

DEVELOPING UNDERGRADUATE RESEARCH AND INQUIRY

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<http://resources.glos.ac.uk/ceal/>; <http://resources.glos.ac.uk/tli/prsi/current/ugresearch/index.cfm>;
www2.warwick.ac.uk/fac/soc/sociology/research/cetl/

**Further and more detailed case studies, including national examples, references and list of useful
web sites may be found at:**

<http://resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/index.cfm>

QUOTES

"Involving students in inquiry - in research - is a way of improving their learning, motivating them more. After all, what motivates large numbers of academics is engaging in the excitement of research. Bringing research and teaching together is a way of enhancing the motivation of both academics and students."
(Brew, in preface to Jenkins et al., 2003, ix)

"... universities should treat learning as not yet wholly solved problems and hence always in research mode." *(Humboldt, 1810 translated 1970, quoted by Elton, 2005, 110)*

"In an age of 'supercomplexity' (Barnett 2000), and given the increased significance of the knowledge economy and the growth of interdisciplinarity, teaching and research are becoming ever more intimately related ... In a 'knowledge society' all students – certainly all graduates – have to be researchers. Not only are they engaged in the production of knowledge; they must also be educated to cope with the risks and uncertainties generated by the advance of science." *(Scott, 2002, 13)*

"For the students who are the professionals of the future, developing the ability to investigate problems, make judgments on the basis of sound evidence, take decisions on a rational basis, and understand what they are doing and why is vital. Research and inquiry is not just for those who choose to pursue an academic career. It is central to professional life in the twenty-first century." *(Brew, 2007, 7)*

"Developing the Student as Scholar Model requires a fundamental shift in how we structure and imagine the whole undergraduate experience. It requires, as a minimum, the adoption of the Learning Paradigm in everything from the first introductory course through the final capstone experience. It requires a culture of inquiry-based learning infused throughout the entire liberal arts curriculum that starts with the very first day of college and is reinforced in every classroom and program." *(Hodge et al., 2007, 1)*

INTRODUCTION

This 'project' grows out a long standing interest in the wider issue of bringing together 'teaching', particularly at undergraduate level, and discipline-based research. But here our focus is centrally on the *learning that follows through engaging students in some form of 'inquiry' or 'research'*. This work is influenced by US undergraduate research programmes, where selected students in selected institutions learn through doing research, often outside the formal timetable and curriculum. A number of similar programmes are now available in the UK (Jenkins and Healey, 2007a). Our main interest is in mainstreaming student inquiry and research for *all / many* students in *all* higher education institutions (Healey and Jenkins, 2008; Jenkins and Healey 2007b; 2009; Jenkins 2007).

September 2009

Our focus here is on issues facing disciplines, departments and institutions. We have commented on some of the initiatives to link research and teaching in national systems elsewhere (Healey and Jenkins 2007). This is very much work in progress and we would welcome comments and in particular case studies of interesting practices in which you are involved. If you are interested please contact the authors.

A: CONCEPTUAL AND POLICY ISSUES

1. Conceptions and Perspectives on Teaching-Research Relations

Table 1: Different ways of linking research and teaching

- Learning about others' research
- Learning to do research – research methods
- Learning in research mode – enquiry based
- Pedagogic research – enquiring and reflecting on learning

Table 2: Examples of ways in which learners may be engaged with Boyer's four scholarships

Types of Scholarship	Illustrative example of ways of engaging learners
Scholarship of discovery	Engage in inquiry-based learning; undergraduate research and consultancy projects; co-research projects with staff
Scholarship of integration	Engage in integrating material from different sources, including across disciplines; integrate life and work experience with academic studies; reflect on implications of studies for personal development
Scholarship of application / engagement	Engage with local, national, and international community service projects; volunteering; knowledge exchange projects; apply knowledge and skills in work-based placements
Scholarship of teaching and learning	Engage in mentoring; peer support and assessment; collaborative group work; learners as explicit partners in educational development and inquiry

Source: Healey and Mason O'Connor (2007, 8)

Table 3: Educational paradigms

Paradigm	Approach
Teaching	Telling students what they need to know
Learning	Engaging students in learning how to learn; emphasis on learning what they need to know
Discovery	Encouraging students to seek and discover new knowledge

Source: Hodge *et al.* (2007, 3)

Table 4: Linking research and teaching: Different views

“Our view is that university research often detracts from the quality of teaching. We regret the continuing elevation of research and the systematic neglect of the quality of instruction.” (Pocklington and Tupper 2002, 7 – about Canada)

“Courses taught by those at the cutting edge of research will necessarily be of higher quality than those taught by those merely using the research results of others – whatever the apparent quality of their style of delivery. Furthermore, if teaching is undertaken by researchers the linkage is automatic, even if, as is often the case they are not always teaching about their own narrow research specialism.” (Lee 2004, 9 – with particular reference to geography in UK)

The New Zealand Education Amendment Act (1990) defines a university as where “teaching and research are closely interdependent and most of their teaching is done by people who are active in advancing knowledge” (cited by Woodhouse, 1998; policy audited in the late 1990s but received less emphasis since).

In *Scholarship Reconsidered* Ernest Boyer (1990, xii) challenged US higher education to “break away out of the tired old teaching versus research debate.”

“... we want all students to access the benefits exposure to teaching informed by research can bring.... This will take many forms including pure and applied research that feeds curriculum development; but also research and development that tackle the challenging questions facing professional business, regional and local employers now and in the future. We’re doing this because we believe an understanding of the research process – asking the right questions in the right way; conducting experiments; and collating and evaluating information – must be a key part of any undergraduate curriculum; whether or not those involved in delivering it are actively engaged in research activity themselves.” (Bill Rammell, Minister for Higher Education, UK, 2006, 3)

“Why does every University, thirty-eight of them, public ones, why do they all have to be doing research, teaching and scholarship and struggling to do it in so many areas? Why can't we have Universities that make a conscious decision to specialise in outstanding teaching and scholarship but do very little research? Why can't we have formal affiliations, one specialising in teaching and another research, between our domestic Universities?” (Brendan Nelson, Minister for Education, Science and Training, Australia, April 2005)

“I propose that colleges and universities provide an opportunity for all undergraduates to conduct research — to create knowledge.” (Ellis, 2006; Professor of chemistry at the University of Wisconsin at Madison, on detail as director of the National Science Foundation's chemistry division through June 2006)

Table 5: Relationships between conceptions of research

Research is oriented towards:	Research aims to:	The researcher is present to, or the focus of, awareness	The researcher is absent from, or incidental to, awareness
↓	↓		
External products	Produce an outcome	Trading view	Domino view
Internal processes	Understand	Journey view	Layer view

Source: Brew (2003, 6)

Brew (2003, 6-7), on the basis of interviews with 57 senior Australian academics has identified 4 different conceptions of research (Table 4):

- Trading view – “in the foreground are the products of research: the end points, publications, grants and social networks, i.e. aspects external to the process of doing the research. These are viewed as being linked together in relationships of recognition and reward.”
- Domino view – “the researcher’s focus is on the solutions to problems and the answering of questions, i.e. it is *external* to the activities of doing the research. It looks outside the immediate context of the research.”
- Layer view – “the focus looks inward. It is *internal* because in the focus of awareness are the data containing ideas together with (linked to) hidden meanings. ... Here, research is interpreted as a process of discovering, uncovering or creating underlying meanings”
- Journey view – “in the foreground are the personal existential issues and dilemmas of the researcher, linked through an awareness of the career of the researcher and viewed as having been explored for a long time. ... the researcher is the focal point of awareness. Research is interpreted as a personal journey of discovery possibly leading to transformation.

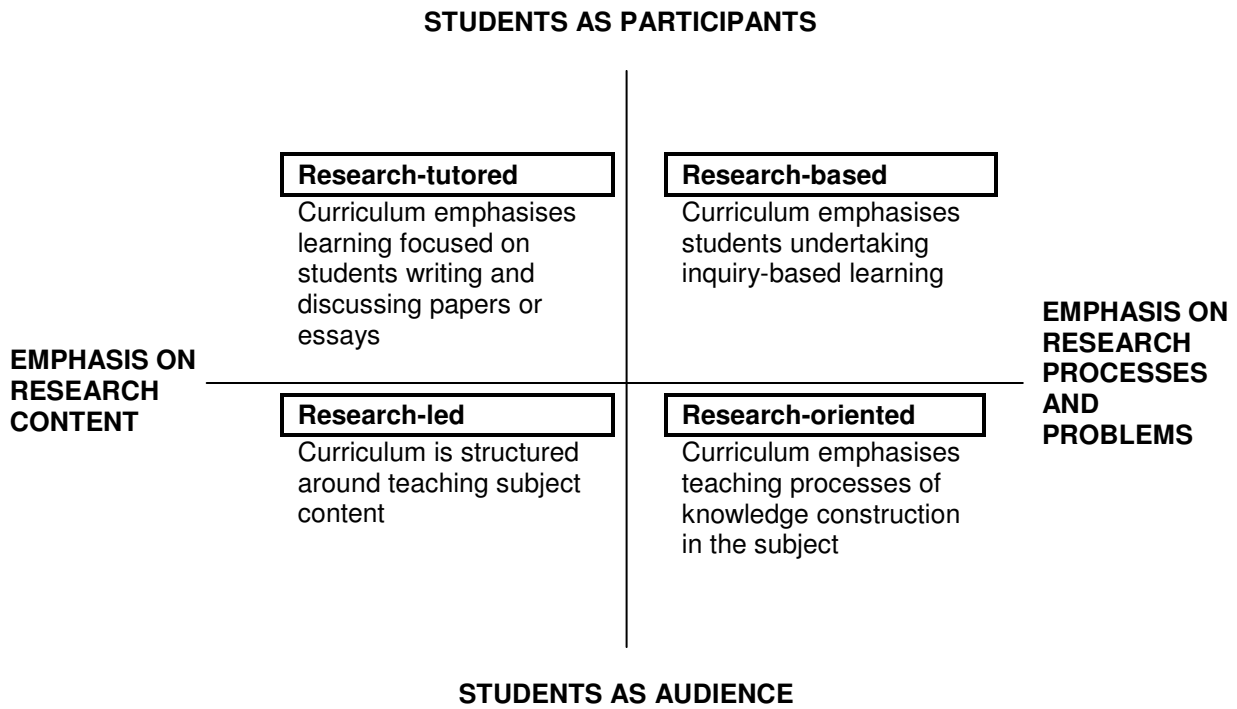
2. Curriculum Design and Teaching-Research Relations

We have found the framework developed by **Griffiths (2004)** effective in supporting staff/faculty to examine both their current courses and institutional policies and practices and in adapting innovations from elsewhere. According to Griffiths teaching can be:

- Research-led: where students learn about research findings, the curriculum content is dominated by faculty research interests, and information transmission is the main teaching mode;
- Research-oriented: where students learn about research processes, the curriculum emphasises as much the processes by which knowledge is produced as learning knowledge that has been achieved, and faculty try to engender a research ethos through their teaching;
- Research-based: where students learn as researchers, the curriculum is largely designed around inquiry-based activities, and the division of roles between teacher and student is minimised.

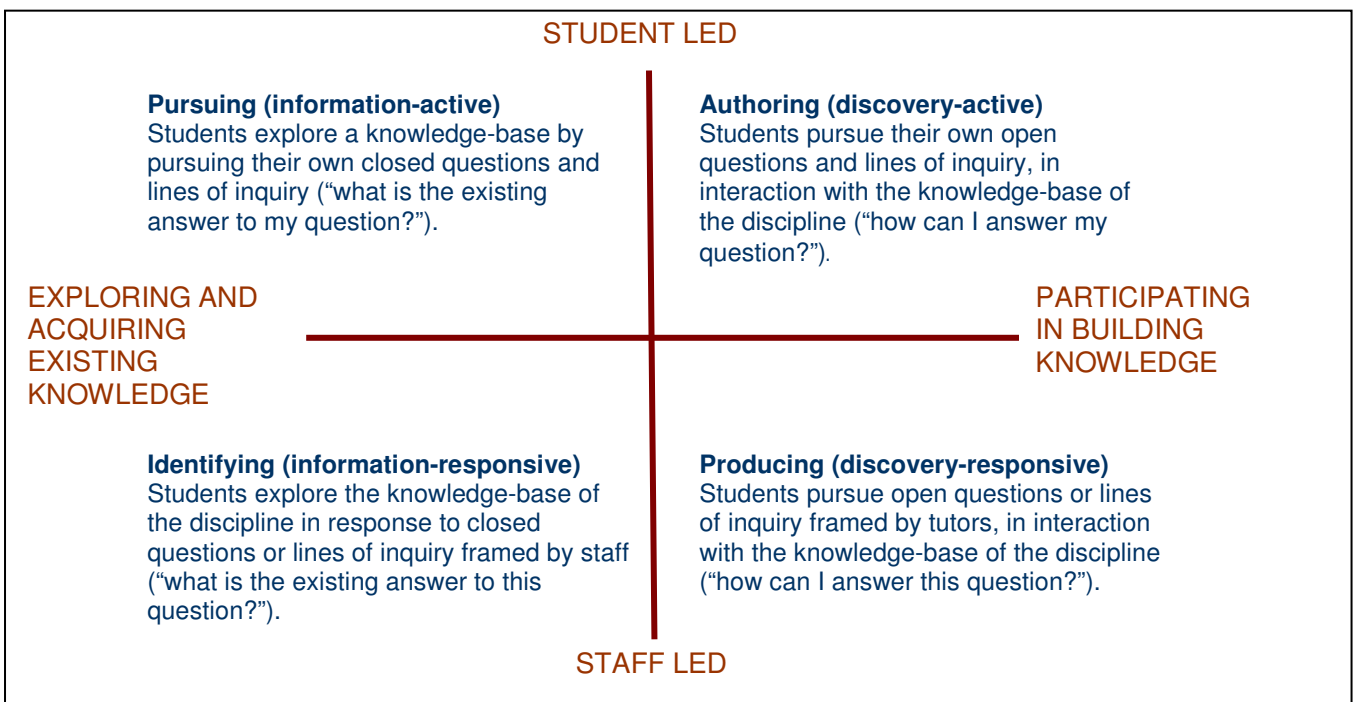
Healey (2005) has expressed these differences diagrammatically using two axes (Fig 1). One classifies approaches to linking teaching and research according to the extent to which they are teacher-focused and students are treated as the audience or student-focused and treat students as participants, while the second axes classifies the approach as emphasising research content or research processes and problems. He identifies a fourth category ‘research tutored’ where students learn in small group discussions with a teacher about research findings. A variant on this matrix has been proposed by Levy and Petrulis (2007). They also have a staff-led and student-led axis and another axis distinguishing between information-led and discovery-led inquiry in which the former is based on existing knowledge and the latter on new knowledge (Fig 2).

Fig 1 Curriculum design and the research-teaching nexus



Source: Based on Healey (2005, 70)

Fig 2: Inquiry-based learning: a conceptual framework



Based on Levy (2009)

Table 6 The developmental journey of the student

Developmental Level	Student traits
Reliance on external references [<i>Foundations</i>]	Knowledge viewed as certain Reliance on authorities (e.g., professors, parents) as source of knowledge Externally defined value system and identity Act in relationships to acquire approval
At the crossroads [<i>Intermediate Learning</i>]	Evolving awareness of multiple perspectives and uncertainty Evolving awareness of own values and identity and of limitations of dependent relationships
Self-authorship [<i>Capstone</i>]	Awareness of knowledge as contextual Development of internal belief system and sense of self capacity to engage in authentic, interdependent relationships

Source: Hodge *et al.* (2008)

An excellent example of mainstreaming undergraduate research and inquiry comes from Miami University Ohio. Drawing in part on the work of Baxter Magolda (2001), they have mapped out the student developmental journey (Table 6). Though as students go through these stages at different rates and many may not reach the self-authorship stage by the end of their undergraduate course, there remains a challenge in converting this framework into the curriculum.

Another useful framework for analysing discipline variation is provided by **Biglan (1973)** identifies different discipline types. He distinguishes between disciplines which are predominantly 'pure' and those which are predominantly 'applied' and those which are predominantly 'hard' or predominantly 'soft'. The latter refers to the dominant paradigmatic approach whether e.g. quantitative scientific or qualitative interpretative. The opportunities and ease with which research and teaching may be linked varies according to these discipline types. Some differences in students' experiences by discipline are shown below.

Table 7 Students' experiences of learning in a research environment

	Physics	Geography	English
What is research?	Breaking new ground; moving forward; exploration and discovery	Gathering information in the world; answering a question	Looking into; gathering; putting it together; a focus of interest
How visible is it?	Laboratories and machinery (i.e. 'tools') but often 'behind' closed doors	Most visible 'in the field'	Not tangibly visible, but apparent in the dialogue
Where is it located?	Out there; at a higher level	Out there in the field	In the library; in the head
Who does it?	Lecturers	Lecturers and (increasingly over time) students	Lecturers and students

Source: Robertson and Blackler (2006, 226). Based on interviews with 36 students (first years to postgraduates) at Canterbury University, NZ

3. Student Experiences of Research

"staff research interests gave students 'the opportunity to see their teachers as real people and to be able to glimpse what they do, how and why' (Neumann, 1994, 335).

'students value highly the experience of studying in a research environment but clearly there is a policy gap between policy intention and student perceptions at UEA (University of East Anglia). While students value being close to research, and to the idea of a university as a research community in which they are included, there are many ways in which they feel excluded (Zamorski 2000, 1).

Jenkins, Blackman, Lindsay and Paton-Saltzberg (1998) carried out focus-group discussions with undergraduate students in a range of disciplines at Oxford Brookes University, and then replicated the

September 2009

study with postgraduates (Lindsay, Breen and Jenkins, 2002). Students who perceived staff members' involvement in research as being incorporated into their teaching tended to see their courses as current and as stimulating intellectual excitement. However, many students did not see themselves as *stakeholders* in staff research – university research was seen as quite separate from them.

A questionnaire-based study at Oxford Brookes (Breen and Lindsay, 1999) analysed student views of staff research in the context of their motivations for study and for attending university. Students who came to university for social contacts or to gain a useful qualification were indifferent to staff research.

A questionnaire of the awareness, experiences and perceptions of final year undergraduate students at the University of Gloucestershire (Healey *et al.*, forthcoming) was taken up by the University of Alberta and Royal Holloway. Although students at all three universities agreed that being involved in research activities was beneficial, they did not perceive that they had developed their research skills (Turner *et al.*, 2008). Generally students at the more research intensive universities were more *aware* of the research that went on in their institutions, but there was no significant difference in the *experience* they had of undertaking research themselves.

“Overwhelmingly, students define UR as a powerful affective, behavioral, and personal discovery experience whose dimensions have profound significance for their emergent adult identity, sense of career direction, and intellectual and professional development” (Hunter *et al.*, 2007, 69).

4. Definitions of undergraduate research and inquiry

These vary widely. For example, definitions of undergraduate research include:

“An inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline”

Centre for Undergraduate Research

“Undergraduate research is original work conducted by undergraduate students working in collaboration with a faculty mentor”

University of Central Florida

“Discovery Learning”

University of Alberta

“Student engagement at all levels in research and inquiry into disciplinary, professional and community-based problems and issues whether individually or in groups and in collaboration with or independently of staff”.

University of Gloucestershire

“Programmes that seek to encourage or support undergraduate research should actively address all or most of the following.

- Expressly engage with ‘undergraduate research’, ‘community based undergraduate research’, or some such, and recast their understanding of ‘student-centred’ or ‘inquiry-’ or ‘problem-based’... ‘learning’ accordingly.
- Adjust the philosophy/values of their programme so as to actively bring undergraduate students (along with others such as librarians, community activists) into the worlds of research.
- Encourage and enable students to learn in ways that parallel or reflect the ways faculty/staff themselves research/learn in their discipline/professional area.
- Build research opportunities into the formative processes and summative outcomes of course assessment for students in ways that retrace and register how faculty/staff develop and disseminate their own research/learning in their own discipline/professional area, e.g. through undergraduate research journals, student research conferences, exhibitions, recordings and broad/narrow casts.

September 2009

- Ensure that the programme is clearly visible and recognised as ‘undergraduate research’ by the university communities (in particular students) and parents, the local community, and possible external sponsors and stakeholders” (Jenkins 2008).

Table 8 Dimensions of undergraduate research

Student, process centred	Outcome, product centred
Student initiated	Faculty initiated
Honors students	All students
Curriculum based	Co-curricular fellowships
Collaborative	Individual
Original to the student	Original to the discipline
Multi-or interdisciplinary	Discipline based
Campus/community audience	Professional audience
Capstone/final year	Starting year one
Pervades the curriculum	Focussed

(Source: Adapted from Beckham and Hensel, 2007)

Definitions of Inquiry

There is considerable overlap between definitions of undergraduate research and inquiry, particularly between the broader definitions.

“Enquiry and Research-Based Learning (EBL and RBL) are terms used to describe a method of teaching and learning based on self-directed enquiry or research by the student. EBL provides a strongly student-centred approach to teaching and learning, enhancing students’ learning experience during their time at university.”

University of Reading, CETL in Applied Research Skills [www.reading.ac.uk/cetl-
aurs/LinkingTeachingandResearch/Enquiry-
BasedLearning/What is Enquiry Based Learning \(EBL\).asp](http://www.reading.ac.uk/cetl-
aurs/LinkingTeachingandResearch/Enquiry-
BasedLearning/What%20is%20Enquiry%20Based%20Learning%20(EBL).asp)

Most forms of undergraduate research would also meet most definitions of inquiry, but not everyone would include all forms of inquiry, particularly those engaged into enquiring into existing knowledge, as undergraduate research.

At McMaster University, inquiry-based courses are offered to all first year students. The following is how this institution defines inquiry-based learning:

“Inquiry is a form of Self-Directed Learning and follows the four basic stages defining self-directed learning. Students take more responsibility for:

- Determining what they need to learn
- Identifying resources and how best to learn from them
- Using resources and reporting their learning
- Assessing their progress in learning”

Source: www.mcmaster.ca/cll/inquiry/whats.unique.about.inquiry.htm

For an exploration of the term ‘enquiry-based learning’ see: Hutchings (2007).

Undergraduate research and job opportunities

In North America adverts for university jobs sometimes specify engaging undergraduates in research. Three examples of jobs advertised on the Council for Undergraduate Research list in September-October 2008 stated that:

“The Department of Biological Sciences at Eastern Illinois University is seeking a Fisheries Biologist (tenure track) position. ... Successful candidates will be expected to develop a productive and funded research program involving both undergraduate and M.S. students.”

“Widener University (Pennsylvania) invites applications for a tenure-track assistant professor in synthetic organic chemistry. ... Engagement of undergraduate students in research is required.”

“The Department of Earth and Environmental Science in the College of Liberal Arts at Mercer University (Macon, GA) announces its search to fill a tenure-track position at the rank of Assistant Professor. The primary instructional responsibilities will be introductory environmental science, geology, environmental geology, Geographic Information Systems, and an upper-division course in the candidate’s specialty. Additional responsibilities will include mentoring of undergraduate student research, and service in support of the department and College.”

B: CASE STUDIES OF UNDERGRADUATE RESEARCH AND INQUIRY IN DISCIPLINARY, DEPARTMENTAL, INSTITUTIONAL AND NATIONAL CONTEXTS

These cases of undergraduate research and inquiry in disciplines, departments and institutions are drawn from Australia, Canada, Denmark, Ireland, Hong Kong, Netherlands, New Zealand, United Kingdom and United States. They are a subset of a wider set of case studies of links between teaching and *disciplinary* research. They represent work in progress and the intention is to add further case studies in the future. If you know of interesting examples please contact the authors. The cases are organised under four main headings:

- 1 Undergraduate Research and Inquiry in Disciplines
 - 1.1 Biosciences, Physical Sciences and Medicine
 - 1.2 Social Sciences
 - 1.3 Business, Law and Tourism
 - 1.4 Geography and Environmental Studies
 - 1.5 Archaeology and Earth Sciences
 - 1.6 Arts and English
 - 1.7 History
 - 1.8 Education and Philosophy
 - 1.9 Interdisciplinary
- 2 Undergraduate Research and Inquiry in Departments
 - 2.1 Biosciences, Chemistry, Medicine and Health Sciences
 - 2.2 Engineering and Mathematics
 - 2.3 Arts and Social Sciences
 - 2.4 Geography, Earth and Environmental Sciences
 - 2.5 Developing research skills and academic practices
- 3 Undergraduate Research and Inquiry in Institutions
 - 3.1 Europe
 - 3.2 Australia and New Zealand
 - 3.3 United States
 - 3.4 Canada

The value of case studies largely lies in the specific ideas they present for adapting elsewhere. We recognise that the form of, and the possibilities for, undergraduate research and inquiry will vary between disciplines / departments, and institutions. However, the particular forms of student research and inquiry and teaching and research contexts are to varying extents transferable and adaptable to other contexts. So when looking at the case studies below also consider how innovations in particular disciplines, departments and institutions can be adapted to your context.

1. Undergraduate Research and Inquiry in Disciplines

1.1 Biosciences, Physical Sciences and Medicine

Asking questions in plant biology at Australian National University

A practical exercise designed for a Level 2 course involves students: making observations in a botanical garden; coming up with 10 questions each (e.g. why do eucalypt leaves dangle?); sharing one of these questions with a group of other students; coming up as a group with hypotheses based on the question (e.g. Eucalypt trees in arid environments have leaves that dangle at steeper angles than those in wet

September 2009

environments); thinking of ways of testing the hypothesis(es); and writing up individually their 10 questions and one hypothesis as a 750 word mini-proposal for a research project.

Source: www.anu.edu.au/CEDAM/ilearn/inquiry/posing_questions.pdf

At University College London, UK, science undergraduates build on research of previous students

Students on a course on the history of science at UCL are involved in an ongoing pilot project aimed at a full integration of teaching and research at the undergraduate level. The chief innovation is the mechanism of inheritance: each year students receive a body of work produced by the previous group of students and make improvements and additions to it; this process can be repeated until publishable materials are produced. This is part of a system of learning that enables students to function as a real and evolving community of researchers. First developed in a final third year course, the “course will now be open to second years which will enable interested students to continue their work as part of their dissertation, and to strengthen the diachronic community by having the previous year’s students present when the next cohort take the course” (Chang 2007, 21).

Sources: Chang (2005; 2007); Chang and Jackson (2007)

<http://network.nature.com/london/news/Q&A/2007/10/31/wiki-book-on-chlorine-heralds-new-style-of-undergraduate-teaching>

At Leicester University, UK, biochemistry undergraduate students are helped to read research articles

The expectation that students in the latter stages of an honours degree will be keeping abreast of developments in a particular field of knowledge requires them to become conversant with research articles. Yet the content of such papers is frequently jargon-rich and impenetrable. In the department of Biochemistry at Leicester University some final third year modules are in effect journal reading clubs around particular research themes. Key components of the first year programme are explicitly structured to introduce them to reading and to writing as researchers. In particular as part of a year-long scientific skills module (c70 students) a set of exercises has students first consider the structure of a scientific report and read and evaluate a given research paper. Subsequently, students are asked to imagine themselves as scientific investigators interested in a specific problem. In tutor-led group discussion, they design an experiment to investigate the problem and then individually write a report based on provided data.

Sources: Wilmott *et al.* (2003);

Inquiry Based Learning – or ‘Scale Up’ – in Introductory Science Classes

SCALE-UP or “Student-Centered Active Learning Environment for Undergraduate Programs”, originally developed at North Carolina State University has been widely adopted and adapted in a wide range of US universities, including the Technology Enhanced Active Learning (TEAL) classroom at Massachusetts Institute of Technology (MIT).

The basic idea is of a radically redesigned classroom and linked web supported learning environment. The traditional lecture and linked laboratory format is replaced by “4-6 hours of activity based instruction per week, typically in 2-hour blocks” (Beichner *et al.*, 2007, 3). Students work in groups at round tables with web support and white boards. “Most of the class time is spent on ‘tangibles’ and ‘ponderables’. Essentially these are hands-on activities, simulations, or interesting questions and problems. There are also some hypothesis-driven labs where students have to write detailed lab reports.”

<http://scaleup.ncsu.edu/FAQs.html>

“In comparisons to traditional instruction we have seen significantly increased conceptual understanding, improved attitudes, successful problem solving, and higher success rates, particularly for females and minorities” (Beichner *et al.*, 2007, 1).

Sources: Beichner *et al.* (2007); <http://scaleup.ncsu.edu/>; <http://icampus.mit.edu/projects/TEAL.shtml>

Engaging large classes of first-year students in the professional practices of bioscientists, University of Queensland, Australia

Each semester since 2005, 400-900 first-year Human Biology students are introduced to the course content and assessment using a pedagogical model developed around the skills and practices of bioscientists. Practising bioscientists teach all course elements. Content knowledge, scientific reasoning, use and understanding of language, laboratory skills and the importance of partnerships are progressively supported through linked assessments. The first task engages them in audio interviews in which scientists describe their cutting-edge research. Students respond to the interviews in short expressive written assignments. Next, students participate in a purposely designed *Biohorizons* eConference modelled around professional conferences. This begins with a face-to-face plenary lecture delivered by an internationally recognised researcher. Over the next 6 weeks, students self-register into one of ten clusters (of up to 45 pairs) based around biological themes. With the support of online tutors (PhD students), they write and upload a paper (15%) and construct a PowerPoint presentation (10%) in pairs. Students use databases to explore primary literature and research a specific topic of interest within broad cluster themes. Students then individually post formal questions and answers about one another's work (5%). The eTutors mark all three submissions using online criteria sheets and audiofiles to personalise feedback.

Sources: Moni *et al.* (2007a, c and d)

Biology start up business final year project, University of Durham, UK

Biology Enterprise is a collaborative venture between Durham Business School and the School of Biological and Biomedical Sciences. This elective module for final year undergraduate students in the School of Biological and Biomedical Sciences aims to introduce science students to the key processes of business start-up and enhance their enterprising skills and behaviours. The module is project-orientated with self-selecting groups of students who generate an idea for a business opportunity that is based on a scientific discovery. Students use their knowledge and understanding of science to develop and research their idea into a technology that can be readily commercialised e.g. a diabetes breath tester, a biodegradable chewing gum. In parallel, the Business School teaches students the necessary skills and knowledge required to develop their idea into a successful business. This course offers science undergraduates an alternative to the traditional laboratory-based project and is useful for those seeking employment in business and commerce. The module was developed by Stefan Przyborski, who is the founder and Chief Scientific Officer of ReInnervate, a biotechnology company founded in 2002 as a spinout from Durham University.

Sources: <ftp://www.bioscience.heacademy.ac.uk/events/dur05/przyborski.pdf>
<http://www.bioscience.heacademy.ac.uk/events/dur05.aspx>
<http://www.cambridge-mit.org/news/article/default.aspx?objid=877>

Reinvented Enquiry Labs in Year One Chemistry at Warwick University, UK

A second term year one laboratory course (c100 students) was reinvented from its previous 'traditional' approach to explicitly support more open ended enquiry based learning. The stimulus came from fourth year students doing their final year research project. Looking back at the predecessor of this redesigned course they stated "they did not feel prepared for their final-year projects. The style of the experiments was perceived to be very 'recipe-like, with little scope for original thought. Additionally, the students felt that the labs ... gave the impression that 'most chemistry works'; after a research project, they appreciated that the reality was somewhat different" (Taylor and Geden, in press).

The revised course was clearly enquiry based and involved major changes to the laboratory manual and the pre lab activities, though the actual experimental procedures to be followed were largely untouched to minimise resource implications. The manual redesigned each experiment as a problem to be solved, with all references to the expected outcome removed; experimental procedures were changed to be, insofar as was sensible with safety considerations in mind, in the style of methods published in research journals; mark schemes were completely revised to support the revised course goals. In addition the previous whole class didactic pre-lab sessions were revised to a more open discussion and enquiry approach.

Sources: Taylor and Geden (in press)

Chemistry 'Concentrated Study' Project at the University of St Andrews, Scotland

This is a core course done by all 3rd year chemistry students (within a 4 year BSc/5year MChem framework); current enrolment is 48. It is taught in the last four weeks of the Spring semester. Students have no other class and are able to spend their full time on this module. Students are divided into (mixed ability) groups of five - six each assigned to an academic supervisor who assigns a topic for investigation. This requires literature research, experimental planning, experimental work, analysis of results and their presentation. The projects assigned vary but generally fall somewhat short of original research while maintaining substantial scope for student input to the direction of the work..

The module has run for the last five years and typically yields grades rather similar to conventional laboratory classes at this level. A consistent observation however is that this really brings out the best in some otherwise weaker students who seem to be inspired by the idea of contributing to the team effort in a way that is not achieved in a more conventional class. There are parallels between this approach to course design and the experimental physics course at the Massachusetts Institute of Technology researched by King and Parlett (1969); and the current credit and non credit courses in MIT's Independent Activities Period.

Sources: Aitken (2008); King and Parlett (1969); <http://ch-www.st-andrews.ac.uk/teaching/aims/Mod3441/a.pdf>; <http://web.mit.edu/iap/>

Employing second year students as laboratory assistants: Biomedical science at University of Newcastle, UK

In 2002 the School of Biomedical Sciences introduced a scheme to offer opportunities to second-year bioscience students to undertake part-time paid work in research laboratories. The aim was to provide students with a greater appreciation of bioscience research, to reinforce their laboratory skills and to encourage them to consider a research-based career. Students work for 8 hours per week during term time and are paid a minimal wage. Hours are negotiated with the supervisor to fit with the student's timetable commitments. The scheme has run for five years employing 74 undergraduates. An evaluation demonstrated positive student and supervisor comments with students reporting a positive effect on their studies and that the experience had encouraged them to consider a career in research. The stimulus to the scheme was the fear that an institutional policy to establish research institutes might lead to structural disconnections between teaching and research and reduce the number of undergraduates seeking research careers.

Source: Hughes *et al.* (2009)

Undergraduate Research Elective in Medicine: Queens University, Canada

At Queen's University, the undergraduate medical curriculum includes a mandatory minimum eight week "Critical Enquiry" elective in year 2. This elective provides each student a block of time, free from other academic assignments, to pursue in depth a medically-related hypothesis of the student's choice. The area of research may be from the basic, clinical, or social sciences, or the humanities. Students may arrange the elective with the supervisor and at the location of their choice. The elective block is placed immediately prior to the summer vacation to afford the opportunity of extending the project into the summer months.

A central reason for introducing the course was a national concern that few physicians were choosing research careers. Research on the impact of the course has demonstrated a significant increase in the number of students expressing an interest in pursuing a research career – and students (including those not seeking a research career) recognising other benefits including the development of critical thinking skills; and developing contacts for postgraduate training.

Sources: Course web site: http://meds.queensu.ca/courses/pbl/phase_iiie; Houlden *et al.* (2004)

1.2 Social Sciences

Inquiry-based learning introductory course for social sciences had a significant impact on students' subsequent performance at McMaster University, Canada

McMaster University has been running a first-year course for social sciences based on inquiry since the late 1990s. It is typically taught in groups of no more than 25 students assigned to an instructor. All of the groups have the same curriculum, reading material, process of assessment, and goals that are outlined in a detailed compendium. The classes meet for 12 three-hour concurrent sessions. Class time consists of a combination of exercises and tasks for building the students' critical abilities and time for students to share ideas about their individual inquiries with other students. Much of class time involves groups of four or five students assisting each other in such things as clarifying understandings or planning research strategies.

All students investigate aspects of a broad social science theme, such as 'self identity' and addressed a common inquiry question, such as: 'Why do images of ethnicity, race, gender, sexuality, age, class, or abilities help to create aspects of personal and community identity?' Students have to propose their own inquiry question, such as: 'Why do some children apparently become violent after watching violent cartoons while others seem to be unaffected?' They have to justify why the question was important in relation to existing literature. They then investigated the question through a process which involved developing and testing hypotheses using secondary sources.

Analysis of five years of data (Justice *et al.*, 2007b), comparing students who took the Inquiry course with comparable students who did not, shows that it has had a significant impact on how well students perform during their academic careers. Taking the Inquiry course is associated with statistically significant positive differences in obtaining passing grades, achieving Honours, staying on the Dean's honour list, and remaining in university. Recent research suggests these differences may reflect that the students are 18 months to two years ahead in terms of learning skills (Justice *et al.*, 2009).

Sources: Justice *et al.* (2002, 2007a and b; 2009);
<http://socserv2.mcmaster.ca/Inquiry/CourseOutline.htm>;
http://www.socsci.mcmaster.ca/socsci_inquiry.cfm

Psychology Students Research Students' Quality of Life at York St John University, UK

First year, non-specialist, psychology students undertook an eight-week project in which they collected data from themselves and three other students using four short inventories and a biographical questionnaire in order to research topics related to students' Quality of Life. This project provided students with the opportunity to collect 'live' data, contribute to a developing database, select data for analysis, and write up findings. The topics available for selection by students were linked to the research interests of the lecturer making the project mutually beneficial. A departmental technician provided assistance with questionnaire design, the development and maintenance of a database, data entry, and tutoring on some portions of the project.

Source: http://www.psychology.heacademy.ac.uk/html/teach_land.asp?id=596

Student Poster Conference Linked to Dissertation: Psychology at St Mary's, UK

The psychology department at St Mary's University College have integrated a required poster session into the dissertation requirements. The research project – some 5,000 words – is handed in the April of their final year. This counts for 80% of the final mark on that course. As with many other UK institutions work on this project is meant to start on the second year. At St Mary's there is a required poster session in May of their second year – where students present and discuss an initial outline of their work. This counts for 20% of the final grade on the project and is assessed on visual content and presentation and student answers to questions on their project. The poster session is run in the form of an academic conference, with all academic staff attending and first year and third year students. Involving first year students both increase the numbers of questions second year students have to answer, and perhaps most significantly orients first year students to how to carry out their research.

Source: Correspondence with Peary Brug

A guide for Undergraduate dissertations in Sociology, Anthropology, Politics, Social Policy, Social Work and Criminology at Sheffield Hallam University, UK

This web-resource was prepared to provide support and guidance for students writing dissertations in the social sciences, but it offers useful guidance for any students carrying out research. It deals with some of the common questions, concerns and practical issues that undergraduate students face when planning a piece of social research – such as research design, ethics, access, and writing styles. The resource also provides some useful information for academic staff who are supervising undergraduate dissertations. It provides case studies of dissertation supervision issues and examples of the students' experiences of completing a project and the 'student voice' should be especially valuable for new supervisors.

Source: www.socscidiss.bham.ac.uk/s1.html; Todd *et al.* (2004)

Engaging students in applied research through a community sports development consultancy project at University of Central Lancashire, UK

Community Sports Development module is a final year capstone module for Sports Coaching students. This module is optional and taken in addition to the honours dissertation. Students work as a project team through a consultancy brief with a partner agency and recommend strategies that can be employed to support community development through community sport and coaching initiatives. There are normally 8-12 briefs divided up among the 40-50 students, with students creating their own consultancy teams. Examples of projects include:

- A "health check" of football refereeing in Blackburn
- Community Sport and Crime Reduction
- Community Sport ("Street Dance")

The emphasis is upon the students creating professional working relationships with the client organisations in order to carry out primary research that is directed by the clients and supported by the Academic staff at the University. Students are expected to hold regular review meetings with the clients, carry out interviews with relevant stakeholders; use secondary research to help analyse their findings; and present their work and recommendations to the organisation through the staging of a mini-conference, where all the partner groups are invited. Representatives from agencies provide the feedback on students' work, judging on the content, feasibility of solutions, and competency in conducting research.

Source: [//resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/index.cfm](http://resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/index.cfm)

Inquiry-based learning in first-year information management at the University of Sheffield, UK

"Inquiry in Information Management" is a first-year, second-semester core module with an enrolment of approx. 30. The course aims to induct students into learning as a community of researchers in the context of a professional applied discipline. Students work in groups on research projects from generating their own valid, practical and worthwhile research questions (e.g. student awareness of the environmental impact of mobile phones) right through to presenting findings at a research 'mini-conference'. Work on these projects starts in the 4th week, following a series of preparatory workshops which include exploring their conceptions of 'research' and how to pose and investigate research questions in Information Management. In the final week, guests at the mini-conference include PhD students, staff lecturers and researchers, and the Head of Department. All guests contribute to assessment of research posters, using criteria that the first-year students on the module have established previously in collaboration with module tutors.

Sources: <http://www.shef.ac.uk/cilass/cases/informationmanagement.html>; Cox *et al.* (2008)

1.3 Business, Law and Tourism

Barak Obama, *The Harvard Law Review* and Undergraduate Research and Publishing

In 1991 Barak Obama, then 28 years old, became the first black editor of the *Harvard Law Review*. He stated a determination to make it a "forum for debate", bringing in new writers and pushing for livelier, more accessible writing (Butterfield, 1990).

September 2009

“The *Harvard Law Review* is a student-run organization. Student editors make all editorial and organizational decisions and, together with a professional business staff of three, carry out day-to-day operations. A circulation of about 8,000 enables the *Review* to pay all of its own expenses. ... The *Review* publishes articles by professors, judges, and practitioners and solicits reviews of important recent books from recognized experts. Most student writing takes the form of Notes, Recent Cases, Recent Legislation, and Book Notes. Notes are approximately 18 pages and are usually written by third-year students. Recent Cases and Recent Legislation are normally six pages long and are written mainly by second-year students. Book Notes, also written by second-years, are six-page reviews of recently published books. All student writing is unsigned. This policy reflects the fact that many members of the *Review*, besides the author, make a contribution to each published piece.”

Sources: Butterfield (1990); <http://www.harvardlawreview.org/>

Modelling the research experience: tourism students’ virtual conference at University of Lincoln, UK

In May every year, final-year Tourism students at the University of Lincoln participate in a live virtual conference. This is part of their assessment for the semester-long unit (Social and Political Perspectives on Tourism). A conference is a useful vehicle for extending insight into the process and practice of knowledge creation and dissemination and for students to participate as in effect research disseminators. An ICT has made it possible: during the specified timeframe of one week, students do not have to be assembled in one place and can participate at any time. Feedback from them has been extremely positive and encouraging. Two qualified web designers built the site and have been on hand to deal with technical issues. Teaching staff have provided support for the conference throughout the unit. Students submit a full conference paper, but it is only a summary that appears on the conference web site. Each student is also required to post a comment on another conference paper. Staff monitor participation and contact students as appropriate.

Source: www.cometravel.lincoln.ac.uk

1.4 Geography and Environmental Studies

Geography students at Glasgow Caledonian University, UK, submit reviews for publication made available to the local community

Practising Geography, the second year undergraduate Human Geography module, offers individual students the option of submitting coursework in the form of a briefing paper based on a small-scale, fieldwork-based research project that they themselves have designed and executed. On completion of the module, students can then elect to have their paper refereed by an independent expert (generally a local resident from the field locality or a member of one of the Royal Scottish Geographical Society’s Regional Centres). Publication on the project website is conditional on an acceptable referee’s report.

Source: McKendrick *et al.* (2003); <http://www.butegeog.gcal.ac.uk/index.html>

Geography students at University College London, UK, and at Oxford Brookes, UK interview staff about their research and views on contemporary geography

All year one students do an assignment in term one, in which students interview a member of staff about their research.

- Each first year tutorial group is allocated a member of staff who is not their tutor.
- Tutorial groups are given three representative pieces of writing by the member of staff along with a copy of their CV and arrange a date for the interview.
- Before the interview students read these materials and develop an interview schedule.
- On the basis of their reading and the interview, each student individually writes a 1,500 word report on a) the objectives of the interviewee’s research; b) how that research relates to their earlier studies c) *how the interviewee’s research relates to his or her teaching*, other interests and geography as a whole (emphasis added).

This curriculum was adapted from one developed for a third-year synoptic course on the philosophy of geography at the then Oxford Polytechnic (now Oxford Brookes), which at the time received little funding for research:

September 2009

- Students were divided into groups and each group was allocated a member of staff, who gave them a copy of their CV.
- A student group then interviewed that member of staff (with the rest of the students attending), about their academic history and views on the nature of contemporary geography.
- The student group then wrote up the interview and set that person's view of the discipline in the wider context of the contemporary discipline.

The aim in this teaching-focused department was to develop students' understanding of recent research developments in the discipline.

Sources: Dwyer (2001); Cosgrove (2001)

Embedding enquiry-based learning in a skills module concerned with sustainability at Gloucestershire, UK

'Skills 4 Sustainability' is a first year course in which skills for enquiry-based learning is embedded in a module on sustainability. The module is delivered from weeks 1-12 of the first semester by a team of 8 tutors to c.150 students with no formal lectures. Students are organised into tutor groups according to their subject specialism with a tutor. Students enquire into and develop a proposal improving the sustainability of the University which they must research and present as a group. The students are prepared for their enquiry-based project by different activities in the preceding weeks..

The best proposal from each tutor group goes forward to the *Green Dragons' Den* for consideration by an expert panel comprising the University Vice Chancellor, Director of Institute for Sustainability and a local business manager. 50% of module marks is the creation of an individual e-portfolio which is built up throughout the module which requires students to reflect on sustainability issues, their own position and action they might take to improve their own sustainability, both environmentally and as a learner. Initial research into the first two years of module delivery is favourable with students enjoying the active learning approach and the promotion of independent enquiry.

Further information: Swansborough *et al.* (2007)

Giving students first-hand experience of research-based consultancy in environmental management at University of Queensland, Australia

Team-based problem-based learning is used in the final year capstone course at the University of Queensland's Faculty of Natural Resources, Agriculture and Veterinary Science to give students experience of research-based consultancy. It is a year-long course, team taught by an interdisciplinary team. Staff solicit suitable 'problems' and clients among their contacts, for instance from government agencies, non-governmental organisations, or land care groups, or the private sector. Students work in groups of c6 as consultants. The clients come to campus at least three times, for an initial briefing to their students, and presentations at the ends of first and second semester. They liaise with the students all year, usually off campus at their offices, and by phone and email. The staff give a flexible program of lectures in first semester, to prepare the students with skills they need towards each forthcoming step of their tasks. At the end of the year the students' report are 'published' for the clients. Peer and self-assessment are used to distribute group marks among the contributors.

Source: Correspondence with Helen Ross, 2006

Engaging students in environmental health research and outreach at Allegheny College, Pennsylvania, US

At Allegheny College, the junior seminar is a required one-semester course, in the third year of a four year course that provides a window into the research experience and which allows students to develop a senior year thesis proposal. Each junior seminar, which typically has between 8 and 24 students, has a different theme, geared to the faculty and students' interests; the example below is based on faculty research interests.

In 2007 Environmental Health, Justice and Development, students developed and evaluated an outreach program. This concerned the critical role of indoor home environments on early childhood health in a rural, low-income community. The course leader provided the causes of childhood diseases and health

September 2009

disparities, the class then evaluated effective and ineffective health campaigns. The class then planned implemented and evaluated an outreach effort, which compared the efficiency of outreach directly targeted to students in 5th and 6th grade (10-12 years of age) to outreach targeted more broadly through family-oriented community events, such as a children's workshops and a Halloween parade. Students presented their findings in a public meeting to community partners, teachers, school district administrators, local public health officials, campus administrators and ES department faculty and students. Using feedback from the presentation, the students completed the semester with a single written document with report overview, background, findings and recommendations.

Sources: For further details and a reflection of the issues faced by the course leader see: [//resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/index.cfm](http://resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/index.cfm); for the Healthy Homes-Healthy Children (HHHC) Website see: webpub.allegheny.edu/employee/c/cwaggett/HHHC.html; for Caryl Waggett's Website see: webpub.allegheny.edu/employee/c/cwaggett/index.html; for a link to the Course Syllabus and Final Product and Poster see: webpub.allegheny.edu/employee/c/cwaggett/courseprojects.html.

1.5 Archaeology and Earth Sciences

Giving Community College students in US their first experience of research in archaeology

At Cuyahoga Community College, in Cleveland, Mark S. Lewine, a professor of anthropology, established a Center for Community Research 12 years ago. The center has provided more than 2,000 students with their first experience with primary research in the field or laboratory. He encourages graduate students and community college students to work together on archaeological digs. In 2006 he was awarded US Professor of the Year in the community-colleges category.

"We're digging on abandoned church property, abandoned hospital property, doing land-use history of the inner city. The 'aha' response is immediate. They say, Oh my god, this land that we're living on actually has a rich history. They get very interested because it connects to them. They enjoy the subject while learning the process. Too many of our students, unfortunately, are working two or three jobs, have family responsibilities, and just don't have the time. Often the participation begins with an hour in the lab or on the site. Then they'll try to find time on a Saturday. What I tell my students is: If you like it, if you're learning with it, if you're reliable and consistent in your work, I will offer you internships. Plus I tell them: When you come from an urban high school that isn't giving you what your potential really needs, and a graduate school looks at your record and sees primary research, that makes your record stand out."

Sources: Bollag (2006a)

www.usprofessorsoftheyear.org/POY_Display.cfm?contentitemid=6516&pid=PR_Resources

Student groupwork assignments based on analysis of current Geoscience discipline journal article analyses at the University of Adelaide, Australia

This Do-It-Yourself (DIY) Interactive Multimedia (IMM) project is an exercise in knowledge engineering that has been used in a final year undergraduate structural geology course since 1996. 2 or 3 students work collaboratively on the development of a multimedia based analysis of one international journal article, interrogate and summarise the text, but also become familiar with the figures, diagrams, plates, tables and these days often simulations and animations which may be available on the author's website.

One very important key to the research-teaching link is when the students have to devise a question to the author(s) and to email that question. Authors generally reply positively to the questions and occasionally a general dialogue occurs. The exercise has now been running continuously for eight years and has been carried out by about 400 students. This has left a legacy of about 150 IMM modules providing interesting summaries of much of the last eight years of cutting edge research in structural geology.

Source: James (2003)

1.6 Arts and English

Involving first year English students in the international research community at the University of Gloucestershire, UK

Arran Stibbe allows students to take on the identity of a researcher right from the start of their time at university. In the *EZ102 Language & Ecology* module the students have an opportunity to share their insights with the wider research community. The research community in turn has something to gain from student contributions because students can critically analyse aspects of their language and culture that others have yet to examine. The students are encouraged to take part in the international research community through working with the *Language & Ecology Research Forum* - the main international forum for research in ecolinguistics. The Forum links together a network of scholars, has an online journal, a range of resources, and a dedicated section for the *EZ102* module. The approach works best when students are becoming critically aware of texts that they are familiar with, rather than struggling to understand new genres understood better by the lecturer than students.

Sources: <http://www.ecoling.net/courses.html>;
<http://resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/activelearningcasestudies/index.cfm>

Introducing enquiry-based teaching methods in literary studies at Manchester University, UK

The traditional form of Literary Studies teaching in HE is tutor-centred. In this case study a group of second year students studying Eighteenth Century Literature are introduced to enquiry-based learning in the first week of the first semester. The course consists of a weekly lecture and a weekly seminar. The latter consists of 15 students divided into three groups. During the seminars the tutor acts as a task-giver and thereafter as both an information resource, responding to student requests and as a facilitator moving from sub-group to sub-group helping discussion to develop. For example, in week 1 the students were given a poem by Samuel Johnson, 'On the death of Dr Robert Levet'. The poem was issued to students without annotations or supporting detailed biographical information. Each sub-group was asked to address two questions: 'What kind of language does the poem use?' and 'What belief system, if any, does the poem imply?'. Most groups responded to this task actively by exploring and considering the possibilities from a range of perspectives, establishing and pooling any existing knowledge and assessing its applicability to the task in hand. By emphasising the need to seek other sources to contextualise their answers the facilitator began to establish the research element crucial to moving from 'problem solving' to something more active.

Source: Hutchings and O'Rourke (2003)

Community Project Work in Architecture at University of New South Wales, Australia

A new approach to community-based design projects in the Architecture Program is being trialled by working in association with FBEOutTHERE!, the University of New South Wales, Faculty of Built Environment's outreach program that engages in community-oriented research and learning. With the real prospect of a selected project being constructed, students are asked to design an 'ageing in place' independent living accommodation project. This project responds to needs identified by a social enterprise group that provide community services for people experiencing multiple intellectual disabilities (service users) in rural New South Wales. With an emphasis on enhancing service users' quality of life, students undertake this task by firstly engaging with the literature, interviewing the service users and staff and visiting the service users' homes to understand their needs. Only after the students have reviewed and evaluated the interviews, home visits and literature are they able to commence the design element of their projects, the progress of which is discussed regularly with the community.

Students keep reflective journals which are intended to help them think about the research findings, their interaction with the service users and their needs, and how these impact upon their design approach to the project. The completed student designs are exhibited. This allows for community feedback on the designs and facilitates discussion about design approaches that best meet the target group's needs.

Source: ALTC Teaching Research Nexus website: www.trnexus.edu.au

Introduction to writing research and contemporary cultures at Miami, Ohio, US

Students in the first year core course in 'writing and cultures' investigate how the forms of writing, and the methodologies for researching writing and culture, are being transformed through web-based communication. Through this reading and writing intensive seminar, students investigate how digitized technologies are transforming the forms of writing and communication. The course culminates in a group assignment where students, using secondary and primary sources, investigate an aspect of contemporary culture (e.g. dating, shopping) and how the forms of communication there are being reshaped by the Internet. They produce a multimodal web site that includes text, digital images, audio, and video. The course fulfils institutional requirements for liberal education goals of critical thinking.

Source: <http://www.users.muohio.edu/mckeeha/h101-09>; http://www.users.muohio.edu/mckeeha/h101-09/final_project.html;
<http://www.units.muohio.edu/led/principles.htm>

1.7 History

History students contribute research findings to a Web site at Victoria University, Canada

In 2002, John Lutz implemented History 481: Micro History and the Internet, a learner-centred and research-oriented course in which the main activity was primary archival research on various aspects of life in Victoria, British Columbia from 1843 to 1900. Students worked in small groups to conduct the research and eventually to publish their findings on the website called "Victoria's Victoria". John reports that "The feedback I get often says, that if they remember only one course from university, this (course) will be it... some alumni contact me to say that the web skills have landed them a job." John notes that the grades in Micro History 481 were approximately 8% higher than the grades that these same students received in other senior history courses that they take from him.

Sources: Anon (2003); <http://web.uvic.ca/vv/>

1.8 Education and Philosophy

Designerly Thought and Action: An investigation into opportunities within the Primary Curriculum at Canterbury Christ Church University, UK

This project engages students within the Faculty of Education in episodes of school-focused research. These episodes will be conducted through school placements. The research will engage our students, our partnership schools and academic staff. As a prelude to a major, externally funded project proposal, we have gained the support of training-based funding agencies such as Smallpiece Foundation.

The proposed development will research the opportunities presented within the primary school curriculum for the development of designerly thought and action. This is seen as vital to the needs of an information-rich, knowledge transfer society, moving into what Pink (2005) has called 'The Concept Age'. This would require a re-definition of the Primary curriculum, incorporating a cross-curricular process model. Many primary schools are moving into more topic-based work and we feel it is opportune to document the way in which this relates to other government initiatives concerned with creativity and a more active approach to children's learning. The project is intended initially to run from January 2007 – July 2008. The proposed research development is seen as a pilot study that will develop and hone research instruments to identify the key skills, capabilities and processes that underlie designerly thought and action across the curriculum.

For our students, there are clear benefits in terms of personal development as reflective learners/ future practitioners as a consequence of engagement with the delivery, modification and evaluation of research instruments in schools. The students may also develop as critical thinkers and become action-researcher in their future classrooms.

For more information on the project please contact Eric Parkinson (eric.parkinson@canterbury.ac.uk) or Gill Hope (gill.hope@canterbury.ac.uk). Source: Based on: <http://www.canterbury.ac.uk/support/learning%2Dteaching%2Denhancement%2Dunit/research-informed-teaching/index.asp>

Learning to think like a philosopher: developing students' research skills in a history of philosophy course, University of Leeds, UK

One aim of most degree courses, at least if they are in a single discipline, is to help students think like, for example, historians, chemists, or planners. Traditionally in philosophy this is attempted by 'sitting at the feet' of experienced philosophers and ploughing through long reading lists. Research into philosophy is seen as something largely reserved for postgraduate study. At the University of Leeds, George MacDonald Ross has developed a more active approach in a final year module, which engages his students directly with a philosophical text – Kant's *Critique of Pure Reason* – and helps them develop key research skills.

He teaches the course by running interactive seminars, rather than lectures, at which students are forbidden to take notes, except for a secretary, who posts minutes on a website within 24 hours. This has the advantage that students focus more on discussion during seminars, and that they treat the minutes as secondary literature, rather than their own intellectual property to be used without acknowledgment. Most of the time is spent discussing the interpretation of key passages projected on a screen. However, most of the students' learning time is taken up by reading the text in conjunction with George's running commentary; preparing short answers to interpretative questions, some of which will form the basis of the following seminar; and writing essays. Researching and writing essays is a small-scale version of what historians of philosophy do as researchers, and it is central to the module. Apart from one final essay, students write three two-page essays during the year. They are given the assessment criteria (presentation, referencing, accuracy, clarity, argumentation, independence, other strengths and weaknesses) before hand and have to self-assess their attempt against them. He does not put the mark on the essay, instead he tells them to guess the mark in the light of his comments, and sign up for a 15-minute individual tutorial at which he reveals the mark, and advises them on how to improve their performance next time.

Source: Based on a draft case study by George MacDonald Ross 2006.

For four examples of the use of **enquiry based learning in education** at the University of Birmingham see case studies 1, 5, 7 and 10 at: <http://www.ebl.bham.ac.uk/index.shtml>

1.9 Interdisciplinary

Involving Students in Interdisciplinary Interactive Media Consultancy Projects at Miami University, Ohio, US

Interactive Media Studies is an interdisciplinary minor (including Computer Science, Engineering, MIS, English, Marketing, Graphic Design, Education, etc.) that brings together students and faculty to investigate how interactive media informs and transforms their disciplinary perspective. The programme has been running since 1996 and uses problem-based learning and team-oriented projects to help students to learn how to apply their theoretical knowledge to innovative digital solutions for a paying client. About 100 students a year take the programme and work in project teams. The programmes are team taught with the last two weeks spent on de-briefing and talking about what they've learnt. The students are typically in class four hours a week, but spend many more hours, for example visiting clients, undertaking research or doing user testing. They make a presentation to their client at the end of the project.

Commercial companies are charged \$20,000 per project paid on delivery; non-profit organisations and charities are typically charged c£5,000. They found the client did not take it as seriously when no charge was made. From the client's perspective, they get out of the box thinking that they would never obtain from a consultant firm. Recent completed projects include:

- Healthcare IT asked IMS to create a new logo for their company and build a new Web presence to highlight their state-of-the art hospital tracking systems
- The Taft Museum of Art needed a complete Web strategy. IMS developed a web identity for them, put their collection online and created e-commerce capability for their gift shop.

Sources: Interview with Glenn Platt 14 November 2007; <http://student.sba.muohio.edu/ims/>; <http://www.miami.muohio.edu/academics/majorsminors/minors/ims.cfm>

Inter-disciplinary inquiry-based learning (IDIBL) focused on action research in the workplace at Bolton, UK

The IDIBL framework project at the University of Bolton has developed an undergraduate and postgraduate module framework for inquiry-based learning. The student is seen as an action-researcher who must identify an opportunity in their work-context for improvement. Learners support each other in an online community to combine study with work.

The modules contained within the framework focus on process, and generic concepts and outcomes, rather than subject content. Through a process of negotiation between the individual learner and the course staff, a personalised inquiry is developed to include learning activities and assessment products that meet the module requirements and informed by the learners' professional practice. The student then plans the action they will take, undertakes it in their own work context, evaluates the action, and revises the plan.

Sources: Milwood *et al.* (2007, 2008); idibl.bolton.ac.uk/; inquirypatterns.wordpress.com/resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/index.cfm

2. Undergraduate Research and Inquiry in Departments

2.1 Biosciences, Chemistry, Medicine and Health Sciences

At Cornell University, USA, all first year biologists have research experiences

The 'Explorations Program', which has been running since 1991, introduces biology first-year undergraduates to research by Cornell staff, in the context of a course of 700-900 students. Large-scale funding has created 100-120 'experiences', each of approximately 3-4 hours, for groups of 6-8 students. Most are designed to introduce students to the kinds of research problems on which the academic staff member works. Programmes take place both in research labs on campus and at field sites near campus. The programme is structured so that each student is required to participate in one 'Exploration' per semester. For example, recent explorations have varied from 'the control of body weight' to 'fossil flowers of the dinosaur age'; and from 'how do you tell if animals have color vision' to 'why do sperm swim in circles?'.

Sources: <http://www.reinventioncenter.miami.edu/Spotlights/spotlight.html>; http://biog-101-104.bio.cornell.edu/BioG101_104/explorations/explorations.html

Department undergraduate student research journals in biology at Chester, Leeds Nottingham and Plymouth UK and a national undergraduate research journal

The biology departments at the Universities of Chester, Leeds and Nottingham have developed journals to publish research by undergraduates in their departments. They are based explicitly on the US practice of undergraduate research journals (Kinkead, 2003). Origin (www.chester.ac.uk/origin/) at Chester is paper-based and generally involves selected students rewriting their dissertations or research projects for external publication. Biolog-E at Leeds (www.biolog-e.leeds.ac.uk) is an electronic journal, as is BURN from Biosciences at Nottingham University (www.nottingham.ac.uk/~sbzml/) and The Plymouth Student Scientist (www.theplymouthstudentscientist.org.uk/index.php/pss). These showcase 1st Class undergraduate research and support those undergraduates seeking academic research careers. Drawing on the expertise of these department journals, in March 2008 the first issue of the UK national undergraduate research *Bioscience Horizons* was published. All papers are written by students and based on final-year research projects.

Sources: biohorizons.oxfordjournals.org/; Knight (2006)

Intergenerational student teams support first-year inquiry courses in chemistry at the University of Michigan

Each year the chemistry department at Michigan has c100 students in term time or summer involved in undergraduate research with the c40 Department research groups. In addition, standard undergraduate

September 2009

laboratory instruction courses have been modified in order to create a more deliberate link to more authentic research practices.

An inquiry-based curriculum for first-year students. The large (c1400 students) introductory organic chemistry courses have been significantly revised to focus more on student inquiry, narrowing the gap between how faculty understand chemistry and how students experience chemistry in their coursework.

Authentic laboratory research for many. A subset of c160 students in this first year course self-select into a supplemental instruction program where they spend two additional hours per week engaged in tasks that involve their connecting with, understanding, and transforming information and data from the primary literature. In the laboratory, after spending about half their time developing manipulative skills around small, open questions they take on the design and implementation of limited but authentic laboratory primary research.

Upper level student support and development. This supplemental instruction program is a collaborative activity between the primary faculty member and a team of 8 upper-level undergraduate students (themselves graduates from the first year course) who have co-designed the instructional materials and who are solely responsible, with guidance from the faculty member, to implement these 2-hour sessions. These students are seen as potentially the next generation of teacher-researchers.

Source: Coppola (2005)

Co-ordinated interventions in Zoology at University of Tasmania, Australia

The department has developed a set of linked strategies/interventions including:

Year One c200 students

- Workshop on the use of animals in research: students put in the position of researcher, considering experimental design and animal ethics to complete an animal ethics application form
- Throughout the year, students encouraged to interact with a web portal (www.zoo.utas.edu.au/rir/rir.htm) with links to 'Hot Topics' in Zoology related to lecture material

Year Two

- Over several weeks an assessed task in which real, experimental data is given to the students for guided analysis and preparation as a manuscript for publication

Year Three

- Courses include group research projects, critical reviews of current literature, writing research grant applications, lectures from scientists outside the school, and training in scientific communication
- Zoology Research Unit (fcms.its.utas.edu.au/scieng/zoo/unitdetail.asp?UnitId=3349) individual students are matched with an academic supervisor to complete a semester-long research project
- Selected students work with staff to prepare a research paper for *Nexus Journal of Undergraduate Science, Engineering and Technology* (<http://www.utas.edu.au/scieng/nexus/>)

Years Two and Three

- All invited to participate in Student Research Volunteers program (<http://www.zoo.utas.edu.au/Staffpg1/summvolunteer3.htm>). Volunteers are matched with mentors, usually Postgraduate or Honours students in the School, for short-term, in-house research placements that may offer either laboratory or field experiences

Years One, Two and Three

- 'Reach into Research' seminars held several times each semester (www.zoo.utas.edu.au/rir/rir2&3.htm). Speakers from industry, collaborating institutions School PhD students present their research, and then all non-undergraduate audience members, except the facilitator, leave the room

Source: Edwards *et al.* (2007)

Integrating research and learning in the chemistry undergraduate curriculum at Utrecht University, Netherlands

Traditionally undergraduate chemistry in the Netherlands only ended with a "real" research assignment, which students undertake in one of the research groups of the University. However, this model is not very effective in developing the required scientific skills for a chemist, such as presenting their work, critically

September 2009

evaluating their work, and designing new experiments based on the results of previous experiments. Most chemistry students in the Netherlands go on to take the masters in the same university (approx 90% at Utrecht). A few years ago Utrecht opted for a curriculum in which learning research skills and knowledge go hand in hand.

First year - On the first day of their studies students start with a group laboratory project in which they are asked to prepare and characterize a polymer (a kind of plastic). The final material which they have to prepare is clear, however, the route to prepare that material is developed by the students themselves. At the end of the first year ALL the students (approx 70) work for three weeks in groups in one of the research departments.

Second year - In order to keep a link between the students, lecturers and researchers, students visit and carry out experiments in the research departments. At the end of the second year students are involved in a 5 week pre-determined group research project. The goal of their project is discussed with the supervisor (in most cases a senior PhD student). In that way the students are involved in a relevant, authentic research project.

Third year - At the end of the third year all students carry out an individual BSc-thesis research project. Students contribute for 10 weeks to an on-going PhD research projects in which they are assigned to their own sub-project.

Source: Personal correspondence Harry Bitter, Utrecht University

Research Emphasis Days in Veterinary Medicine at Edinburgh and Florida

Each year the School of Veterinary Studies at University of Edinburgh organises a 'Research Emphasis Day' where local researchers present current work to students of all years in a conference style format. In addition the School invites speakers from a variety of potential research employers to an event called VetChoice where students from any year are invited to learn about research opportunities for veterinary undergraduates and graduates. These range from talking about research opportunities within the Veterinary School to opportunities outside the School. The University of Florida College of Veterinary Medicine organises a similar event.

Sources: Struthers *et al.* (2008); <http://www.vet.ed.ac.uk/oldweb/red.htm>;
<http://www.vet.ed.ac.uk/Default.htm>; <http://www.wlcastleman.com/ufvetmed/phizeta07/index.htm>

Ways of knowing and research literacy in undergraduate nursing, health and behavioural sciences at University of Wollongong, Australia

Research subjects are built into each year of undergraduate nursing. By the time students reach the end of their course, some are potential researchers and all are committed to evidence-based practice. The aim is to build research awareness, access and appreciation in students through engaging curriculum design. Approx 200 students on three different sites explore research in three modules over the curriculum:

NURS164, Patterns of Knowing in Nursing

They begin by addressing questions such as: "what is the knowledge you need and where does it come from"? The students then explore where they will find each of Barbara Carper's (1978) four ways of knowing: empirical; aesthetic; personal; and ethical in the curriculum. They look at articles that apply each way of knowing to a topic (elder care). The subject is team-taught, and each way of knowing is woven through the lecture series. We give emphasis to ethical and legal issues, as well as critical thinking and argument. Each student chooses two case studies and then writes a reflective piece on using Carper's model to understand different perspectives of the case studies.

NURS264, Reflection and Practice

In this module students look more deeply into sources of evidence, and further develop critical thinking and reflection skills. In tutorials, students are encouraged to share stories and reflect on the ways of knowing that they contain. They examine arguments and discourses. During the sessions, students work on their ability to present logical arguments and critique the arguments of others. For their assignment, students take a dramatic episode or movie with a health care setting, and draw it as a conceptual map.

September 2009

NURS364, Research Appreciation and Application

This module is built around the assumption that all graduates need to be able to appreciate and apply research. A registered nurse needs to be aware of how their knowledge informs practice, and appreciate evidence-based practice. They need to know how to find out about new knowledge and implement change management. Students examine literature from an evidence perspective. Which assertions in articles and textbooks are backed up by evidence? During the session, different researchers come in to talk to students about their research. Their first assignment involves them formulating a nursing question on a topic of their choice, carrying out a literature review and drawing a conclusion. For their second, students work in groups and critically analyse the methodology of a published research article.

An evaluation showed improved information literacy skills and enhanced levels of self-confidence in developing search strategies and accessing current research evidence. The other theme that comes through is "retrospective appreciation" where students indicated that they did not fully appreciate the usefulness of the research skills they developed until their final year of study.

Source: <http://teaching.uow.edu.au/ltgp/search.aspx?RT=CS22>

2.2 Engineering and Mathematics

Introducing students to staff research: department of mechanical engineering, Imperial College, London, UK

This activity was a feature of the first year course in Mechanical Engineering at Imperial College London in the 1990s. We lack firm details on some of the aspects of this activity. If anyone has them please contact us.

- In January of their first year mechanical engineering students were divided into 10-15 groups of 4-5 students
- Each student group was given an engineering 'artefact' e.g. a safety razor; the bottom frame of a bicycle. In the next few weeks these student groups could knock on the doors of any of the department's research groups or staff, and ask questions around the issue of 'what research are you doing that might effect how this artefact will look like and function in c5 years time?'
- Later all student groups presented a poster which provided a summary of their findings
- The poster session was held in large public space in the department with some 700 attending; academic staff, support staff, postgraduates and first year and other students

Source: Correspondence with Eric Meyer (Durham University) who witnessed this as a visitor to the department

Across Department Undergraduate Research Programme in College of Engineering, Maryland, USA

Gemstone is a highly innovative programme for selected 'honors' students in engineering and other disciplines. The programme is now in its eleventh year. Student teams, formed in the freshman year, undertake three-year, student-initiated research projects in which they analyze and propose solutions to societal problems, which generally involve a significant technology focus. Team members work as a coordinated group, investigating their project from the perspective of individual majors, under the guidance of a faculty mentor. In their first two years students are encouraged to live together on a residence hall floor reserved for Gemstone participants. The research projects e.g. 'a comparative study of erosion control measures in the Chesapeake Bay area and homeowner response to such interventions', are developed in consultation with outside experts and agencies. In their final year student teams present their research to experts in the field or outside agencies and write a team thesis. The learning process mirrors the team based consultancy style research that students are likely to carry out after graduating.

Sources: <http://www.gemstone.umd.edu/>; <http://ws.cc.stonybrook.edu/Reinventioncenter/spotlight.html>

A department undergraduate research pathway in Mathematics at Ithaca College, US

The Department of Mathematics at Ithaca College, New York, over some 7-8 years radically changed its course offering, its culture and organisation to make “research with students, designed as part of the curriculum... a distinguishing characteristic of mathematics at Ithaca College”. There is a blend of inquiry / research for all students – including non majors – and an elective research focus for those interested.

The main components of this overall focus include:

- A first year course for all students *Mathematical Experimentation*. Students use computer software (in particular Mathematica (<http://www.wolfram.com/>)) to conjecture and test mathematical ideas, much like a natural scientist uses the laboratory to test hypotheses. Since these are first year students, there is not an expectation of rigorous proof, but rather to focus on the manner in which mathematicians go about creating new ideas. Examples of student work are at <http://www.ithaca.edu/faculty/dabrown/courses/Math185/>
- A second year course for all students (majors and non majors) – *Sophomore Seminar* brings together all students and all staff to explore mathematics. Groups of students work with staff and give class presentations on particular issues e.g. voting methods, group theory in kinship and so on.
- The main development has been a research sequence of two courses in the junior year. These focus on the pre-graduating class and both supports those honours/major students who wish to take a research thesis in their final year and education majors with mathematics as a minor who wish to take this research focus forward into their role as a teacher.
- The first such course, *Junior Seminar*, is required of all maths majors and introduces students to mathematical research methods, writing and citation. Students in groups also work on small research projects guided by staff.
- *Research Experience in Mathematics* is the main course in the research sequence. It has students working in groups on research questions shaped by staff research interests and those posed by students in previous years' projects. (Note the course is team taught and is rotated around the department to better ensure effective integration of 'undergraduate research' into the department culture. Students investigate “a research question initiated in the Junior Seminar. Completion of the research project involves, in addition to the mathematical arguments, a written report consistent with the standards of publication in mathematics and a public presentation at an academic symposium or conference” (Brown and Yurekli, 2007, 576).

Sources: Brown D personal communication (2008); Brown and Yurekli (2006; 2007)

<http://www.ithaca.edu/hs/depts/math/>

Research summer schools in mathematics and statistics at St Andrews, UK

In the context of a four year degree, selected third year students (those with high scores in the third year January exams –and selected students from other universities) participate in an intensive un-assessed 6-8 weeks 'course'. Students are introduced to topics on the interface between their undergraduate degrees and research interests of the staff involved. It serves as motivation and advertising for PhD courses. In Pure Mathematics, typically lectures occur during the first half of the school and in the second half of the school, the students are set projects relating to research topics. In Applied Mathematics, the schools are conducted more similarly to PhD supervision.

Sources: Quick (2009); <http://www-circa.mcs.st-andrews.ac.uk/CIRCA/summerproj.html>;

<http://www.mcs.st-and.ac.uk/pg/pure/Analysis/Summer.html>

Developing a complete research cycle in science, technology, engineering, and mathematics at University of Maryland East Shore (USA)

The institution is an historically black largely undergraduate institution. In these disciplines faculty have designed a set of linked curricula interventions in the mainstream curriculum to give many students and faculty experience of the whole research cycle, from project design to research dissemination. They argue that “Too often, undergraduate research projects are conducted during summers or other shortened periods, or concluded without determining possible extensions or formally presenting results in scholarly venues including professional meetings, conferences, and journals” (Johnson *et al.*, 2005, 28). A range of initiatives have been built into the curriculum over the four years of the degree to include defining research questions, grant proposal preparation, year round undergraduate research project and

September 2009

research dissemination. This initiative has been supported by bids to the Minority Science and Engineering Improvement Programme of the Department of Education and National Science Foundation.

Source: <http://www.ed.gov/programs/idadesmsi/index.html>

Linked degree programme of engineering clinics at Rowan University (USA)

Rowan is a regional largely undergraduate university in New Jersey. Students in its engineering programme can concentrate in Chemical, [Civil & Environmental](#), [Electrical & Computer](#) and [Mechanical](#) engineering. However, all students take 'Engineering Clinics', an eight-semester course sequence from the freshman to the senior year. Their common features include an emphasis on 'design' or the solution of open-ended problems that challenge students to apply higher-level skills such as analysis, synthesis and evaluation. The clinics focus on multidisciplinary problems often of an applied nature and students and faculty generally work in teams. Through the four years the problems become more complex and research like – with those in the junior and senior year often being supported through external research grants and through research-based consultancies. Research indicates these clinics / programmes are effective in supporting more students into graduate school and supporting high retention, in particular for women students.

Sources: Sukumaran *et al.* (2006); www.rowan.edu/colleges/engineering/programs/

Minority science and engineering improvement program Department of Education (USA)

This program assists predominantly minority institutions in effecting long-range improvement in science and engineering education programs and increasing the flow of underrepresented ethnic minorities, particularly minority women, into science and engineering careers. The program funds are generally used to implement design projects, institutional projects, and cooperative projects. The program also supports special projects designed to provide or improve support to accredited non-profit colleges, universities, and professional scientific organizations for a broad range of activities that address specific barriers that eliminate or reduce the entry of minorities into science and technology fields.

Source: www.ed.gov/programs/idadesmsi/index.html

2.3 Arts and Social Sciences

Department and institutional research resources support undergraduate research in history at Virginia, US

This case study demonstrates how the research resources of a research-intensive university department can support undergraduate research in a large' course. The course leader, Edward Ayers, is Dean of Arts & Sciences at the University of Virginia and a leading researcher on the American South. The School hosts the Virginia Center for Digital History. The resources of this Center, University and School research archives, research librarians, a postgraduate research and teaching team, support a range of undergraduate research programmes including research in an undergraduate course with an enrolment of c180 students for which Ayers is the course leader. The course involves undergraduate student teams using university archives to research a specific time or place and then publish their research to a web site for use by current and future students and other researchers nationally.

Sources: <http://www.vcdh.virginia.edu/SHD/howtobegin.html>;
<http://www.reinventioncenter.miami.edu/conference2006/edayers/summary.htm>

A Department Undergraduate Research Scheme: Psychology at York, UK

This initiative started in 2005 and replaced and developed previous informal arrangements. It enables students who wish to gain research experience to volunteer to assist with current department staff projects. Any 1st or 2nd year student can take part in the scheme though preference is normally given to second year students. Third year students are typically busy with their own projects and tend not to participate. Staff enter details of their projects on PsychWeb together with an outline of the research questions, what research assistance is needed and the rate of pay. Generally the payments to students come from research grants.

Source: Goebel and Gennari (2006); www.york.ac.uk/depts/psych/www/research/ures/

Introductions to academic practice: humanities and social sciences at Windsor, Canada,

'Ways of Knowing' in the departments of Arts and Social Sciences at the University of Windsor focuses on students developing disciplinary skills in research and critical thinking. Each year a particular theme is identified - generally one that reflects a Windsor community issue - and student teams investigate and present in public the results of their inquiries. Senior student mentors and community members act as mentors to these investigations. There are institutional discussions on extending this 'model' to other departments.

Source: apps.medialab.uwindsor.ca/cfl/reflexions/volume01/issue01/Ways_of_Knowing.htm

Using undergraduates to evaluate student experiences of teaching and learning in the Sociology Department, University of Warwick, UK

In the Department of Sociology at Warwick selected second and third year Sociology students led an evaluation of their peer's experiences of teaching and learning. They used a variety of social research methods – including focus groups, interviews and participant observation – to explore the learning experiences of their peers. The results were widely discussed within the department, and at a department away-day, and have led to students being more involved in department academic debates. Clearly it is more transferable to those departments and disciplines such as sociology, education, psychology, management, where students developing research skills 'match' the research focus.

Source: Hughes (2005)

Junior Research Bursaries in Social Sciences and Cultural Studies at Sussex (UK)

From 2008 the School of Social Sciences and Cultural Studies at Sussex University is offering competitive awards to selected first and second year students for summer research bursaries at a rate of £200 (not taxed) per week for 8 weeks for summer research projects. Applications must be sponsored by a member of faculty in the School, who must be willing to act as supervisor for the duration of the award. Bursaries are awarded to projects that clearly link to the research agenda of the supervisor and support their Department's research strategy. Bursaries are not awarded for projects that are part of assessed work for a degree (e.g. projects or dissertations), or for projects involving work away from Sussex

Source: <http://www.sussex.ac.uk/soccul/1-7-1.html>

2.4 Geography, Earth and Environmental Sciences

Integrating the development of inquiry and research skills through a whole degree programme: geography and earth sciences at McMaster

In Level One the development of inquiry and research skills begins in courses where students are introduced to inquiry-based learning through the use of a Socratic, 'questioning style' of lecturing and lab assignments that require students to formulate and answer their own research questions.

Many Level II and III courses involve students in short- term (several weeks) independent or team research projects. Students present the results of their research as a written paper, a poster or an oral presentation.

In Level IV all students are required to undertake some form of individual research project, either as a one term (13 week) research paper, or as a full year (minimum 26 weeks) undergraduate thesis that usually involves gathering of primary data prior to the start of Level IV.

Undergraduate Research. Many thesis students are employed as research or field assistants by faculty during the summer months or on a part-time basis during term-time. Funding is available to help offset the costs of hiring a student through McMaster University and competitive scholarships are available through funding agencies such as NSERC (Natural Sciences and Engineering Research Council of Canada)..

Source: Correspondence with Carolyn H. Eyles and Susan Vajoczki, School of Geography and Earth Sciences, McMaster University

Students across all three years of an environmental studies degree course at Sunderland University, UK, work together on local sustainability projects

Students on an Environmental Studies degree at the University of Sunderland undertook local sustainability projects, which brought levels 1, 2 and 3 students together in small research groups to work in collaboration with Sunderland City Council's Local Agenda 21 personnel, and other local environment and development agencies.

Source: Hughes *et al.* (2001)

Academic Journal Writing as Part of Course / Programme Requirements: Geography at Oxford Brookes, UK

The geography programme at Oxford Brookes has developed a set of linked programme requirements that support all students learning to write research articles. In the second year all students undertake field based research in a range of venues. A third /final year compulsory first semester course 'Geography Research and Practice' has as its main aim "to develop your skills in writing scholarly reports of your own research." The one assessment is for students to "write an article of up to 4000 words from the data that you collected in your (second year) fieldwork. The article will conform to existing academic practice for the preparation and submission of scholarly work." Relatedly the department has also just initiated an undergraduate e-Journal *Geoversity* to publish selected 'high quality' articles by students in the department including articles that were originally written for the module 'Geography Research and Practice. In addition some students take that experience / expertise to revise their article, or the research for their capstone dissertation for publication in the departmental undergraduate research journal *Geoversity*, or even in the linked newly established national geography e-Journal *Geoverse*. The author guidelines and requirements for this national journal represent the requirements for all programme students writing their journal article for 'Geography Research and Practice'

Sources: <http://www.brookes.ac.uk/schools/social/geoversity/index.html>;
<http://www.brookes.ac.uk/schools/social/geoverse/>;
<http://resources.glos.ac.uk/ceal/resources/casestudiesactivelearning/undergraduate/index.cfm>.

Developing an undergraduate research culture in earth sciences at Oxford University, UK

Departments have cultures which may unwittingly or purposefully keep students "at arms length" from research (Brew 2006, 52) or bring them into that experience. Philip England (2007) of the department of earth sciences at Oxford University, comments on the culture of his department:

"Fieldwork is a central aspect of Geology and, almost irresistibly, it imposes a flavour upon our teaching. ... A day in the field typically involves more than 12 hours of close-contact teaching, in which the agenda is set by the observations that the students make, and the questions that they pose. Frequently, those questions have no known answer. ... By the time they are in their second year, most undergraduates are on first-name terms with the academic staff ... A variety of practices underpin this informality in ways that, separately, do not appear particularly powerful but which, because they are valued by all, have a large cumulative effect. Interaction space is highly valued, and it is an (unwritten) guiding principle that anyone can interact with anyone else in the common space (library, staff coffee room, undergraduate common room, etc.)."

That perspective of the department culture is validated by external reviews and performance indicators. Thus Graham Gibbs (2007) analysis of the department observed that:

"The central social space in the department has posters on the walls that have just come back from conferences, and which change regularly. It would not be possible for students to be unaware of what research was being undertaken or who was undertaking it. In this social space, informal discussion of research, with undergraduates involved, seemed to be going on constantly. Students were invited into research projects in the lab or the field in an ad hoc way if they showed interest. Students were being inducted into a community of practice rather than only being taught."

Sources: England (2007); Gibbs (2007)

2.5 Developing research skills and academic practices

Auditing and developing student research skills at Adelaide, Australia and Reading, UK

Selected departments at both Adelaide and Reading have systematically audited department based undergraduate and postgraduate programmes for the extent to which they develop student research 'skills'.

Research at Adelaide has developed both a conceptual framework on student research development and based on this a diagnostic tool to support interventions to strengthen student research skill development in courses. Thus two consecutive first year courses in Medical Science have adapted their assessment tasks to explicitly and systematically develop student research skills in accordance with the Research Skill Development (RSD) framework. A broadened application of the framework is being trialled, including with laboratory-based and numeracy-rich research, and to other disciplines and departments, including Petroleum Engineering, Nursing and English. The framework is publicly available for other institutions to adapt (Willinson and O'Regan, 2007).

Within Departments methods to collect data on undergraduates' research skills teaching and learning can be time-consuming and ineffective. At the University of Reading a related electronic 'research skills audit tool' has been developed for staff to systematically map research skills teaching and assessment within their own modules. The tool facilitates quick and easy collation of modular data across entire degree programmes, thus making it a valuable Departmental resource for reviewing undergraduate curriculum design (Fraser *et al.*, 2007).

Source: Willison and O'Regan (2007); Fraser, *et al.* (2007)

Introductions to academic practice: economics and business at Sydney, Australia

The Faculty of Economics and Business at the University of Sydney has radically rethought its approach to issues of plagiarism and academic honesty. Through a collaborative action research project they have moved from an approach of compliance to inducting students into the nature of academic practice. Starting with a voluntary on-line first year module in 2004, academics are supported to reshape their courses and practices across the faculty in ways that reflect a view of students 'as uninformed, but willing participants in the promotion of academic honesty.' The Faculty's management system has instituted 'multiple linked activities' to promote academic honesty amongst students and engage staff in such discussions. Thus in 2005 the module was made compulsory for all new students before submitting their first assignment. Videos of students talking about academic honesty are used in orientation and induction activities. Faculty are being supported in revising their assessments and course work to more explicitly integrate academic practices re research honesty and ethics into their courses, in part prompted by the institutional commitment to research-enhanced teaching.

Sources: Freeman *et al.* (2007)

3. Undergraduate Research and Inquiry in Institutions

3.1 Europe

Undergraduate Research Opportunities Programme (UROP) at Imperial College London, UK

<http://www3.imperial.ac.uk/urop>

The Undergraduate Research Opportunities Programme (UROP) gives students the chance to take part in the activities of College research groups. Founded in 1980, this is the earliest example of such a programme in the UK and was directly based on the MIT scheme. The scheme focuses on students in year two and is often used to develop ideas for their final year dissertation or project. While most projects are undertaken in the summer they can also take place in term time. Students are awarded bursaries for their work from a variety of sources but most commonly from supervisors' research funds, general departmental funds or external funds such as the Nuffield Foundation's Undergraduate Research Science Bursaries. The scheme is also open to students from outside from Imperial. Over 3,300 students have participated since 1980. In 2005-6, 320 students participated of whom 185 were from Imperial (mainly summer 2006).

Undergraduate research at University of Gloucestershire, UK begins at induction

In 2007 over 650 students in the Faculty of Education, Humanities and Science undertook discipline-based inquiry projects during induction week. This involved them working in small groups to collect information from the library and in the field, analyse it, present it to tutors in novel ways, and receive formative feedback. For example, the human geographers and the sociologists researched the experience of Gloucester residents of 'the Great Flood of 2007'. The Biologists and the Psychologists investigated primate behaviour at Bristol Zoo, while English Literature students visited an arboretum and explored the use of trees in literature. Other Faculties in the University are developing their own versions of developing undergraduate research as part of induction. It has also proved a significant staff development activity both for the many academic tutors in designing inquiry-led activities and the library staff who changed their approach to library induction to support the specific student research projects.

Source: Further information is available at: <http://resources.glos.ac.uk/ceal/pre-induction/index.cfm>

University of Roskilde, Denmark: Half of the work of all students is spent undertaking projects (www.ruc.dk/ruc_en/about/)

At least 50% of student time in the assessed curriculum in five years from BA to MA is taught through project work. The projects involve students working in groups guided by staff. 'Problem-orientated project work... [is] participant directed indicating that it is the group members that collectively... take the responsibility for the project. ... The result is a body of knowledge owned for the most part by the students that produced it and not borrowed from the teachers who taught it' (Legge, 1997, p.5). The first two years are interdisciplinary group projects, later projects tend to be within one discipline and sometimes may be undertaken individually.

Oxford Brookes University (UK): Building undergraduate research into the curriculum

From 2007 all Schools and Departments are required to develop a more structured approach to developing all students as researchers in all course programmes in years one and two; and through specialist pathways to support those students who choose a more extended research curriculum. Such pathways may include a focus on community-based undergraduate research. The requirements build on a previous university-wide intervention. In the context of the move to semesters, in 2002-3 all undergraduate and taught postgraduate courses were redesigned with the requirement that they 'demonstrate how the linkages between research and teaching and learning are realised in the formal curriculum and the wider student experience.' This process was overseen by a university-wide steering group, the Redesign Advisory Group.

Source: Huggins *et al.* (2005; 2007a)

Embedding undergraduate research and inquiry at University of Gloucestershire

Following a nine-month development and consultation process the University adopted a new Learning, Teaching and Assessment Strategy. The core value underpinning the Strategy is 'learning for life through active engagement.' Drawing on work of the Centre for Active Learning undergraduate research and inquiry are key elements of the engaged learner. To be inclusive of different academic disciplinary and professional cultures a broad definition of the undergraduate as researcher is used in the university to describe student engagement at all levels in research and inquiry into disciplinary, professional and community-based problems and issues whether individually or in groups and in collaboration with or independently of staff. The strategy is underpinned by research into 'Leading, Promoting and Supporting Undergraduate Research in the New University Sector'

Source: <http://resources.glos.ac.uk/adu/clt/Itaframework/index.cfm>; [resources.glos.ac.uk/ceal;](http://resources.glos.ac.uk/ceal/resources.glos.ac.uk/tli/prsi/current/ugresearch/index.cfm)
resources.glos.ac.uk/tli/prsi/current/ugresearch/index.cfm.

Integrating staff and students at different levels through 'subject families' at University of Oxford, UK

As part of overall institutional planning, Oxford University is using the idea of 'subject families' to help integrate undergraduates and postgraduate students with research staff and academics in the Colleges. Periodically students and staff in related subjects come together for academic and social activities which showcase and discuss current research by College members. These changes have also opened up

September 2009

opportunities to develop inter-disciplinary links and for undergraduates to appreciate better the research done by staff in their college and the prospects for some of them of pursuing research careers. This may be an idea that other institutions could adapt for departmental implementation.

Sources: Correspondence with Claire Stocks; University of Oxford (2005);
<http://www.st-annes.ox.ac.uk/study/undergraduate/subject-families.html>

Institutional Research Skills Certificate at Warwick and York Universities, UK

Many (UK) institutions have strategies (including Personal Development Planning - <http://www.heacademy.ac.uk/ourwork/learning/pdp>) to help students record their developing employment related skills and achievements – including research skills. Warwick University and York University have developed institutional (research) skills certificate/awards to help students identify and develop the graduate attributes and skills developed through involvement in research.

Sources: www2.warwick.ac.uk/study/csde/usp/wsc/; www.york.ac.uk/services/careers/skills.cfm

Nottingham Trent University (NTU): Research Informed Teaching

NTU have introduced a Postgraduate Diploma (PGDip) in Research Informed Teaching which helps members of academic staff develop skills in research practice in order to become better placed to teach and to supervise projects at undergraduate / postgraduate / PhD level. It is aimed particularly at those lecturers who have previously worked as practitioners before entering university teaching, and have therefore joined the university sector as teachers in mid-career. It offers a teaching and learning experience for lecturers who wish to familiarise themselves with the skills and perspectives that inform current research practice, and who wish to gain direct experience in conducting high-quality empirical research.

Source: www.ntu.ac.uk/apps/pss/courses/cf/60565-1/10/PGDip_Research_Informed_Teaching.aspx

Undergraduate research for North American exchange students at Aachen, Germany

The Undergraduate Research Opportunities Program at RWTH Aachen University fosters research partnerships between undergraduates from top US and Canadian universities and Aachen research faculty. The program's duration is ten weeks. The first two weeks are dedicated to an intensive German language course and an introduction to research and culture. Weeks 3 to 10 are settled around a mentored research internship in one of the faculties. The programme is organised through the International Office.

Sources: www.irtg1328.rwth-aachen.de/071121-UROP.pdf;
www.sfp.caltech.edu/opp/UROPinternational%20Okt%202008%20A4-small.pdf

3.2 Australia and New Zealand

Australian National University: Introduction to Inquiry

(<http://www.anu.edu.au/CEDAM/ilearn/inquiry/index.html>)

The University aims to ensure that ALL their undergraduate students are introduced to inquiry learning from the beginning of their program of study. An inquiry-based approach to learning involves students directing their learning by formulating questions, defining problems and investigating issues relevant to their future roles as researchers and professionals. Examples are presented from courses on The Big Questions in Physics; Human Biology; Resources, Environment and Society; Money, Power, War; Science and Public Awareness; and Introduction to Psychology. The site also includes two examples of inquiry-based learning in more advanced courses.

Advanced Study Courses at Australian National University (ANU)

In 2003 ANU established the Bachelor of Philosophy degree to provide a research based education for elite students. They undertake research at a high level from the beginning of their undergraduate degree through the inclusion of six or more research-led projects during years one to three of their degree (Wilson *et al.*, 2007, Newitt 2007). These research projects replace lecture based courses and “may consist of a reading course with a world-leading scientist or joining a research team to assist in the advance of knowledge” (ANU, 2009). These students then take an Honours year which normally involves both course work and a substantial piece of original research. Those ‘teaching’ on the programme include specialist researchers from ANU’s Institute of Advanced Studies. There is a university wide forum that supports spreading insights and resources from this programme to more ‘mainstream’ courses at ANU (Centre for Educational Development and Academic Methods, nd).

Sources: ANU (2009); Centre for Educational Development and Academic Methods (nd); Wilson *et al.* (2007); Newitt (2007)

The University of Queensland, Australia, funds research staff to engage in teaching

Since 2006 the University of Queensland has used some of the money raised through the Enhanced Student Contribution (levied at 25% additional charge to students) to pay for research staff to engage in teaching at undergraduate and/or graduate coursework level for 10 or 25% of their time. In 2009 AUS\$4 million has been set aside for this purpose. The scheme, named ResTeach, is designed to remove a frequently stated impediment to utilising research staff, namely resource allocation, and thereby:

- expose students to key researchers, who hopefully can convey the excitement of their field;
- improve the student: teacher ratio in an effective and efficient manner;
- provide an opportunity for interested researchers to expand their portfolio;
- strengthen the relationship between research and teaching to improve the student learning experience, and
- reduce the teaching loads of existing T&R academics.

The primary purpose of ResTeach is to improve the learning experience of students, not to be a prime source of funds for centres or institutes or the operating budgets of schools. A review of the scheme in 2008 concluded that “the ResTeach scheme is now a key component of UQ’s strategy to link teaching and research and is, in fact, one of the few mechanisms that has effectively supported the teaching-research nexus.”

Sources: www.uq.edu.au/teaching-learning/index.html?page=92623f; Correspondence with Deborah Terry

University of Sydney: Strategic use of performance indicators to stimulate linkage of teaching and research

The purpose of the Performance indicators is to provide a mechanism for auditing progress towards reaching the university’s strategic goals for strengthening the relationship between teaching and research, and to encourage the development of research-enhanced teaching.

Examples of performance indicators

- Student awareness of and active engagement with research

September 2009

- Undergraduate and postgraduate student awareness of the research culture of the university and the research being done in their school/department/faculty
- Curriculum designed to engage students in a variety of research-based activities, induct them into the research community and develop their awareness of research
- Proportion of units where students engage in research-based activities
- Existence of an advertised student research seminar program or evidence of engagement of undergraduate students in departmental seminars
- Audit of research-led teaching carried out on a triennial basis and benchmarked with other Universities

Although these performance indicators for promoting the links between teaching and research were discussed, an implementation policy backed up by redistribution of resources has not been put in place.

Source: Brew and Prosser (2003)

Griffith University: Identifying programmes including research-based learning component

To meet the strategic target that '70% of all Griffith programs include a research-based learning component by 2010' the University has developed a policy to define what evidence is needed for a program to satisfy the minimum requirements to qualify as including a 'research-based learning component' and the criteria against which Course Convenors should assess whether their courses contain such components.

For a program to contribute to meeting the University's strategic performance indicator for research based learning at least 20% of the student course enrolments are in courses identified as having significant elements of research-based learning. Course Convenors assess their courses against the following categories:

- Systematic introduction of a significant amount of current discipline related research into the course content and teaching
- Use, as the primary pedagogical approach for the course, of inquiry-based processes that are modelled on the research approaches that are common in the discipline or field
- Research methodology courses are included in the undergraduate program.

3.3 United States

Barak Obama, *The Harvard Law Review* and Undergraduate Research and Publishing

In 1991 Barak Obama, then 28 years old, became the first black editor of the *Harvard Law Review*. He stated a determined to make it a "forum for debate", bringing in new writers and pushing for livelier, more accessible writing (Butterfield 1990).

"The *Harvard Law Review* is a student-run organization. Student editors make all editorial and organizational decisions and, together with a professional business staff of three, carry out day-to-day operations. A circulation of about 8,000 enables the *Review* to pay all of its own expenses. ... The *Review* publishes articles by professors, judges, and practitioners and solicits reviews of important recent books from recognized experts.

Most student writing takes the form of Notes, Recent Cases, Recent Legislation, and Book Notes. Notes are approximately 18 pages and are usually written by third-year students. Recent Cases and Recent Legislation are normally six pages long and are written mainly by second-year students. Book Notes, also written by second-years, are six-page reviews of recently published books.

All student writing is unsigned. This policy reflects the fact that many members of the *Review*, besides the author, make a contribution to each published piece."

Sources: Butterfield (1990); <http://www.harvardlawreview.org/>

Hampshire College: Linking research and teaching is key element of the college's mission
(<http://www.hampshire.edu/>)

Hampshire is a small private liberal arts US college focused on self-initiated, individual research programs of study negotiated by students with academic staff. More specifically:

Beginning and Division 1 Requirements: 'Students must formulate substantive questions on a range of specific subjects and then reflect critically on the implications of the analytical frameworks and methods they used in pursuing the questions' (Prince and Kelly, 1997, p.7).

Division 2 Requirements: 'Working with at least two or three faculty, students ... define a substantive area of study and then specify key questions that will serve as general guides through the concentration... In the second step ... the student designs a program of study, including ... independent study' (ibid., p.8).

Division Three and Capstone Requirements: This is 'primarily devoted to a ... thesis or artistic project' (ibid., p.9).

Women in Science and Engineering (WISE): University of Southern California, US

Research Fellowships are granted each year to support summer and academic year research. The goal is to familiarize students with laboratory research and link them with a mentor early on. It is hoped that through the experience of first-hand research at the undergraduate level, the chances will increase that students will choose to pursue a graduate degree in science or engineering. The WISE programme was established in 2000 through a £20 million pound anonymous endowment.

Source: http://www.usc.edu/programs/wise/programs/undergrad_research/

Massachusetts Institute of Technology: Undergraduate Research Opportunities Program
(<http://mit.edu/urop/>)

The Undergraduate Research Opportunities Program (UROP) supports research partnerships between MIT undergraduates and academic staff. Formed in 1969, it is one of the earliest such programmes. "UROP projects take place during the academic year, as well as over the summer, and research can be done in any academic department or interdisciplinary laboratory. Projects can last for an entire semester, and many continue for a year or more. UROP students receive academic credit, pay, or work on a voluntary basis." MIT is now working with the department of engineering at Cambridge University (UK) to develop an undergraduate research programme there (<http://www.eng.cam.ac.uk/teaching/urops/>). MIT conducts an audit of UROP participation among graduating seniors each year. For the class of 2004, 82 per cent of graduating seniors had participated in UROP at least once during their undergraduate careers (Huggins *et al.*, 2007).

Mainstreaming Undergraduate Research and Inquiry at Miami University, Ohio, US

Miami University, Ohio is moving from a teaching paradigm to a learning and discovery paradigm. *The TOP 25 project* calls for innovative approaches that moves learning away from "too much time telling students what we think they need to know, and not enough time using their curiosity to drive their learning." The TOP 25 Project involves the largest recruiting courses (actually 31 of them) being rewritten as inquiry-based courses. Each course has been allocated \$35,000 to fund curriculum revision. Learning technologists and educationalists support the teams of staff involved. Seven or eight courses per annum are being redesigned over a four year period. Together the courses account for almost a quarter of total credit hours. All courses with more than 1,000 credit hours are in the programme. Many of the courses are being redesigned using the inverted classroom model in which most of the lectures are provided electronically using, for example, videos, I-pods, and VLEs, while most of the contact time is used for interaction between faculty and students. Some of the physical spaces are being redesigned to provide flexible furniture to encourage discussion.

Sources: Hodge *et al.*, 2007; 2008; http://www.units.muohio.edu/led/Top_25_Project/Index.htm

Final Year Project Presentation at Alaska Pacific University

At Alaska Pacific University, a small private university, all students in all disciplines undertake a senior project and present it to the campus community on designated days at the end of each semester. Thus students experience both the experience of doing research, but also communicating it through spoken presentation.

September 2009

The institution has a strong commitment to active and research based learning and they now market themselves as "The University of Active Learning." They have a strong year one orientation to active learning and a range of required courses in all years involving research techniques and projects which lead into the required final year senior project. This has a strong applied focus. As well as a formal research paper, students in discipline groups (mainly Environmental Sciences, Human Services, and Business) present their research as a professional public presentation. These end of semester presentations are advertised for the faculty, staff and students, as well as interested members of the public. Other classes are cancelled so that the student body may attend. Often members of the site where the investigation takes place attend. The final assessment is on the 40-60 page research paper, the quality of the presentation and handling of questions at the presentation. While numbers of graduating students are small (c70 per year) the idea of a public presentation as part of the final year project could be adapted by larger departments and institutions.

Sources: Correspondence with Carl Hild; <http://distance.alaskapacific.edu/course/info.php?id=387>
<http://www.alaskapacific.edu/Pages/default.aspx>

Undergraduate research programmes to support first year success racial and cultural diversity and widening participation: University of Michigan, US

A number of Undergraduate Research Opportunity Programs (UROPs) focus on what in the UK would be called 'widening participation'. At the University of Michigan there is targeted support for largely Afro-American students from inner-city Detroit. While the University had been successful in recruiting these students, their drop out rate was high. Special UROPs were targeted at these students in year one and two to enhance their integration and academic success. There has since developed related projects to support transfer students into Michigan from community colleges and four-year colleges. Research demonstrates significant positive impacts (Locks and Gregerman, 2008). In addition linked to the University wide UROP programme a first year residential programme for some 80 students is aimed at culturally and geographically diverse US students and international students. Research is conducted with selected faculty and supported by resident second and third year peer mentors.

Source: Huggins *et al.* (2007); Locks and Gregerman (2007); <http://www.lsa.umich.edu/mrc/index.htm>

Arts of Citizenship Program at the University of Michigan, US

In this program students combine learning and research with practical projects that enhance community life. Each year Arts of Citizenship directly sponsor 8-12 projects, and awards grants for another 8-12 projects. Projects in the arts, the humanities, and design are wide-ranging and include:

- In the Underground Railroad project, Arts of Citizenship has collaborated with the African American Cultural and Historical Museum of Washtenaw County to research 19th-century antislavery activism and African American community life in the area. The youth-oriented historical exhibit, *Midnight Journey*, has
- In partnership with Detroit's Mosaic Youth Theatre, Arts of Citizenship teams used oral history and archival research to help create *2001 Hastings Street*, a nationally touring musical drama about coming of age in 1940s Detroit. The production and an accompanying exhibit were part of the celebration of the Detroit's 300th anniversary in 2001.

David Scobey (2006), the key originator of this programme has now led its adaption to a whole institution initiative, and its adaption to other disciplines - The Harvard Center for Community Partnerships - at Bates College Maine.

Sources: www.artsofcitizenship.umich.edu/about/program.html; www.bates.edu/harvard-center.xml

Undergraduate Research Celebration Days

Many US institutions have a special day, days or a whole week in which students from across the institution present their research – generally by posters but also by talks, exhibitions or performances. These are often accompanied by talks from leading researchers in that institution or nationally. Audiences for such events are faculty, fellow students; and in some cases, e.g. Boston University and Bates College, the dates for such events are carefully selected to ensure parents, potential students, alumni and potential sponsors can attend (Huggins *et al.*, 2007b). In 2008 the University of New Hampshire celebrated its 9th undergraduate research conference; over 800 students participated in 23 events over

September 2009

nine days. The Council for Undergraduate research web site provides useful details on many of such events.

Source: Huggins *et al.* (2007b); www.unh.edu/urc/; www.cur.org/Publications/celebrationdays.asp

First-year on-line introduction to research course at Virginia Tech University, US

The Undergraduate Research Institute at the College of Liberal Arts and Human Sciences at Virginia Tech is piloting in 2008-9 an on-line course to introduce students to undergraduate research. Virginia Tech, like many other large research universities faces the dilemma of knowing the importance of exposing undergraduates in year one to the research culture of the institution while not having the resources to give each one of them an individualized experience with a faculty member.

Research about undergraduate inquiry was explored in addition to models from other institutions, and student development theory pertaining to working with first-year students. LAHS 2984: Introduction to Undergraduate Research spans both semesters. Assignments vary from readings that help students understand the culture of a research university and the importance that research plays in university life, to them attending the Undergraduate Research Institute Kickoff and experiencing the Virginia Tech Undergraduate and Prospective Graduate Student Research Conference. Students are not just exposed to what research means in their major field of study, but gain an interdisciplinary perspective by examining the ways that research and creative work is conducted across disciplines.

In its first year enrolment is limited to c30 students – but the intention is to use this ‘experiment’ to then ‘scale-up’ the course so that it can support many students by crafting assignments that would be thought provoking and informative but easily evaluated by graduate students and second year students who have passed the course.

Sources: Correspondence with Diana Ridgwell, Director of Student Development and the Undergraduate Research Institute, College of Liberal Arts and Human Sciences, Virginia Tech.

<http://www.uri.clahs.vt.edu/Student%20Resources.html>

Experiential learning for all at Indiana University-Purdue University, US

In 2008 the university launched an initiative to encourage all students to undertake experiential learning activities in two of four areas: undergraduate research (defined within each department), service learning, international experience, or other experiential active work. The work must be within a course and pass muster, for undergraduate research, as meeting the university’s broad definition of ‘undergraduate research’. The Assistant Vice Chancellor for Research “expect(s) this initiative to increase student research on campus and looks forward to it ultimately being required for all students. Right now only some of our departments require this.” (Wilson, 2009)

Sources: Kathryn J. Wilson, Assistant Vice Chancellor for Research, Indiana University-Purdue University Indianapolis (IUPUI), posting to Council on Undergraduate Research web site 30 January 2009;

http://www.iupui.edu/administration/acad_affairs/rise/;

http://www.iupui.edu/administration/acad_affairs/rise/rise_proposal.pdf

On campus undergraduate research employment: Northwest Missouri (US) and York University (UK)

Undergraduate students being employed in a variety of roles, including academic roles, on campus is an important feature of many US universities. The scheme at Northwest Missouri is a strong example of such structured programmes - with c40% of university employees (over 540) being students. Some have roles of considerable responsibility and their employment is an integral part of their learning experience. In the UK and elsewhere there is strong pressure from government to expand and link employment and higher education. York University, through its careers service and supported by a National Teacher Fellowship, aims to expand the breadth and number of part-time and temporary higher level employment opportunities available to York students - in part shaped by the Northwest Missouri example. The project involves scoping and prototyping a comprehensive on-campus student employment scheme, with a particular focus on higher skilled work, and to explore the application of this scheme with local

September 2009

businesses. York is particularly interested in exploring how the scheme may be used to involve students in a variety of forms of undergraduate research.

Further information

Charlotte Melia, York University; DIUS (2008); catpages.nwmissouri.edu/m/lgmf/documents/

Investigating 'writing across the curriculum' at Utah State University, US

At Utah State undergraduate students with outstanding communication skills are selected to serve as rhetoric associates to support student writing. This institutional strategy came out of a project which reviewed the amount and kinds of writing in over 700 syllabi at the undergraduate level. It was undertaken by about 20 undergraduates as part of a seminar on tutoring writing across the curriculum. "Although the research problem - what is the nature of writing assignments at this institution - was not one developed by the students, they engaged in the research process and decision making from thereon" (Kinkead, 2009). They started by studying current research on writing across the curriculum and, guided by the instructor, devised common research protocols and methodologies which each then separately applied to particular departments and shared the results and proposed interventions.

Sources: Kinkead (2009); www.usu.edu/raprogram/

3.4 Canada

University of British Columbia: University-wide research-based learning experience

(<http://www.trek2000.ubc.ca/index.html>; <http://www.research.ubc.ca/UGConf.aspx>)

TREK 2000, 2010 and the University Academic Plan state that every undergraduate should have the opportunity to engage in research should they desire. The Undergraduate Research Committee out of the VP Research Office developed the Multidisciplinary Undergraduate Research Program (MURP) in 2004. Supported by a Teaching and Learning Enhancement Fund Grant (TLEF), MURP's goal is to develop a cohesive undergraduate research program at UBC that will support the enhancement of research experiences for our undergraduate students.

Undergraduate students are selected from all possible disciplines to participate in this novel and exciting program. Students who participate have the opportunity to develop skills to support a research project they are involved in within their discipline (be it through directed studies, honours programs, volunteer work or research assistantships).

University of Alberta: Institution-wide project 'Research makes sense to students' leads to strategic focus on 'discovery learning'

In 2003-4 the University introduced a "Research Makes Sense for Students" initiative under the Office of the VP (Research). This raised awareness among faculty of the issues and international literature on teaching research relations, and various task forces considered how then policies and practices could be enhanced. Relatedly in conjunction with the Student Guild there was a range of activities focused on undergraduates and graduate students making them aware of the potential benefits of learning in a research environment. This led in the 2007-2011 planning cycle to a range of funded initiatives and policies to support 'discovery learning' with a clear focus on year one courses and final year small capstone courses.

Source: www.uofaweb.ualberta.ca/researchandstudents/; www.president.ualberta.ca/daretodiscover.cfm; www.president.ualberta.ca/pdfs/DaretoDeliver.pdf

McMaster University: Inquiry-based courses available across the curriculum

(<http://www.mcmaster.ca/cll/inquiry/index.htm>)

The University has a tradition of innovative problem-based learning in medicine and engineering. In 1998 it launched an initiative to develop an inquiry-based approach across the whole curriculum, starting initially in selected courses in years one and two. "Inquiry courses are skill-driven rather than content-driven, focusing on the skills required to perform effectively at university and well beyond university. These generalizable skills help students hone skills equally useful for advanced levels of academic

September 2009

research.” This is supported through the teaching development unit and through programme leadership responsibilities for senior staff. Teaching is done in teams of generally research active, tenure stream staff, with a three-year rotation, reflecting the commitment needed to teach such courses, but also better ensuring that the skills of inquiry teaching are disseminated across the university.

Some 20% of students in year one and two take at least one inquiry-based course and the research evidence is that such students generally achieve well in subsequent courses (Elliot, 2005; Sutherland, 2005). For details of the research evidence on the beneficial impact of the Social Science Inquiry course see section 2.2 above.

Vancouver Island University: Building design to link research and teaching

The institution is in the initial stages for planning for a new Integrated Science Centre. This provides the Faculty of Science and Technology with the opportunity to link research and teaching into the design of the facilities. Students will take specific courses with a strong research component, often requiring extended use of laboratory spaces instead of the traditional three-hour classroom sessions. New lab spaces will be designed to accommodate this. Faculty research areas will be places where students will engage in research with their teachers using an apprenticeship model combined with problem-based teaching. The new building will also contain many spaces where students can work in groups, with each other and with academic staff, on research projects, both inside and outside the laboratories.

ANNEX ONE

Departmental and course team strategies to mainstream undergraduate research and inquiry (based on Healey and Jenkins 2009)

Review understanding and practice of undergraduate research and inquiry

Work with colleagues to review their conceptions of undergraduate research and inquiry and then build that understanding into the curriculum.

Develop a set of related curricula interventions

The Boyer Commission on *Educating Undergraduates in the Research University* (1998, 15-22, 27-28) called for ten key changes in undergraduate education, four of which directly call for organisational changes at department and institutional level to strengthen the undergraduate experience of research:

“1: Make Research-Based Learning the Standard – Learning is based on discovery guided by mentoring. Inherent in inquiry-based learning is an element of reciprocity: faculty can learn from students as students are learning from faculty.

2: Construct an Inquiry-Based Freshman Year – The first year of a university experience needs to provide new stimulation for intellectual growth and firm grounding in inquiry-based learning and communication of information and ideas.

3: Build on the Freshman Foundation – The freshman experience must be consolidated by extending its principles into the following years. Inquiry-based learning, collaborative experience, writing and speaking expectations need to characterize the whole of a research university education.

7: Culminate with a Capstone Experience – The final semester should focus on a major project and utilize to the full the research and communication skills learned in the previous years.”

Offer undergraduate research and inquiry as a pervasive and early element of the curriculum

Give students experience of undertaking research and inquiry with different levels of independence

Link undergraduate research and inquiry to student employability

If the concept of a ‘knowledge economy’ has any validity then undergraduate education for all has to include some understanding of, and ability to do or use, research. Calling this ‘undergraduate research’ and making explicit to students the fact that this may well aid their employability, can ... help them to appreciate better the role of research in the university

Ensure assessment practices and policies support students as researchers –this might include rethinking the form of the final year dissertation to make it closer to research processes and forms of dissemination in the discipline? Perhaps the final year displays by arts students and undergraduate student journals are two strategies to adapt? Perhaps

Include all and be selective

While clearly involving all students in some form of research, course teams may also choose to offer special undergraduate opportunities to selected students.

ANNEX TWO : Institutional strategies to mainstream undergraduate research and inquiry (Healey and Jenkins 2009)

A. Develop supportive institutional strategies and policies

1. *Embed in vision and teaching and learning and research strategies of university.*
2. *Develop supportive institutional curricula frameworks and structures.*
3. *Link undergraduate research and inquiry to institutional policies for employability.*
4. *Link undergraduate research and inquiry to institutional policies for widening participation.*
5. *Link undergraduate research and inquiry to institutional policies for civic and community engagement.*

B. Encourage and support student awareness and experience of undergraduate research and inquiry

6. *Embed undergraduate research and inquiry from day students enter university.*
7. *Raise students' awareness of research.*
8. *Provide opportunities for selected students to undertake undergraduate research and inquiry within and outside the curriculum.*
9. *Provide opportunities for all students to undertake undergraduate research and inquiry within and outside the curriculum.*
10. *Have students investigate issues that are of importance to the university or other students.*
11. *Value the role that student organisations can play in supporting undergraduate research.*
12. *Celebrate undergraduate research and inquiry.*
13. *Provide support and encouragement to students undertaking undergraduate research and inquiry.*

C. Ensure institutional practices support undergraduate research and inquiry policies

14. *Ensure quality assurance, quality enhancement and institutional assessment processes and policies support students as researchers.*
15. *Ensure appropriate learning spaces are available to support undergraduate research and inquiry.*
16. *Align student support from library, information and communication technology services and laboratories with needs of students undertaking undergraduate research and inquiry.*

D. Encourage academic staff awareness and support and reward engagement with undergraduate research and inquiry

17. *Increase academic staff awareness of undergraduate research and inquiry.*
18. *Provide support to academic staff with regard to professional development so that they are encouraged to become engaged in undergraduate research and inquiry.*
19. *Provide incentives and rewards for academic staff to support undergraduate research and inquiry, particularly through workload planning, institutional and departmental recruitment, criteria for appointment, performance review and promotion processes.*

