over that time period. The only category of employer with a substantial increase in ASSSI members has been that of consultants (15 in 1988, 125 in 2008) – anecdotal evidence suggests that this employer group will continue to increase its share of the ASSSI membership in the future.

So how will this change in the workplace of soil scientists affect what we teach them? Well, for a start, in this age of out-sourcing routine laboratory analysis of soil to commercial laboratories, it is probably not so critical that soil science undergraduates be trained to use every shiny piece of gear in an analytical laboratory. Certainly, graduates need to be aware of what the acronyms AAS, GC and XRD mean, what the new and emerging bits of technology are, and how they might interpret the data to emerge from such machinery, but for many of them a university practical might be the first and last time they ever use such a machine. Instead, as indicated by others already (e.g. Smiles *et al.* 2002; Hartemink and McBratney 2008; Ferris *et al.* 2010), soil science graduates must be prepared to use their discipline knowledge and understanding to solve complex environmental and agricultural problems as part of multi-disciplinary teams. They must be able to apply their knowledge to a variety of scenarios, be able to confidently analyse and interpret soil data, know where to go to get relevant information and be able to communicate effectively to a wide range of clients or stakeholders. With the steady infiltration of soil science graduates into the world of policy and regulation, more than ever our graduates need to be able to clearly put across technically strong information to an often disbelieving and ignorant client.

The ‘how’ of undergraduate soil science teaching is slowly changing in reaction to the changing role of soil science graduates. As unpalatable as it might seem to traditional educators, most undergraduates feel no qualms about ‘Googling up’ answers to quizzes or exams set by academics. The days of students needing to rote learn Darcy, Langmuir and Stokes have passed (‘why, when I can get it from the internet?’); the modern mantra is ‘problem-based learning is best’. Of course, there’s always got to be a solid nugget of domain knowledge that needs to be passed on before students can reasonably be expected to solve multi-faceted soil problems, but the in-built extras of problem-based learning include the development of student independence, the development of team-work, an appreciation of the social and economic contexts in which soil science operates, and an appreciation of the sorts of soil-related problems that confront Australia and the world. The challenge of soil science undergraduate education is to give our students the interpretation and communication skill-set to effectively utilise their nuggets of soil science knowledge in a moveable feast of opportunities.

References

- Collins ME (2008) Where have all the soils students gone? *Journal of Natural Resources and Life Sciences Education* **37**, 117–124.
- Ferris DR, Hattey JA, Mullen MD (2010) Growing the soil science profession through investment, vestment, and validation. *Soil Science Society of America Journal* **74**, 453–460.
- Hartemink AE, McBratney AB (2008) A soil science renaissance. *Geoderma* **148**, 123–129.
- Smiles DE, White I, Smith CJ (2000) Soil science education and society. *Soil Science* **165**, 87–97.

The soil scientist in the 21st Century

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There is increasing awareness amongst policy makers that soils often play a key role within the global environmental system. The debate on climate change and the need to sequester carbon has relatively recently recognized the important role of the soil carbon pool, and soil scientists are increasingly involved in setting national and international strategies for managing soil carbon and where appropriate increasing the carbon pool in some soils through an understanding of the fate of carbon in the soil system. Coupled with these concerns about carbon budgets there is also increased awareness of the need to sustain and increase food production and the importance of maintaining soil quality in meeting new food production targets. It is now more widely recognized, perhaps somewhat belatedly that soil management is a key component of the sustainable food production system.

For the final third of the twentieth century there was in many countries of the world a decline in the number of soil scientists being trained and the opportunities for employment in the University, Research and Business sectors were limited. Within these early years of the twenty first century this increasing awareness of the importance of soils in so many aspects of our lives, is giving rise to increased demand for well trained soil scientists. Soil Science has a need to catch up if we are to meet this demand, we must train more soil scientists. The question which must be addressed however is what skills do we expect of our new breed of soil scientists? In the past many soil scientists had chemistry as the underlying academic training and whilst this is still important we must ensure that our new breed of soil scientists have a broader awareness of environmental systems and the role of soils in these systems and the contributions of soils to the ecosystems services provided by these systems. Soil science and soil scientists must be able to work across disciplinary boundaries and be able to communicate their knowledge to the non-specialists. If we are not able to rapidly communicate our information in a clear and understandable form to those who make decisions we shall not be listened to and the key role of soils will be recognized but no appropriate action taken. The training we provide must embrace both the scientific and social context of soils and must focus on communication across a broad range of media. Increasingly in the United Kingdom we are looking to internships to provide an additional aspect to the training where students are able to experience the practical application of their education. In most cases those experiencing internships are more readily employable at the end of their studies. This presentation will present examples of recent experiences in the changing nature of the training of soil scientist and suggest some ideas for the future.