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LINKING DISCIPLINE-BASED RESEARCH AND TEACHING THROUGH MAINSTREAMING UNDERGRADUATE RESEARCH AND INQUIRY

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

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).

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

- | |
|---|
| <ul style="list-style-type: none"> • 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

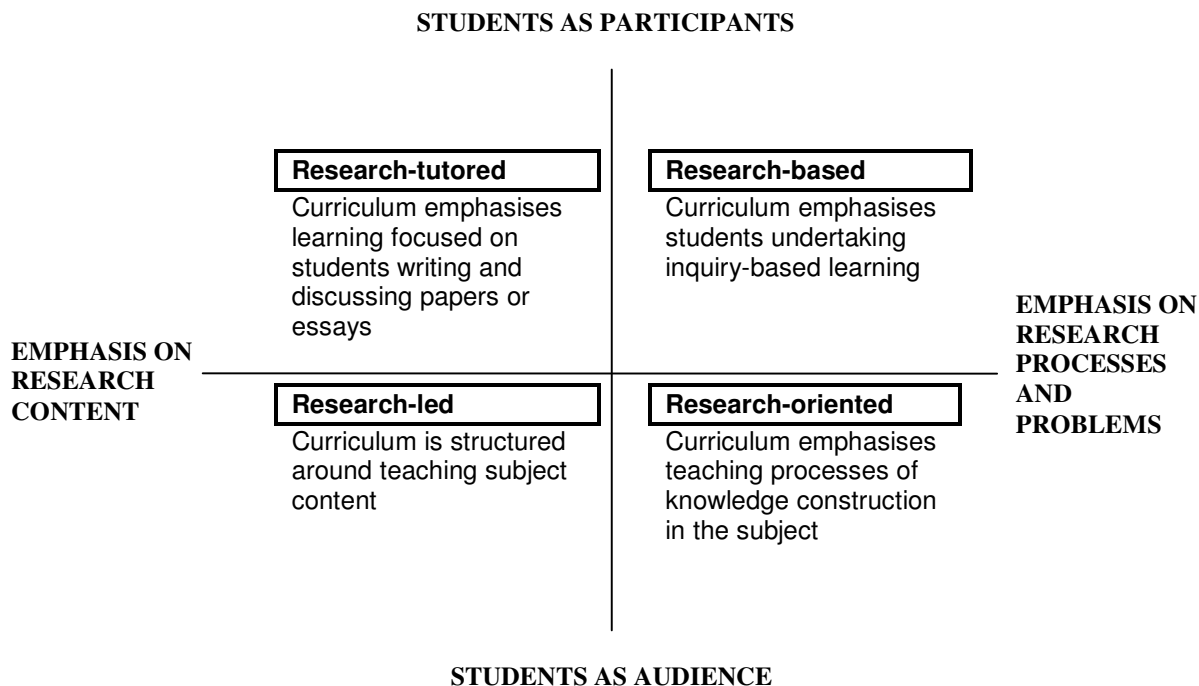
We have found the framework developed by **Griffiths (2004)** effective in supporting staff/faculty to examine both their current courses and institutional policies and practices and in adapting innovations from elsewhere. According to Griffiths teaching can be:

- 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

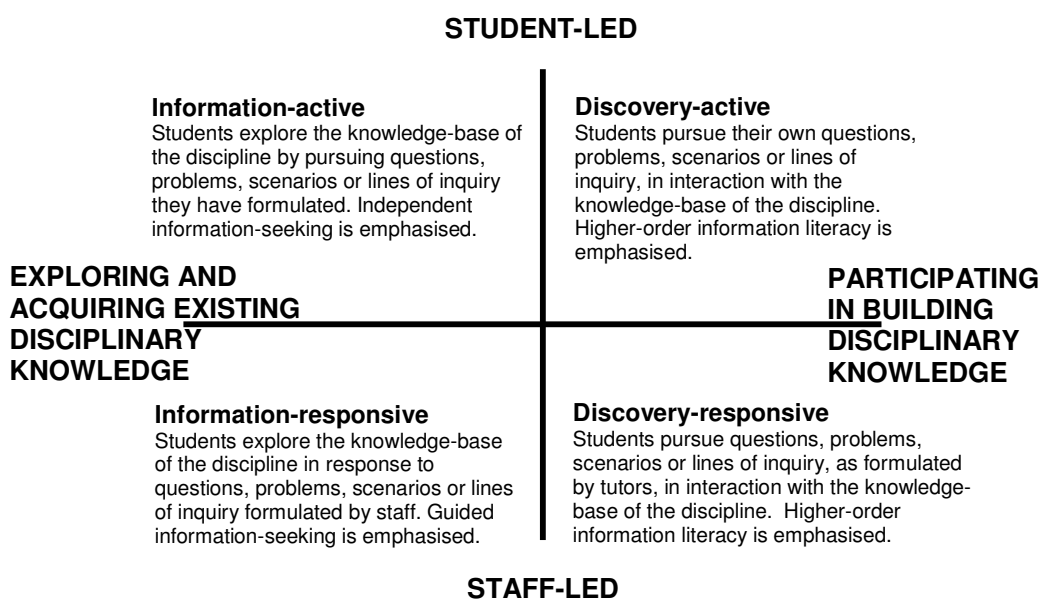
research processes and problems. He identifies a fourth category 'research tutored' where students learn in small group discussions with a teacher about research findings. A variant on this matrix has been proposed by Levy and Petrulis (2007). They also have a staff-led and student-led axis and another 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: Healey (2005, 70)

Fig 2: Conceptions and modes of student inquiry



Source: Based on Levy and Petrulis (2007, 3)

Table 6 The developmental journey of the student

Developmental level	Student traits
Reliance on external references [Foundations]	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 [Intermediate Learning]	Evolving awareness of multiple perspectives and uncertainty Evolving awareness of own values and identity and of limitations of dependent relationships
Self-authorship [Capstone]	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 (ie 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: Drawn from Robertson and Blackler (2006). 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 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.*, in submission) 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.*, in submission). 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”

Adopts a broad definition of the undergraduate as researcher 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.

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.
- 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.”

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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/cil/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
- 2 Undergraduate Research and Inquiry in Departments
 - 2.1 Biosciences, Chemistry and Medicine
 - 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
- 4 National and International Initiatives to Support Undergraduate Research and Inquiry
 - 4.1 Research Councils
 - 4.2 UK National Organisations
 - 4.3 National Government Support for Undergraduate Research, UK
 - 4.4 National Support for Undergraduate Research and Inquiry, US
 - 4.5 International Initiatives to Promote Undergraduate Research and Inquiry

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 Bioscience, 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 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

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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 /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).

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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, at The 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 the following innovations in summative assessment. The initiative was funded as part of an institutional focus on enhancing the first year experience for undergraduates.

The *Personal Response* assignment acknowledges the interests and experiences which diverse groups of students bring to university (Moni *et al.*, 2007a). The 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 purposively designed *Biohorizons* eConference modelled around professional conferences. This begins with a face-to-face plenary lecture delivered by an internationally recognised researcher (Moni *et al.*, in press a). 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.

All students need to develop core manipulative skills (and confidence) in laboratory classes (Moni *et al.*, in press b). These skills are individually assessed within regular laboratory sessions through a system of mastery learning and feedback. Evaluations indicate high levels of engagement in the course and high levels of academic success across diverse cohorts – Pharmacy, Human Movement Studies and Science degree programs.

Sources: Moni *et al.* (2007a); Moni *et al.* (in press a); Moni *et al.* (in press b)

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.

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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, 2008).

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 (2008)

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

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 some 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 and how to best achieve the goal set.

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/>

Research in action - integrating science with clinical practice - at Peninsula Medical School (PMS), UK

In this fourth-year special study unit (SSU), students 'piggy back' an active research group and experience the process of research. They have the opportunity to try out techniques, analyse data

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and pose questions. Staff are given some guidance and examples of what is appropriate to give students to do. The SSU involves three one-week blocks across the fourth year. Students are able to choose the type of research group they join, and often there are three or four students with each research group.

After the first contact session, students are asked to produce an overview of the research topic in the form of a *BMJ* critical review. This review is formatively marked, and is set in order to ensure that students have a good understanding of the field. In the second contact week, students are expected to analyse data generated by the research team and use it to produce a research poster. The poster is summatively marked and contributes one-third of the overall mark. Students present their posters at an internal PMS research-in-action poster day, but this is not part of the summative assessment.

At the end of the third week, students are expected to produce a future work proposal, which should build on the data presented in the poster and state where they would take the project in the next 12 months. The future work proposal is summatively marked and provides the remaining two-thirds of the overall mark. The mark contributes to the overall assessment of the SSU modules, of which this is one of three in the fourth year. Students must pass the SSU module, but can compensate marks over the three SSUs.

Source: Mattick (2008); p78-9 in:

http://www.enhancementthemes.ac.uk/documents/ResearchTeaching/Med_Dent_Vet_final_report.pdf

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. This case study discusses this award-winning course as it evolved over the first five years (see Justice *et al.* 2002; in press a), since then other instructors have taken on the course and is taught to reflect their interests. It was typically taught in groups of no more than 25 students assigned to an instructor. All of the groups had the same curriculum, reading material, process of assessment, and goals that were outlined in a detailed compendium. The classes met for 12 three-hour concurrent sessions. Class time consisted 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 involved groups of four or five students assisting each other in such things as clarifying understandings or planning research strategies.

All students investigated 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 had 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 had 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. The course emphasized the development of skills, including critical reading and thinking, independent and collaborative learning, information searching and evaluation, analysis and synthesis, oral and written communication, and self and peer evaluation.

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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. The findings allow for initial differences between the two samples. 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.

Current research is investigating in what way(s) Inquiry 1SS3 students changed that might explain their long-term enhanced performance at university. A quasi-experimental study compares a randomly selected group of 54 students who took Inquiry 1SS3 in their first semester with 71 comparable students who did not. The research goes beyond self-reports of learning and directly measures abilities and performance. Taking Inquiry 1SS3 is associated with meaningfully higher scores in actual performance tests of many intellectual and academic skills and that often the magnitude and significance of the difference between groups is comparable to that between upper- and lower-level students (~2 years of university).

Sources: Justice *et al.* (2002, 2007a and b) <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 undertake an eight-week project in which they collect 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

Most UK institutions have a dissertation / senior thesis as a graduating requirement. 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

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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.

The content for the site was written by academic and support staff who have a particular interest in this area and have a great deal of experience in supervising undergraduate dissertations in the fields of sociology, anthropology, politics, criminology, social policy and social work. They have not produced this resource with the aim of providing a set of definitive answers; instead they recognise that there are many ways in which the 'journey' through the process can be completed. The notes included here draw on the experiences of dissertation supervisors, academic research into the student and staff experiences of study and supervision, and examples of good practice.

Source: www.socscidiss.bham.ac.uk/s1.html

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 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/>

Involving students in organisational consultancy, Middlesex University, UK

The module "Consulting to Organisations" aims to provide student with "real life" experience by engaging them directly as consultants with organisations and the issues that those organisations have identified as significant. On organisational premises, and in collaboration with the internal personnel there, a small team of students clarify the issue with their client. Information is then collected, using a variety of research methods, and analysed in the light of both academic theory and the specific organisational context. Recommendations for action, both orally and in writing, are made to the client. As well as experiencing the reality of the organisation, students also experience working with a team of diverse peers to produce credible outcomes. Initially, four developmental

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workshops are provided: these cover team building, consulting, organisational culture and client contact. Four feedback sessions are organised during the subsequent consultancy phase of the module. The parameters of the module are set out in a handbook, and within these students are expected to take responsibility for their own work and that of their team. This is a Level Two module of eleven weeks, normally undertaken by undergraduates in their second year. It carries the same credit award as any other module and feedback from students, from organisational clients and from a number of external examiners over the fourteen years the module has been in operation has been extremely positive.

Four modes of assessment are employed and they reflect the aims of the module and also provide a range of methods, which is thought to reflect the different strengths and weaknesses of the student group. All students are required to attempt, though not pass, all four of the elements: a written report and oral presentation to their respective clients, a team peer-assessment exercise and an individual learning report. The learning report requires students, on an individual basis, to identify and review their learning from both their experience of the module, with specific reference to their client contacts, and their experience of working in a team. The areas addressed are knowledge, skills, attitudes and emotions.

Sources: Correspondence with Philip Frame (2006); Frame and O'Connor (2003)

Students participate in a research project on Criminal Justice linked to staff interests at Australian National University

Students at ANU have the opportunity to participate in a research project based on current research being conducted by members of the Faculty of Law, the Australian Institute of Criminology and Research School of Social Science. 'Criminal Justice' is an advanced law elective which critically examines the principal institutions, processes and legal rules relating to the administration of criminal justice. The iLearning project is an assessable option that allows students to devise research projects which have both academic value and practical outcomes.

Source: <http://www.anu.edu.au/CEDAM/ilearn/research/crimjustice.html>

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

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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:

- 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 enquiry-based learning is embedded in a personal learning and skills module concerned with 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 with relevant specialist skills. The format varies from week to week including tutorials (commonly consisting of time in the classroom followed by independent time for students to explore topics raised), an organised debate for the whole cohort, and presentations.

The aim is to encourage students to take charge of their own learning and develop a community of enquiry within the group as a whole and in smaller groups within which students work on the main enquiry-based component of the course. This is a project where students enquire into and develop

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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, which encourage students to engage with sustainability through discussion, research into sustainability topics and formulating questions for a Sustainability Question Time debate. Tutors encourage exploration of the skills needed for research and collaborative working and introduce the use of an e-portfolio package to promote reflection and group communication between students and tutors which contributes to the enquiry-based learning (EBL) approach. A module blog is run through the e-portfolio package which further facilitates engagement with issues around sustainability and elicits contributions from both tutors and staff, further strengthening the community of enquiry.

There are 3 points of assessment. The first is concerned with researching, retrieving and presenting information on sustainability in a short essay with full references in the Harvard style. The second is the main enquiry-based project with groups enquiring and putting together the proposal for improving the sustainability of the University and presenting it to the group for tutor and peer assessment. Following this, 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. The EBL activity is designed to engage students with a real-world problem and entrepreneurship.

The third assessment, carrying 50% of module marks is the creation of an individual e-portfolio which is built up throughout the module and carried on until near the end of the second semester when it is submitted. The construction of the e-portfolio aids the enquiry process by encouraging 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 for the Environmental Management, Rural Management Environmental Tourism and Tropical Forestry degrees 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 staff (in recent years, a social scientist and an ecologist for the internal students, a multi-skilled environmental manager taking the external students).

The 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. The staff may help the client mould the topic to achieve appropriate degrees of difficulty, and equity in workload and difficulty across the student groups. The students work like consultants to their client, coping if the client changes the brief during the year (as many do a couple of times).

They work in groups of about six students. 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

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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, and in group processes. At the end of the year their report is 'published' (printed and bound) for the clients. Peer and self-assessment are used to distribute group marks among the contributors.

Source: Correspondence with Helen Ross, 2006

Helping students to engage more effectively with the research process in undertaking their undergraduate dissertations at Keele University, UK

Undertaking an independent research project in the form of a dissertation can be the most challenging and rewarding part of an undergraduate student's university experience. However, students often suffer from disjuncture expressed as lack of motivation, hesitancy and avoidance when faced with the daunting enormity of the task and the high demands placed on them as independent learners and problem solvers. Robson (2006) undertook a case study of her efforts as a supervisor, using action research, to help students to engage more effectively with the research process. The aim of the research was to make effective changes to improve students' motivation, commitment and achievement with regard to completing a geography dissertation.

It is argued that listening to students and responding to their perceived needs is an effective way to improve supervision practices. Initial findings showed students to be lonely and insecure about their dissertations and the supervisor pressured by a considerable supervisory burden. Four cycles of action research were subsequently conducted with a group of eight dissertation students during one academic year. The research implemented and evaluated four interventions whereby the supervisor-researcher invited the students to:

- (i) evaluate their progress
- (ii) learn from examples of completed dissertations
- (iii) share and support each other
- (iv) engage in peer assessment.

Qualitative evidence demonstrates a shift from a status quo of individual supervisory meetings between poorly motivated students and a frustrated supervisor, to highly motivated students effectively empowered as independent self-learners and peer supporters. It is concluded that given the right circumstances students can be facilitated to 'do it better themselves'.

Source: Robson (2006)

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

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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 continually since 1996. The exercise involves groups of 2 or 3 students working collaboratively on development of the multimedia assignment and on the seminar. Students are given an introductory and explanatory session describing the aims, objectives, tools and methods, together with a short hands-on practical class on how to use the available multimedia authoring system (eg Hyperstudio) and how to access the array of digital resources which might be needed to carry out the assignment.

The exercise clearly provides a close link to the teaching of structural geology in this course and the most current research being carried out in the discipline. Students not only have to read and understand one international journal article, but they must also search through the bibliography of that article for a number of relevant papers. They must interrogate and summarise not only 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. Receiving a reply (which does not always happen), is most exciting to the students and is a critical point in the realisation that the author is a real person and is carrying out their research usually at a University. Authors generally reply positively to the questions (it at least shows that someone is reading and interested in their own research), 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.

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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)

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/>

Students taking a historical methodology course engage in original oral history research at Indiana State University, US

The 30 or so students taking the introductory historical methodology course are engaged in original research. Anne L. Foster, an assistant professor of history, who teaches the course, was eager to find topics in which her students could "become experts" and make a real contribution to local knowledge.

In 2004, the class produced a history of the black community of the Wabash Valley, including Lost Creek, a neighbourhood of Terre Haute, Indiana, the city that is home to the university. Lost Creek was established in the 1820s by freed and runaway slaves with the help of local Quakers. The course stresses oral histories, and that year's project included a video interview with a 104-year-old woman whose grandparents were slaves. Another group of students, in the fall of 2005,

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interviewed three elderly local men with connections to the Holocaust: a concentration-camp survivor from Latvia, a Jew whose family managed to flee Germany, and a former U.S. soldier who helped liberate a concentration camp in Germany. One student did an independent project that turned the class material into a permanent exhibit at Terre Haute's Holocaust museum.

Students would have interviewed more people, but changes in the university's rules on human research subjects made it difficult. Ms. Foster says she expects the university's research board to relax the new rules to facilitate the taking of oral histories.

Source: Bollag (2006b)

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,

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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.

George has also attempted, though so far with only limited success, to establish 'buddy groups' to mimic the informal networking found in research communities. This means trying to shift a culture of competition in assessment to one of co-operation in research. He has also been given a grant by his university to devise multiple-choice questions (MCQs) which will develop the ability of students to consider reasons for and against different possible interpretations of key texts, and for and against the validity of the ideas and arguments as so interpreted. They won't be told whether they are right or wrong, but they will be forced to think argumentatively about the text they are reading; and the change in activity from mere reading and note-taking to active engagement with an MCQ should improve their motivation. More importantly, the sort of thinking they will be engaged in will be precisely the sort of thinking that is characteristic of the mature historian of philosophy.

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

1.9 Interdisciplinary

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

Interactive Media Studies at Miami University is an interdisciplinary programme (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. Demand is high and they have to turn away 2-5 students a day from the programme. With 2-3 sections running each semester; the students work in groups of up to 20. The students themselves decide how to divide up tasks; typically there are groups undertaking development, design and marketing. 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,

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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. The clients typically end up with something that far exceeds their expectations. The students find it surprising and challenging to manage the changes which commonly occur during the development stage of the project.

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. IMS assessed needs and built the site, a product demo and a back end administrative system for managing sales and customer support.
- Procter & Gamble's Beauty Care Division contracted with IMS to develop a Web-based expert system that would allow customers to get product recommendations suited to their personal needs. A kiosk was designed to be deployed in a major retail chain.
- 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/>

2. Undergraduate Research and Inquiry in Departments

2.1 Biosciences, Chemistry and Medicine

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

The 'Explorations Program' 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.

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 and Nottingham, 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 explicitly based 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/). These showcase first class undergraduate research

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and support those undergraduates seeking academic research careers from these research-intensive departments. 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
<http://biohorizons.oxfordjournals.org/>

Sources: <http://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 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 and 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

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- 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 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

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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>

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 X 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/>

2.3 Arts and Social Sciences

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

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

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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

Department initiatives to formally support undergraduates doing research – in close involvement with staff research – are a feature of many US departments (Kinkead, 2003). A growing number of UK departments are now developing their own undergraduate research programmes (Jenkins, 2006). That in the psychology department at York University was initiated in 2005 and replaced and developed previous informal arrangements. The scheme 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 supports their Department's research strategy. Bursaries are not awarded

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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

Departments have the power and resources to better ensure that the disciplinary case studies that feature in earlier sections of this handout are at some point integrated into a coherent structure such that (undergraduate) students are systematically and progressively developed as researchers through their degree. Over the last c10 years, in part response to McMaster's institutional policy to encourage 'student inquiry, the School of Geography and Earth Sciences has radically redesigned its Earth & Environmental Sciences (EES) programme.

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. Students also develop introductory oral and written communication skills through research presentations to small groups of their peers and through writing short reports.

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). McMaster University hosts an Undergraduate Research Poster Session each year and many undergraduate students are encouraged to present the findings of their research at national or international conferences and to submit manuscripts (co-authored with their research supervisors) for publication in scientific journals.

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)

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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* <http://www.brookes.ac.uk/schools/social/geoversity/index.html> 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* <http://www.brookes.ac.uk/schools/social/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'

Source: Correspondence with Helen Walkington

Undergraduate and postgraduate student conservation science conferences at Cambridge (UK) and Duke (US) Universities

An annual student research conference has been held since 2001 at Cambridge and since 2005 at Duke. The series aims to build links among young conservation scientists from biological, environmental and geography departments of universities as well as conservation and resource management agencies. Delegates include students from around the world, as well as conservation practitioners from leading international conservation bodies.

Sources: <http://www.sccs-cam.org/>; <http://www.env.duke.edu/sccs/>

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, 2006; Willinson and O'Regan, in press).

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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.*, in press).

Source: Willison and O'Regan (2006; in press); Fraser, *et al.* (in press)

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. 3300 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

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visited an arboretum and explored the use of trees in literature. Social and academic activities were integrated, the students and staff had fun, and, importantly, they made friends, all before going to their first class. The approach was developed, and initially supported, by the Centre for Active Learning. It has proved a significant staff development activity both for the many academic tutors and the library staff who changed their approach to library induction to support the specific student research projects. Over the next two years other Faculties in the University are developing their versions of developing undergraduate research as part of induction.

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 / 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. These requirements derive from a study visit to selected US institutions and are being supported through the Reinvention Centre for Undergraduate Research at Brookes and Warwick Universities.

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.* (2004; 2007)

University of Gloucestershire

(<http://resources.glos.ac.uk/adu/clt/taframework/index.cfm>; resources.glos.ac.uk/ceal)

Following a nine-month development and consultation process the University has 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. The strategy is underpinned by research into 'Leading, Promoting and Supporting Undergraduate Research in the New University Sector' (resources.glos.ac.uk/tli/prsi/current/ugresearch/index.cfm).

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: <http://www2.warwick.ac.uk/study/csde/usp/wsc/>
<http://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: http://www.ntu.ac.uk/apps/pss/courses/cf/60565-1/10/PGDip_Research_Informed_Teaching.aspx

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.

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% or 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: <http://www.uq.edu.au/teaching-learning/index.html?page=92623f>; Correspondence with Deborah Terry, 30 Oct 2008

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.

Key criteria for judging research-led teaching:

- Student awareness of and active engagement with research
- Academic staff capacity to integrate research and teaching
- Curriculum designed to engage students in a variety of research-based activities, induct them into the research community and develop their awareness of research
- Departmental encouragement for aligning research and teaching
- Faculty support and encouragement for strengthening the nexus between research and teaching
- College recognition and support for the development of the links between research and teaching
- University commitment to the development of strong relationships between teaching and research

These key criteria derive from the scholarly literature on research-led teaching. The indicators are designed to focus on aspects that can be demonstrated and that would clearly distinguish good practice in research-led teaching. The table shows indicators of these criteria, and whose responsibility it would be for gathering and providing the information. It also suggests indicative audit requirements.

Examples of performance indicators

- Student awareness of and active engagement with research
- 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 the purposes of the University's *Strategic Plan*, each program that claims to demonstrate research-based learning must be able to provide evidence that the approaches and activities that are built into the degree program are relevant, systematic, auditable, connected in philosophy, and are not dependent on particular teachers being available for teaching particular courses. In other words, the research-based character of a program should be robust. The activities or opportunities in question must be ones that all students in the program experience, and are not to be confined to electives.

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. To determine whether 20% of the program's courses contain significant elements of research-based learning, the Office of Quality, Planning & Statistics is responsible for mapping students enrolled in a course, with a status of including a research-based learning component, to the students' program of enrolment.

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.

Details of the criteria to determine whether they have a research-based learning component can be found on the web site.

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/>

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 (personal communication, 2005).

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 pa 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

Undergraduate research programmes to support racial 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’. These include 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.

Source: Huggins *et al.*, 2007

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).

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:

- Students on Site is a major collaboration with the Ann Arbor and Ypsilanti Public Schools. SOS staffers and UM students teach weekly class lessons over a three to five week period. Through field trips, hands-on classroom work, and an online archive, third- and fourth-graders learn to investigate the history of their communities (www.artsofcitizenship.umich.edu/sos).
- 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 been displayed to over 20,000 people at schools, libraries, and museums in Michigan and Ontario.
- The Broadway Park Design project (a collaboration with the Ann Arbor Department of Parks and Recreation) proposes designs for public art, public history, and cultural amenities in the historic park on the Huron riverfront. (www.artsofcitizenship.umich.edu/broadway).
- 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.
- In partnership with UM's School of Art and Design, UM students in Arts of Citizenship's Detroit Connections serve as mentors for after school art workshops in Detroit elementary schools. By using art to reinforce maths and science concepts, this project aims to improve overall educational outcomes.
- Arts of Citizenship has collaborated with Michigan Radio on a series of student-created radio documentaries, including award-winning pieces on the 1967 Detroit riots and on Arab-American youth. The latter has a companion website at www.artsofcitizenship.umich.edu/listen. Plans are underway for additional documentaries on citizenship, youth, and diversity.

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

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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 – eg 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.*, 2007). The Council for Undergraduate research web site provides useful details on many of such events <http://www.cur.org/Publications/celebrationdays.asp>.

Source: Huggins *et al.* (2007)

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 undergraduate students who choose to attend UBC should have the opportunity to benefit from attending a major research institution. Every student should have the opportunity to engage in research and experience the excitement of discovery should they desire. In order to support this type of learning experience, 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). In this way, we hope to bring together the wide variety of research avenues students can take part in, demystify the research process, and helping students to get the most out of their research experience.

University of Alberta: Institution-Wide Project 'Research Makes Sense to Students'

(<http://www.uofaweb.ualberta.ca/researchandstudents/>)

The University of Alberta has introduced a "Research Makes Sense for Students" initiative under the Office of the VP (Research). Some of the activities undertaken through this initiative have been an 'Integrating Teaching and Research Awareness Week' aimed at faculty and graduate students, promotion of undergraduate research linked to the student orientation week organised in conjunction with the Student Guild, a university-wide environmental scan of teaching-research linkages, and specific policy and funding proposals to strengthen teaching / research connections.

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

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levels of academic 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. The institution is now faced with the challenge of scaling this innovation across the whole institution or keeping it for those students who select these perhaps more demanding 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.

Victoria 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.

4 National and International Initiatives to Support Undergraduate Research and Inquiry

4.1 Research Councils

Research Councils UK

<http://www.rcuk.ac.uk/default.htm>

RCUK is the organisation which is the strategic partnership between 7 Research Councils which support research in the UK higher education sector “The role of the Research Councils has evolved beyond its traditional place on one side of the Dual Support system, and the Councils are taking a more pro-active role in promoting and supporting the broader context for research and research careers. Vacation Bursary schemes and the RCUK Academic Fellowships are two examples of the way in which Councils are seeking to strengthen this broader context as one in which research, and the innovative thinking of the next generation of researchers, can develop” (Lyne 2007).

Vacation Bursary schemes operated by the Research Councils (currently BBSRC and EPSRC) are a way of supporting the recruitment of the best undergraduate students into research degrees – and therefore ultimately about improving the supply of researchers (ESPRC 2007).

Sources: Diamond (2006); EPSRC (2007); Lyne (2006, 2007)

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The Biotechnology and Biological Sciences Research Council

<http://www.bbsrc.ac.uk/>

http://www.bbsrc.ac.uk/funding/training/vacation_bursaries.html

The Biotechnology and Biological Sciences Research Council (BBSRC) in 2004 established a pilot scheme to offer Vacation Bursaries to give promising undergraduates an opportunity to experience first hand a period of time during the summer vacation in a research laboratory in a UK university or a BBSRC-sponsored research institute to encourage them to consider a career in scientific research. The pilot in 2004 proved to be so successful that in 2006 it was expanded to 80 bursaries per year, and also in 2006 'Vacation Bursaries in Mathematical Biology' were introduced. In 2007 BBSRC awarded 100 Vacation Bursaries to 65 different departments. The bursaries are primarily allocated pro rata with the award of our Quota PhD studentships. Studentship quotas are allocated through a competition process which looks at the broad training environment offered by a department. In November 2006, BBSRC and EPSRC held a joint good practice event to discuss the use and objectives of Vacation Bursaries.

Source: EPSRC (2006)

The Engineering and Physical Sciences Research Council

<http://www.epsrc.ac.uk/PostgraduateTraining/VacationBursaries/default.htm>

The Vacation Bursary Programme provides funding for undergraduate students to gain first-hand experience of research in a UK university to help them consider a research career. A pilot programme was carried out in the summer of 2006. An evaluation of that programme concluded that "the pilot was shown to have been very successful for all those involved. Students said that it was a positive experience and that they would recommend to others. Based on this evaluation, we will now consider continuing the programme in the future and what improvements can be made" (EPSRC, 2007, 4). Students carry out a research project lasting around 10 weeks during the summer vacation. Students were in the middle years of a first degree within EPSRC's remit, and could fulfil EPSRC doctoral training grant eligibility requirements by the end of their undergraduate degree. Projects have a clearly defined objective within EPSRC's remit, but are not to be part of a normal degree course. In 2007, 15 universities have been selected to take part the activity, based on their EPSRC research income. Projects will take place during the 2007 summer vacation. Each university is awarded £20,000 to support up to 10 students (based on a suggested stipend of £180 per week plus research consumables of £200).

Source: EPSRC (2007)

US: National Science Foundation (NSF) have established the Undergraduate Research Collaborative Program which seeks to include first and second year college students

<http://www.nsf.gov/pubs/2006/nsf06521/nsf06521.htm>

The Undergraduate Research Collaboratives (URC) Program seeks new models and partnerships with the potential (1) to expand the reach of undergraduate research to include first- and second-year college students; (2) to broaden participation and increase diversity in the student talent pool from which the nation's future technical workforce will be drawn; and (3) to enhance the research capacity, infrastructure, and culture of participating institutions. Collectively, these outcomes will substantially strengthen the nation's research enterprise. For this program, research should be in the chemical sciences or in interdisciplinary areas supported by the chemical sciences. Projects should allow students to create new knowledge that is potentially publishable by providing exposure to research of contemporary scientific interest that is addressed with modern research tools and methods.

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The program developed from two NSF workshops - *Exploring the Concept of Undergraduate Research Centers: A Report on the NSF Workshop* (<http://urc.arizona.edu/>) and *Workshop on the Implementation of Undergraduate Research Centers* (<http://www.scu.edu/cas/research/urc.cfm>).

The emphasis on participation of first- and second-year students in authentic research – the creation of new knowledge that is potentially publishable - will challenge the *imagination* and *creativity* of the community to rethink the directions of undergraduate education.

“Each award provides approximately \$3-million over a five-year period. The projects under way through that program can provide blueprints for research-oriented curricula for thousands of first- and second-year college students http://www.nsf.gov/news/news_summ.jsp?cntn_id=104533. An initial award, for a project led by The Center for Authentic Science Practice in Education, Purdue University, includes nine academic institutions in Illinois and Indiana.

<http://www.purdue.edu/dp/caspie/>

The project has created research modules for traditional courses around such themes as biodiesel fuels, solar-energy conversion, and food chemistry. The consortium will:

1. Provide first and second year students with access to research experiences as part of the mainstream curriculum.
2. Create a collaborative, “research group” environment for students in the laboratory.
3. Provide access to advanced instrumentation for all members of the collaborative to be used for undergraduate research experiences.
4. Help PUI faculty develop research projects so that their own research capacity is enhanced and the students at these institutions can participate in this research.
5. Create a research experience that is engaging for women and ethnic minorities and appropriate for use at various types of institutions, including those with diverse populations.

Part of the collaborative framework for undergraduate research is the remote instrumentation resource. This networked resource allows partnership institutions to have an authentic research focus for our laboratory course by making a suite of high-end instruments available to first- and second-year students via the Internet. These instruments are integrated into the research projects that the students will be carrying out in the course.

Another project includes 15 public colleges, led by Ohio State University, across Ohio. It is expected to involve 15,000 first- and second-year undergraduates in research projects annually by 2010. ...

New types of institutional partnerships are a particularly promising aspect of the URC awards made thus far. Especially noteworthy has been the participation of two-year institutions that traditionally have been outside the research mainstream. A project led by the University of South Dakota, for example, embraces community and tribal colleges. Nearly half of all undergraduate students attend community colleges, and those students represent a huge, diverse, largely untapped talent pool. By involving them and their instructors in research, we can both build our institutional capacity for innovation and encourage talented students who may otherwise overlook promising, productive careers in science and technology” (Ellis, 2006, B20).

Ireland: Science Foundation for Ireland (SFI) sponsor undergraduate research experience and knowledge awards (UREKA)

http://www.sfi.ie/content/content.asp?section_id=505&language_id=1

SFI’s Undergraduate Research Experience & Knowledge Award (UREKA) Programme offers undergraduate students the opportunity to work in research and to acquire a range of scientific skills

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during a ten to twelve week period during the summer. Students get the chance to conduct an independent research project within a cutting edge research group. Students participating in a UREKA site will also attend a variety of events to further develop the skills needed for a career in research. The programme aims to afford students from Ireland and abroad with an exceptional chance for interaction with world-class scientists and engineers in an innovative environment. SFI currently funds eleven UREKA sites at academic institutions throughout the country. It is expected that up to 200 students will participate in the UREKA programme during Summer 2006.

Brazil: The Program of Scholarships for Scientific Initiation (PIBIC) sponsor undergraduate research experience

<http://www.memoria.cnpq.br/english/aboutcnpq/index.htm> Note the general text is in English - with full details in Portuguese

The National Council for Scientific and Technological Development (CNPq) is a foundation linked to the Ministry of Science and Technology (MCT), to promote and stimulate the scientific and technological development in Brazil. CNPq is one of the major funding sources for research in Brazil, contributing directly to the training of researchers in all levels and fields of knowledge. Specifically to promote scientific knowledge, engage new talents into research, and strengthen the link between undergraduate and postgraduate programs, CNPq sponsor undergraduate scholarships through the Institutional Program of Scientific Initiation (PIBIC). The Council distributes a number of scholarships for teaching and research institutions that have a clear program of students' engagement in research. The scholarships last for 12 months and provide opportunities for the students to work part-time in research projects under the advisory of qualified professionals. The number of scholarships available annually to each institution depends on the annual budget of the Council and the qualification of the research institution within the criteria established by the Council. The students have to apply for specific projects and the award is given primarily on the students' grades and secondarily on their skills relevant to the project. The PIBIC aims to stimulate students to continuing education, to improve their qualifications and skills, and to reduce the average time students require to obtain their postgraduate degrees.

Source: Correspondence with Luciana Esteves, University of Plymouth, 2007

Portugal: Undergraduate Research Grants

The government recently initiated a programme of competitive undergraduate research grants. The stimulus were the curricula reforms – including supporting transferable credits between (Portuguese) institutions – prompted by the Bologna process.

All Portuguese research units and associated laboratories - both from public or private HE institutions - can offer research grants. All first-year undergraduate students can apply for a one-year grant in any institution. In the following year they can apply for another grant, but this work has to be developed in a different institution or research unit. This strategy emphasises the importance given to mobility and to the contact with several research realities, methodologies and subjects. The selection of students is made by the institutions they apply for and the evaluation is based on their academic success. Students will be supported by a qualified supervisor and by the end of the grant, the student needs to write a report to be presented and discussed in a public session, organised by the foster institution. Moreover, the research units or associated laboratories may establish an agreement with the institution so that the learning outcomes achieved from the involvement on a specific research activity can be converted in student credit.

Source: personal communication Isabel Huet, University of Aveiro

4.2 UK National Organisations

British Society for Animal Science (BSAS) Summer Placement Scheme

[http://www.bsas.org.uk/funds_ awards &_ jobs/summer_placement_scheme/](http://www.bsas.org.uk/funds_awards_&_jobs/summer_placement_scheme/)

Since 1995, BSAS, commercial companies and research institutes have been cooperating together with motivated college and university students on the Summer Placement Scheme. The scheme enables companies and institutes to have access to students to help complete specific projects and tasks at a busy time of year. For students it means practical work experience in an environment that will match their area of study or interests. Long term it will help career prospects for young people. Depending upon the individual companies and institutes involved, the work available ranges from practical field work or laboratory studies to computerised data handling of literature reviews and report writing. BSAS helps match appropriate companies and students and put them in touch with each other. Placements last for a minimum of 6 weeks. BSAS has £500 for each project. This sum is expected to be matched by an institute or company.

Cancer Research UK Undergraduate Bursaries

http://science.cancerresearchuk.org/gapp/personalfund/otherbursaries/long_vacation_bursary?version=3

These bursaries are used to encourage exceptional undergraduates to consider a career in cancer research, by providing research experience during the long summer vacation. The bursary provides a subsistence allowance for the student in the region of £180 per week. No location allowances are provided. A contribution of £500 is made towards laboratory expenses. The duration of the project is 6-10 weeks. Applicants must be long-term Cancer Research UK grantees (ie in receipt of core Institute, Programme grant, Senior Fellowship or Career Development Fellowship funding). Applications should include the name of a nominated student who will take up the award. Students should normally be completing the penultimate year of their degree in the summer in which the award is taken up. Cancer Research UK does not anticipate funding more than one student in a particular laboratory in any one year.

Carnegie Trust (Scotland) Vacation Scholarships and Undergraduate University Expeditions

http://www.carnegie-trust.org/our_schemes.htm

Undergraduates who were born in Scotland or who have a parent born in Scotland or who have at least two years of secondary education in Scotland, may be considered for the award of a *Vacation Scholarship* for the pursuit of a full-time research project, usually in the vacation between their second and third years. Vacation Scholarships cannot be used for attendance at conferences. Candidates can only be considered on the nomination of Deans, who are asked to rank in order of merit all applicants from their Faculty. Scholarships are for maintenance of up to a maximum of eight weeks, whether based at home, elsewhere in the United Kingdom, or abroad. Nominees can come from any Faculty and nominations by Deans must be received by April 1st. Applications can only be accepted via University Faculties.

The Trust will consider applications for a grant towards the cost of *expeditions* which are approved and supported by a Scottish University. The expedition, which must bear the name of the University and comprise at least five undergraduates from that University; it must have as its purpose the training of undergraduates in research techniques through the discovery of new knowledge. The expedition must have a coherent research programme and must be accompanied throughout by a member of staff or someone of equal standing acceptable to the Trust.

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Experimental Psychology Society: Undergraduate Research Bursaries

<http://www.eps.ac.uk/grants/bursaries.html>

This scheme finances a limited number of bursaries (5) to support undergraduates in the summer vacation immediately prior to their final year. Awards are made to members of the Society and provides up to 10 weeks' support (£200 per week) for their nominated undergraduate. It is intended that the bursaries be targeted at undergraduates who are considering a research career in experimental psychology (as defined by the content of the Society's journals). The bursary is administered, and the research project carried out, at the applicant's institution, although this need not be the institution at which the student is currently registered for a degree. The purpose of these bursaries is to allow the student to learn at first hand about experimental procedures and analyses employed in the host laboratory. Awards will not be granted for work that is a central part of an already-funded project. The award is for a maximum of £2,000, and any additional expenses must be borne by the host institution.

Genetics Society Summer Scholarships

http://www.genetics.org.uk/genetics_society_summer_studentships

The Summer Scholarships provide financial support for undergraduate students in any area of genetics, to gain research experience by carrying out a research project in the long vacation, usually prior to their final year. Studentships will only be awarded for students who have yet to complete their first degree. A maximum of 40 studentships will be awarded. They will consist of an award of £150 per week for up to 10 weeks to the student plus an expenses grant of £500 to the host laboratory. The award will be made to the host institution. Applications are invited from members of the Genetics Society who run a research group within a University or Research Institute or an industrial research facility. Applications for a named student, with CV and reference from their tutor (or equivalent) will be an advantage. Undergraduate students are encouraged to seek a sponsor and develop a project application with the sponsor.

Institute of Structural Engineers (URGS)

<http://www.istructe.org.uk/technical/db/index.asp?page=227&bhcp=1>

The Undergraduate Research Grants scheme sponsors undergraduate research projects carried out during term-time as part of a degree programme. The scheme is funded by the Institution's Research Fund and aims to support challenging and satisfying research at undergraduate level. Up to ten grants of up to £500 each will be available in 2006. Supervisors submit applications during March and April for a particular project idea to be carried out in the next academic year. If the application is successful the supervisor then selects a suitable student to undertake the project. The timing of the project is decided by the supervisor and is intended to coincide with the university's usual arrangements for term time undergraduate projects that are assessed for a degree.

Nuffield Foundation: Undergraduate Research Bursaries in Science

http://www.nuffieldfoundation.org/go/grants/nsbur/page_412.html

These bursaries provide support to enable undergraduates who are considering research as a career to work in a research laboratory during the summer vacation before their final year. The bursaries provide student support normally for a period between 6 and 8 weeks, plus a sum for research expenses. Established in 1990 with a linked scheme at secondary school level, 4000 undergraduate bursaries have been awarded since then. A 2006 review of both schemes concluded they were "strikingly effective ... seen as crucial encounters at a critical stage in career choice." In 2007-2012 the scheme is to be expanded with £1 million committed to 1500 bursaries in 2007.

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Source: Hughes (2006)

Paul Kelly: Undergraduate Research Opportunities in Software Performance Optimisation

<http://www.doc.ic.ac.uk/~phjk/phjk-UROP.html>

Undergraduate Research Opportunities are provided for up to three students to spend the summer working in the Software Performance Optimisation research group. The objective is to involve them in the Group research work. A successful UROP project should lead to them being co-authors on a published paper, and/or being responsible for an open-source software release. The criterion for selection is that the students need to be able to get stuck into very complex software, and make it work.

Society for General Microbiology Vacation Scholarships

<http://www.sgm.org.uk/grants/vs.cfm>

Vacation Studentships are small awards to enable undergraduates in the UK and Republic of Ireland to work on microbiological research projects for 6-8 weeks in the summer vacation before their final year. There are elective grants for medical, dental and veterinary science students. These are small awards to enable medical, dental and veterinary science undergraduates to work on microbiological research projects during their elective periods.

Universities Federation for Animal Welfare (UFAW) Vacation Scholarships

<http://www.ufaw.org.uk/vacationScholarshipawards.php>

UFAW established the vacation scholarship award scheme in 1983 to encourage students to develop an interest in animal welfare and to provide them with the opportunity to conduct relevant research. Applications are welcome from undergraduates (or equivalent) in agricultural, biological, medical, veterinary or zoological sciences. Students must be registered at a university or college in the British Isles. Preference is given to undergraduates.

Welcome Trust Vacation Scholarships

<http://www.wellcome.ac.uk/Funding/Biomedical-science/Grants/Undergraduate-support/wtd004448.htm>

The Vacation Scholarship is intended to provide promising undergraduates with 'hands-on' experience of research during the summer vacation and to encourage them to consider a career in research. Applicants should be university undergraduates in the middle years of their first degree studies (i.e. not the first or last year) and registered for a basic science or veterinary degree, or medical students between the end of their second year and the end of their penultimate year. Scholarships are not available for the completion of student projects that are part of the normal degree course. Preference will be given to undergraduates without previous research experience. Students are encouraged to arrange their scholarship away from their usual place of study.

4.3 National Government Support for Undergraduate Research and Inquiry, UK

England: Some of the Higher Education Funding Council for England's (HEFCE) Centres for Excellence in Teaching and Learning (CETLs) are focused on student research and inquiry

<http://www.hefce.ac.uk/cetl>

HEFCE established 74 CETLS in 2005 each of which received up to £2.35m capital and £0.5m recurrent expenditure pa for five years. Several are centrally concerned with supporting undergraduate research and inquiry:

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1. Sheffield Hallam University, the Centre for Promoting Learner Autonomy (<http://extra.shu.ac.uk/cetl/cplahome.html>)
2. University of Gloucestershire, the Centre for Active Learning in Geography, Environment and Related Disciplines (<http://resources.glos.ac.uk/ceal/http://www.glos.ac.uk/ceal>)
3. University of Manchester, Centre for Excellence in Enquiry-Based Learning (www.manchester.ac.uk/ceeb/)
4. University of Oxford Centre for Excellence in Preparing for Academic Practice (<http://www.learning.ox.ac.uk/cetl.php?page=54>)
5. University of Reading Centre for Excellence in Teaching & Learning in Applied Undergraduate Research Skills (<http://www.reading.ac.uk/cetl-aurs/>)
6. University of Sheffield, Centre for Inquiry-based Learning in the Arts and Social Sciences (CILASS) (<http://www.shef.ac.uk/cilass/>)
7. University of Surrey, Surrey Centre for Excellence in Professional Training and Education (SCEPTRE) (<http://www.surrey.ac.uk/sceptre/>)
8. Universities of Warwick and Oxford Brookes, The Reinvention Centre for Undergraduate Research (<http://www2.warwick.ac.uk/fac/soc/sociology/research/cetl/>)

Seven of these have formed the Learning Through Enquiry Alliance (LTEA) www.ltea.ac.uk

England: The Higher Education Funding Council for England (HEFCE) are supporting the development of research-informed teaching environments, with funds allocated *inversely proportional to an institution's research funding*

(<http://www.dfes.gov.uk/hegateway/hereform/herereformforum/index.cfm>;

http://www.hefce.ac.uk/pubs/hefce/2006/06_11/

<http://www.hefce.ac.uk/learning/enhance/quality.htm>)

HEFCE announced in March 2006 additional funding to support research informed teaching (RIT) to be allocated in inverse proportion to an institution's research funding. This is part of HEFCE's Teaching Quality Enhancement Fund. £40m has been allocated over three years. The division between which universities received funding and those which did not, largely mirrors the old/new university divide.

HEFCE (2006, 6-7) stated that: "We have identified four areas where institutions could seek to invest funds:

- keeping the curriculum up-to-date and active, effectively supported by appropriate learning resources linked to recent research
- enabling staff to engage with developments in their field and link to developments in their teaching
- ensuring that courses are designed in ways that support the development of learning outcomes appropriate to the knowledge economy, including appropriate pedagogy – that is, students experiencing research, and developing research skills
- embedding research-informed teaching in institutional structures, including human resources strategies and quality assurance processes."

Some institutions including University of Central Lancashire have used their funding to support institutional initiatives re undergraduate research and inquiry

<http://www.uclan.ac.uk/host/nexus/index.htm>.

4.4 National Support for Undergraduate Research and Inquiry, US

US: Reinvention Center

<http://www.reinventioncenter.miami.edu/>

The Reinvention Center at Miami is a national center focusing on undergraduate education at research universities, including supporting undergraduate research. The Center was born of the excitement and intense national and international interest generated by the Boyer Commission Report, [Reinventing Undergraduate Education: A Blueprint for America's Research Universities](#) (1998).

US: Council for Undergraduate Research (CUR)

<http://www.cur.org/>

The mission of the Council on Undergraduate Research is to support and promote high-quality undergraduate student-faculty collaborative research and scholarship. The Council on Undergraduate Research (CUR) and its affiliated colleges, universities, and individuals share a focus on providing undergraduate research opportunities for faculty and students at predominantly undergraduate institutions. CUR believes that faculty members enhance their teaching and contribution to society by remaining active in research and by involving undergraduates in research.

CUR has recently (2007) been awarded a Course, Curriculum, Laboratory Improvement grant in the amount \$499,066 from the National Science Foundation. The program includes eight regional workshops over the next two years and follow-up activities for institutions that participate in the regional workshops. The purpose of the program is to assist campuses in making institution-level changes to establish, formalize and expand undergraduate research opportunities.

<http://www.cur.org/ccli.html>

US: National Conferences on Undergraduate Research (NCUR)

<http://www.ncur.org/>

Holds an annual three-day conference of (mainly) student presenters, which has become a national celebration of undergraduate scholarly activity involving all academic disciplines and all institutions of higher education. NCUR's annual conferences also include sessions for faculty members and administrators to discuss starting, supporting, or maintaining departmental or institutional undergraduate research programs.

US: Project Kaleidoscope

<http://www.pkal.org/>

Project Kaleidoscope (PKAL) is one of the leading advocates in the United States for building and sustaining strong undergraduate programs in the fields of science, technology, engineering and mathematics (STEM)

4.5 International Initiatives to Promote Undergraduate Research and Inquiry

Carnegie Academy for the Scholarship of Teaching and Learning (CASTL) Institutional Leadership Programme

<http://www.carnegiefoundation.org/programs/sub.asp?key=21&subkey=2021&topkey=21>

One of the themes under CASTL's institutional leadership three year programme (2006-09) is on undergraduate research. Malaspina University College is coordinating 10 institutions from Canada, UK and USA. The University of Gloucestershire is the only UK institution involved.

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C.2 Further reading

For over 200 references and a list of useful Web sites see: Healey, M *Linking Research and Teaching: A selected bibliography* <http://resources.glos.ac.uk/ceal/resources/litreview.cfm>

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C.3 Useful web sites

Australian Learning and Teaching Council *The Academic's and Policy-Maker's Guides to the Teaching-research Nexus* <http://www.trnexus.edu.au/>

Council on Undergraduate Research (CUR) <http://www.cur.org/>

Higher Education Academy <http://www.heacademy.ac.uk>

Research and teaching <http://www.heacademy.ac.uk/ourwork/research/teaching>

Research and Teaching Forum <http://www.heacademy.ac.uk/ourwork/research/teaching/forum>; for 2007

Colloquium see: http://portal-live.solent.ac.uk/university/rtconference/rtcolloquium_home.aspx

Learning through enquiry alliance <http://www.ltea.ac.uk/>

McMaster University Centre for Leadership in Learning, Inquiry-based learning resources www.mcmaster.ca/cll/inquiry/inquiry.resources.htm

New Zealand Inquiry Based Learning Project <http://akoaootearoa.ac.nz/projects/inquiry-based-learning>

Reinvention Center at University of Miami <http://www.reinventioncenter.miami.edu/>

Research Skill Development Framework <http://www.adelaide.edu.au/clpd/rsd/>

The Scottish Higher Education Enhancement Committee (SHEEC) Enhancement Themes: Research-Teaching Linkages <http://www.enhancementthemes.ac.uk/themes/ResearchTeaching/default.asp>

University of Gloucestershire: NTFS Project 'Leading, promoting and supporting undergraduate research in new universities' <http://resources.glos.ac.uk/tli/prsi/current/ugresearch/index.cfm>; and Centre for Active Learning 'Undergraduate Research case studies'

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

University of New South Wales Research-Teaching Nexus

http://learningandteaching.unsw.edu.au/content/Randl/research_nexus/rtn_resources.cfm?ss=5

University of Sydney, Institute for Teaching and Learning, Research-led teaching and the scholarship of teaching <http://www.itl.usyd.edu.au/RLT/>

UREKA (Undergraduate Research Experience & Knowledge Award)

http://www.sfi.ie/content/print_friendly.asp?section_id=448&language_id=1