LINKING RESEARCH AND TEACHING IN THE EARTH AND ENVIRONMENTAL SCIENCES THROUGH THE CRC LEME EDUCATION AND TRAINING PROGRAM

Patrick R. James

CRC LEME, Department of Geology & Geophysics, School of Earth & Environmental Sciences
University of Adelaide, SA 5005.

INTRODUCTION

The Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) is a large and complex research and research training enterprise in the Earth and Environmental Sciences, which began operations on July 1 2001. Almost 100 researchers are currently working on CRC LEME research projects, and are not only based in capital cities across southern Australia, but also often work on field-based projects in remote areas. Likewise, almost 80 postgraduate and Honours students are currently working independently, with multiple research supervisors and in research teams across Australia. These students not only carry out active research involving data gathering, synthesis and publication, but are also participants in a range of coursework and short course training programs (e.g., Roach 2003). There is also a significant population, within the core party universities and others, of undergraduate earth and environmental science students, who are studying landscape and regolith-related topics, forming a potential pool of future postgraduate research students. The integrated linkage of the research activities with undergraduate and postgraduate training provide an excellent opportunity to investigate, develop and implement synergies between them, in order to provide beneficial outcomes to both.

THE RESEARCH ACTIVITY

The purpose and vision of CRC LEME are focussed on achieving breakthroughs in mineral exploration and contributing to environmental management through knowledge of the regolith (Smith & Wilkes 2002). The core science of CRC LEME is developing and utilising new aspects of geophysics, geochemistry and geology. This effort is concentrated on understanding and dealing with the regolith, which is commonly both thick and ancient, and includes soils, sands, sediments and weathered rock that overlie bedrock across much of Australia. The application of this science is principally for mineral exploration, mining and environmental conservation and management. New knowledge is also being generated in collaborative studies of the important environmental problems of dryland salinity and water quality, which will also generate new knowledge and data sets for mineral exploration. Regolith geoscience is fundamental to many aspects of Australian life yet this is not widely recognised in the community. A simple example is that many decisions are made in the construction industry with little or no regard for the regolith on which these structures will stand. CRC LEME aims to solve problems vital to the future wellbeing of the Australian community.

CRC LEME research activities are organised under a number of umbrella research Programs (each headed by a Program Leader). Within the Programs, students and research staff work in teams on individual research projects, which may range from single researchers to teams of 5-10 staff and students. Up to 50 projects may be active at any one time. Projects may also be carried out in remote field areas and range, for example, from mapping large areas, which are highly prospective for gold in the western Australian goldfields, to mapping salinity hazards in the Murray basin, and overall cover all States and Territories of Australia (except Tasmania and the Australian Antarctic Territory). As well as remote area field studies, most researchers and students are based and work in laboratories in Capital cities using arrays of sophisticated analytical and computer equipment and visualisation and presentation software.

THE EDUCATION AND TRAINING PROGRAMME

There are multiple challenges within the CRC LEME Education and Training Program (Program 5) which include: improving the regolith knowledge and skills of current students and working scientists; educating professionals in areas other than regolith geoscience; informing decision-makers at Federal, State and Local Government levels on how improved regolith knowledge is important to solving many fundamental issues in Australia; educating the community about regolith and regolith-related issues; and finally providing a dynamic and vibrant communication environment for education and technology transfer using innovative and emerging information and communication technologies.

In terms of topic speciality, students from within each core party University are spread across the range of research activities. Thus, one challenge of the education and training program, has been to facilitate

interactions across the country between students with similar research topics and problems, and also to allow students to interact with specialists in their topics of interest, but from widely separated geographic locations. These activities are not only focussed on the honours and postgraduate students undertaking research during their training, but also on the cohorts of undergraduate students learning regolith-related topics and eventually feeding in to the research.

DEFINITION OF THE TEACHING-RESEARCH NEXUS

A key factor in the re-evaluation of the role of universities, brought on by the recent rapid growth in the student population related to the change to mass higher education and the global expansion of the knowledge and information society, is a much closer investigation of the links between research and teaching, more commonly referred to as the "teaching/research nexus". Conflicting ideas have variably led the debate to conclusions where "separatists" argue that no such nexus exists. For example, Feldman (1987) asserts that the likelihood that research productivity actually benefits teaching is extremely small, and the two are essentially unrelated. Also, Hattie & Marsh (1996) conclude that the common belief that research and teaching are inextricably entwined is an enduring myth and at best, research and teaching are very loosely coupled.

On the other hand, "integrationists" have long valued and championed the linking of teaching and research in universities. From the earliest studies of the Robbins report in 1963 (Robbins 1963), which stated that "the element of partnership between teacher and taught in a common pursuit of knowledge and understanding, present to some extent in all education, should become the dominant element as the pupil matures and as the intellectual level of work done rises", the cultural value of the teaching/research nexus has been integral to the pursuit of higher education. Most recent pedagogic research in the 21st century has argued that with current supercomplexity of knowledge and information students' understanding of knowledge generation through research (and perhaps their ability to do research) the link between teaching and research is vital (Barnet 2000)

According to Brew & Boud (1995). The fundamental and common link between teaching and research is that both are concerned with the act of learning. The teaching/research nexus is not only valuable to students who benefit from the observation of knowledge discovery, creation and integration, but it can also be valuable to staff who can learn to better manage conflicting demands on limited time and improve morale and pride in their own endeavours. The role of the academic department/discipline in underpinning the teaching/research nexus is recognised as critical and the fundamental arguments are that the teaching/research nexus is central to higher education, and also that the linkage is not automatic and has to be developed (Jenkins & Zetter 2003).

Many of these arguments and a variety of related articles investigating the links between teaching and research can be found in issue #3 of Exchange, entitled "Linking Teaching and Research" (http://www.ltsn.ac.uk/genericcentre/index.asp) published by the UK Learning and Teaching Support Network (LTSN). The LTSN includes a large number of subject and discipline centres, with the LTSN Generic Centre in Oxford supporting national cross-disciplinary projects. One such project is entitled Linking Research and Teaching in the Disciplines and a recently published guide (http://www.ltsn.ac.uk/genericcentre/index) outlines and summarises many of the issues, whilst also providing ideas, examples and guidance based on research, evidence and experience. It aims to explore how to embed teaching/research links in disciplinary communities, to create generic support materials, including web pages and also to involve five of the LTSN Subject Centres in the project.

The Geography, Earth and Environmental Science (GEES) LTSN Subject Centre, based at the University of Plymouth, is a partner in the Linking Teaching and Research in the Disciplines project. Its brief is to develop dedicated pages on the GEES website, prepare an annotated bibliography, collect, edit and publish at least 20 case studies, organise a national conference (June 30/July 1, 2003), prepare a review essay and to publish a special edition of Planet its biannual magazine/journal. A full description of the current study on linking teaching and research within LEME is in press in this forthcoming issue of Planet (James *et al.*, in Gaskin in press)

Case studies from the UK are being collected by GEES as exemplars for the promotion of the teaching/research nexus and are shown on the GEES website <http://www.gees.ac.uk>. At Liverpool University final year students work in teams on field-based projects related to staff research in Santa Cruz, while students across all three years of an environmental studies degree course at the University of Sunderland work together on local sustainability projects. Students at University College London interview

staff about their research and geology students from Greenwich University annually carry out independent research projects with local companies and government organisation in Cyprus. At Durham University the techniques of digital geological mapping are being taught at undergraduate field camps in areas of current staff research. Likewise other examples of teaching/research links in undergraduate education from around the world are being compiled. A problem-based learning approach to teaching research methods in geography is used at the University of Canterbury, New Zealand. Students and staff from the University of Canberra (and CRC LEME) have been involved in joint research on regional geological mapping projects for many years, and team-designed and -implemented projects have been developed to simulate a Qualitative Research Methods course at Wollongong (Waitt 2003). Also at Adelaide University third year undergraduates communicate with journal publication authors whilst developing Interactive Multimedia (IMM) modules based on cutting edge research articles. They are also beginning to learn geophysical techniques and their application in postgraduate research student field areas and shortly they are about to embark on a gold drilling program associated with real world mineral exploration.

One area in the EES subjects, where the link between teaching and research can be perhaps most closely understood, is in the program of field studies or fieldwork that is crucial to all investigations and scholarship. Fieldwork is highly valued both as a critical educational element (Kern & Carpenter 1984, 1986, Locke 1989, James & Clark 1993) and as a link between teaching and research (Edwards 2003, McCaffrey *et al.* 2003, Shah & Treby 2003) in the earth and environmental sciences. Field exercises, tours, excursions and camps allow close encounters between active researchers and their students, often in areas where the current research activity is being carried out. Field teaching is inherently motivating, effective, interesting, enjoyable and rewarding and is valued both by the students (Fuller *et al.* 2003) and by academic staff (Andrews *et al.* 2003). The linking of teaching and research in the field makes both more relevant, in that research informs and affects the teaching, and the teaching provides a reality check and critical appraisal of the research. Fieldwork has long been fundamental and immoveable in the undergraduate curriculum. Likewise field studies form the basis for the majority of EES research projects and studies. In 2001 the UK foot & mouth disease outbreak caused the cancellation of most undergraduate EES field teaching in the UK. A comprehensive study of the student perceptions of the effects of this dramatic change to teaching methodology caused by this significant event, demonstrated by its enforced removal from the curriculum, confirmed the intrinsic value of fieldwork and the research experience in the overall student learning experience (Fuller *et al.* 2003)

CASE STUDIES OF LINKED TEACHING AND RESEARCH WITHIN CRC LEME

One case study linking teaching and research in the geosciences was recently described within LEME News (issue# 23) and involves the Level 3 Mineral and Environmental Geophysics field training in Pedo-Geophysics in the Adelaide Hills. The Herrmann's Catchment about 40 km northeast of Adelaide is currently the research area of two University of Adelaide CRC LEME-funded PhD students, and is being used to train undergraduate students in field geophysical techniques and exploration targets. The field-site geology hosts Cambrian massive sulphide mineralisation and a variety of related environmental problems, principally salinity, acid drainage and acid sulphate soils (Fitzpatrick *et al.* 2003). The two PhD students who work in the area are Andrew Baker, an isotope geochemist mapping mineral pathways through cover sequences, and Mark Thomas, who is working on transient salinity effects using geophysics to map areas susceptible to salinity.

In May 2003, eighteen undergraduate students designed and carried out a geophysical investigation to address some of the fundamental regolith issues in Herrmann's catchment, which had previously been defined within the research aims of the postgraduate student projects. In terms of environmental objectives these included the definition of near-surface hydraulic structure, mapping of clay concentrations, the identification of salinity pathways and areas of transient salinity and the relationship of geophysical signatures to pedological information. Mineralisation identification included definition of depth to basement, location of sulphides, fracture orientation as potential pathways for fluid flow and aquifer structure (Skwarnecki *et al.* 2002).

Nine different geophysical techniques were carried out along profiles across the catchment including DC resistivity and induced polarisation (IP), seismic refractions, gravity, magnetics, magnetic susceptibility, electromagnetics (EM), self potential (SP) and elevation. Initial results of the surveys were very exciting for the postgraduate researchers as well as the undergraduate students. The most interesting features discovered were short-wavelength (< 20 m), but very highly magnetic responses within the valley probably due to maghaemite concentrated in palaeochannels sourced from colluvial accumulations after bushfires on the valley slopes. Mapping mineralisation beneath cover was the second series of objectives. Locating sulphide

mineralisation at the head the catchment is important in determining the controls on formation of acid sulphate soils, and sources of acid drainage. The resistivity and IP surveys found clear evidence for sulphides in basement beneath cover and although the formations have been drilled previously, profiles collected in one afternoon at very low cost, provided considerable extra constraint on the depth and extent.

The Herrmann's catchment field geophysics has been valuable as a combined teaching and research exercise. Students were presented with real CRC LEME exploration and environmental problems, and developed field data collections to address some of the issues. The students developed teamwork skills and gained a better understanding of the importance of integrating geophysical, geological and geochemical constraints. For the LEME postgraduate researchers, the teamwork effort of the students provided new data and models that would have been time consuming to achieve otherwise.

In another example where research and teaching are being linked in the geoscience education program, twenty five Adelaide University students in a Level 3 Mineral Deposits course are undertaking a week-long exploration drilling program around the Barnes prospect in the newly named Central Gawler Gold (CGG) Province of South Australia (Ferris & Schwarz 2003), some 600 km west of Adelaide. The Proterozoic Gawler Craton of South Australia contains the world class Cu-Au-U Olympic Dam mineral deposit, the newly opened Challenger gold deposit and many new and emerging gold prospects and targets. It is thus the site of intense research and exploration activity, much of which is being carried out by State and Federal geoscience organizations (Primary Industries and Resources South Australia and Geoscience Australia), mining and consultancy companies, research organizations (CRC LEME and CSIRO Exploration and Mining) and academic researchers.

Much of the research activity has been fuelled by the high-resolution geophysical (airborne magnetics, gravity, radiometric and multi- and hyperspectral) surveys, and the success of geochemical sampling focused around using the widespread surficial calcretes as surrogates for buried basement mineralisation. The Barnes Gold Project (Drown 2003) is a recently discovered gold prospect, where Adelaide Resources Limited have drilled a blind bedrock-hosted gold mineralisation target beneath a gold-in-calcrete geochemical anomaly Company drilling so far has revealed mineralisation associated with phyllic and propylitic alteration, and quartz vein systems with significant gold intersections, including an 8 m interval at 2.97 g/t and a maximum published intercept of 2 m at 67.6 g/t gold.

The CGG Province is thus in the midst of an emerging resources boom and gold rush. Students on the excursion will work with the most modern and up-to-date research and exploration data. They will plan and carry out a variety of drilling and sampling procedures using a rotary diamond drill rig and percussion drill. Further definition and resolution of the gold-in-calcrete anomaly and its extension beneath transported and surficial colluvium and dune deposits will be investigated. As well as conducting the drilling and sampling, they will return the samples to the laboratory for assay and analysis, and it is hoped that many of them will continue to further study (Honours), research (Postgraduate) or exploration (company) with industry on related projects.

At the University of Canberra, there has been a long tradition of integrating undergraduate field mapping exercises in geological research programs by Ken McQueen, Leah Moore and others, and in the current volume, Hill (2003) outlines a similar whole of catchment field training study which exemplifies the value of this link and its wider use across the LEME nodes.

CONCLUSIONS

As a cooperative research and research training organisation, CRC LEME has a unique opportunity to link the research projects of it staff with the undergraduate teaching and research training activities of its students. This link potentially provide benefits to both and must be considered in the future development of its education and training and technology transfer program.

REFERENCES

ANDREWS J., STEWART M., SOUGNEZ W., STOTT T. & KNEALE P. 2003. Staff perceptions of the role of fieldwork in the UK GEES curriculum. *Linking Teaching and Research in the Geography, Earth and Environmental Sciences Conference* **abstracts**, p20.

BARNETT R. 2000. Realizing the University in an age of supercomplexity. *The Society for Research into Higher Education,* Open University Press, Buckingham.

BREW A. & BOUD D. 1995. Teaching and research: establishing the vital link with learning. *Higher Education* **29**, 261-273.

DROWN C. 2003. The Barnes Gold Project – discovery in an emerging district. *MESA Journal* **28**, 4-9.

EDWARDS S. 2003. Integrated teaching and research in geography and the earth and environmental sciences as exemplified by the Greenwich-Cyprus initiative. *Linking Teaching and Research in the Geography, Earth and Environmental Sciences Conference* **abstracts**, p9.

FELDMAN K.A. 1987. Research productivity and scholarly accomplishment of college teachers as related to their instructional effectiveness: A review and exploration. *Research in Higher Education* **26(3)**, 227-298.

FERRIS G. & SCHWARZ M. 2003. Proterozoic gold province of the central Gawler Craton. *MESA Journal* **30**, 4-12.

FITZPATRICK R.W., COX J.W. MUNDAY B. & BOURNE J. 2003. Development of soil-landscape and vegetation indicators for managing waterlogged and saline catchments. *Australian Journal of Experimental Agriculture* **43**, 245-252.

FULLER I., GASKIN S. & SCOTT I. 2003. Student perceptions of geography and environmental science fieldwork in the light of restricted access to the field, caused by foot and mouth disease in the UK in 2001. *Journal of Geography in Higher Education* **27/1**, 79-102.

GASKIN S. in press. Linking teaching and Research in the Geography, Earth and Environmental Sciences. *The Planet*.

HATTIE J. & MARSH H.W. 1996. The relationship between research and teaching: A meta-analysis. *Review of Educational Research* **66(4)**, 507-542.

HILL S.M. 2003. An undergraduate regolith-landform education and training program within the Shoalhaven River catchment, NSW. *In:* ROACH I.C. ed. *Advances in Regolith*, pp. 182-186. CRC LEME.

JAMES P.R. & CLARK I.F. 1993. Grid sketching to aid geological mapping in an area of complex polydeformation. *Journal of Geological Education* **41**, 433-437.

JAMES P.R., HEINSON G. & SCHMIDT MUMM A. in press. Linking teaching and research in the undergraduate fieldwork training program at the University of Adelaide, South Australia. *In:* GASKIN S. ed. *Planet*. Special edition on linking teaching and research in the Earth and Environmental Sciences, Geography, Earth and Environmental Science. LTSN (Learning and Teaching Support Network), University of Plymouth, UK.

JENKINS A. & ZETTER R. 2003. *Linking research and teaching in the Departments*. LTSN Generic Centre, 25p.

KERN E.L. & CARPENTER J.R. 1984. Enhancement of student values, interests and attitudes in Earth Science through a field oriented approach. *Journal of Geological Education* **32**, 299-305.

KERN E.L. & CARPENTER J.R. 1986. Effect of field activities on student learning. *Journal of Geological Education* **34**, 180-183.

LOCKE W.W. 1989. A non traditional geology field trip. *Journal of Geological Education* **37**, 107-109.

MCCAFFREY K., HOLDSWORTH R. & WILSON R. 2003. Digital structural mapping of the Moine Thrust foreland at Loch Assynt: and example of interaction between research and teaching. *Linking Teaching and Research in the Geography, Earth and Environmental Sciences Conference* **abstracts**, p10.

ROACH I.C. 2003. Three years of MTEC. *In:* ROACH I.C. ed. *Advances in Regolith*, pp. 345-351. CRC LEME.

ROBBINS 1963. Future of higher Education in the UK, Committee on Higher Education CMND 2154

SHAH A. & TREBY E. 2003. Linking teaching and research within the Bourne Stream partnership: a community based project. *Linking Teaching and Research in the Geography, Earth and Environmental Sciences Conference* **abstracts**, p11.

SKWARNECKI M., FITZPATRICK R.W. & DAVIES P.J. 2002. Geochemical dispersion at the Mount Torrens lead-zinc prospect, South Australia, with emphasis on acid sulfate soils. CRC LEME **Restricted Report No 174**.

SMITH R. & WILKES P. 2002. A vision for regolith research in Australia. *Geoscience 2002: Expanding Horizons.* Australian Geological Society **Abstracts 67**, p. 432.

WAITT G. 2003. Qualitative research methods: a team designed and implemented project. LTSN GEES "Linking Teaching and Research Case study". Http://www.gees.ac.uk/linktr/Waitt.htm.