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Strategies and practices for engaging students in research and inquiry

Professors' Lounge

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A. Some Institutional and Faculty Case Studies

1.1 Students are involved in research-based education at University College London (UCL), UK

“At University College London, our top strategic priority for the next 20 years is to close the divide between teaching and research. We want to integrate research into every stage of an undergraduate degree, moving from research-led to research-based teaching”

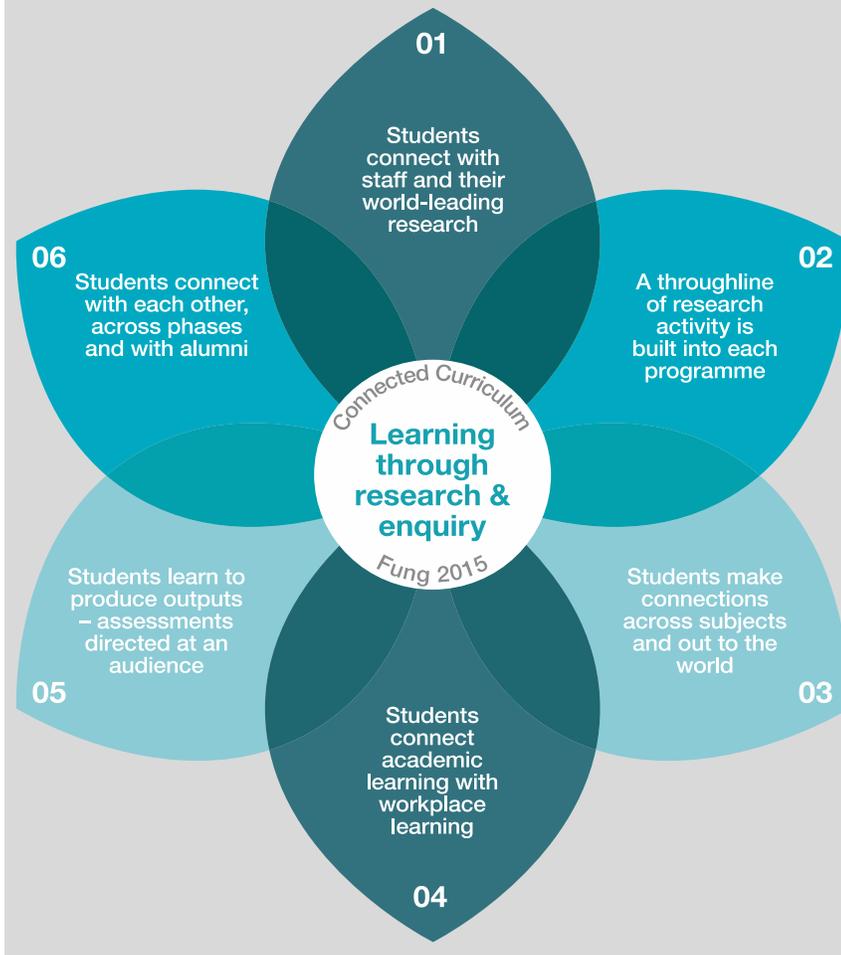
Michael Arthur, president and provost, 30 April 2014: 22

UCL are developing a ‘Connected Curriculum’ initiative, as the means by which in five years all undergraduate programmes of study will have a profile of ‘research-based’ characteristics. Research-based education is the focus of UCL’s initiative. The connected curriculum has six dimensions based around the core principle of learning through research and inquiry.

1. Programmes include a connected ‘throughline’ of learning activities and assessments, which require students to synthesise different elements of their learning
2. Students make connections across subject disciplines and outwards into local and global communities and organisations
3. Students can connect explicitly their academic learning with their wider learning and skills for future employment
4. Students can connect with an external audience and external partners through producing assessment ‘outputs’
5. Students can connect closely with staff
6. Students can connect closely with one another and with alumni.

The initiative, which is co-ordinated by the Centre for Advancing Learning and Teaching (CALT), requires changing the criteria for promotion, so that excellence in education is as significant to advancement as excellence in research and innovation. The implementation also involves reviewing all programmes and designing clear strategies for working more closely with students, who can act as partners and change agents. A guide has been developed which presents four benchmark descriptors (a-d) for each of the six Connected Curriculum dimensions: a) Beginning, b) Developing, c) Developed, and d) Outstanding. This will help departments map their progress in implementing the connected curriculum in taught programmes.

Fig. 1 UCL's Connected Curriculum Framework



Further information: Arthur (2014); Fung (2015, 2016, 2017); http://www.ucl.ac.uk/teaching-learning/strategic_priorities/connected-curriculum; https://www.ucl.ac.uk/teaching-learning/connected-curriculum/CC_Guide; <http://www.ucl.ac.uk/teaching-learning/case-studies>; <https://www.ucl.ac.uk/changemakers>.

1.2 Embedding small-group discovery in undergraduate learning at University of Adelaide, Australia

In 2013 the University developed a policy that a Small Group Discovery Experience (SGDE) will be a core component of a credit bearing course in each undergraduate programme. Drawing on ideas from Humboldt and Boyer the policy envisaged that a small group of students meeting to work at the discovery of new knowledge under expert guidance will be a signature pedagogy of the University in every year of all of its programs. It was proposed that the SGDE will involve at least two face-to-face encounters with the academic per course, and the size of group will be determined by what will deliver the optimal learning outcomes deemed appropriate by the discipline. In 2016 Levy reported significant progress including: senior championing and leadership roles in place; operational plan, timeline and KPIs established; principles and guidelines established; major learning spaces redesign project; and resources for development committed. But she also notes tensions in the implementation of the policy including: between preparing students for professional vocation and leading them toward knowledge creation; limited commitment to Boyer's scholarship of discovery and Humboldtian ideals of students and academics researching new knowledge together; commonly felt that 'true' discovery not possible before gaining thorough knowledge of disciplinary content and theoretical grounding; 'learning to research' seen as more appropriate for 1st year students than independent discovery. Students generally positive about SGDE, especially contact with academic mentors and understanding of research process. Recognise that need to move beyond compliance to cultural change and potential of students as partners to bring about embedded change.

Further information: University of Adelaide (2013); Levy (2016)

1.3 Student as Producer is the organising principle for learning across the University at Lincoln, UK

'Student as producer' is central to the learning and teaching philosophy at the University of Lincoln. In this approach, the emphasis is on students producing knowledge in partnership, rather than just consuming it. The focus of student as producer is the student, working in collaboration with other students and academics in real research projects, or projects which replicate the process of research either in or outside of their discipline. Students work alongside staff in the design and delivery of their learning, and in the production of work of academic content and value. Staff and students can apply for development funds to the Undergraduate Research Opportunities Scheme (UROS) and Student Engagement in Educational Development fund (SEED) to support work that further enables the principles of Student as producer to be embedded at Lincoln. This approach has made research-engaged teaching an institutional priority. As new courses are developed and existing ones undergo re-validation, staff and students are asked to consider student as producer in terms of the following key principles:

- Discovery – students learning through their own enquiry;
- Collaboration – working together to develop knowledge and understanding;
- Engagement – being part of a community of staff and students;
- Production – students as producers of knowledge rather than consumers.

These principles are enabled through assessment, citizenship, employability, pedagogy and curriculum, resources, skills, space and technology. The University of Lincoln also promotes students as active partners in in quality enhancement through working collaboratively with staff, recognising that students are experts in their student experience.

Further information: <http://edeu.lincoln.ac.uk/student-as-producer>; studentasproducer.lincoln.ac.uk/; Crawford *et al.* (2015); Neary with Winn (2009); Neary (2010); Neary *et al* (2014); Ryan and Tilbury (2013, p. 17)

1.4 How to Change the World: Interdisciplinary engineering design aimed at addressing major global challenges at UCL, UK

How to Change the World is a two-week facilitated design studio, in which 700 year 2 engineering students from different engineering disciplines tackle a 21st global challenge using their engineering, business and IT skills. External partners work with staff to set challenges and with the students on two days of their programme. They come from private, public and third sectors and provide students with real-world checks, a chance to network and information about a range of different roles engineers are employed in.

How to Change the World is a design and problem solving activity, aimed at getting engineering students to see their expertise in a social context. They are given very broadly defined challenges that range from such issues as supplying energy services to rural African locations, to redesigning domestic appliances and markets for re-use rather than disposal, and finding solutions to overcrowded and congested transport systems in growing urban centres. The students must produce a design concept that involves multiple sets of expertise.

The challenges are set by partners from the third, private and public sectors in collaboration with research and teaching staff from UCL. All challenges are real issues that require, engineering expertise, along with business and IT. Partners come in and work with the teams on two days of the two week programme. The final day consists of a trade-show style event, which includes a 'Dragons Den' style panel pitching session. Students are assessed by academics and partners and prizes are awarded for the best ideas. Academics and partners are invited to the final showcase, along with alumni and postgraduate students.

Some of the external partners have invited winning teams to present to their colleagues in their own offices. The aim is to make certain this happens for all winning teams. Ten challenges are will run in the coming year and an overall winning idea will be chosen from each. Students are encouraged to keep working on their ideas. In 2015 the overall winners were given a Student Fellowship at the RSA, where they have been able to contact the networks and support they need to progress their ideas.

Further information: <http://www.ucl.ac.uk/steapp/how-to-change-the-world>

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

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

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

1.6 Linked degree programme of engineering clinics at Rowan University, USA

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

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

1.7 Minority science and engineering improvement program Department of Education, USA

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

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

1.8 Compulsory research project with cultural engagement: Civil and natural resources engineering, final-year students at University of Canterbury, NZ

Students in small groups conduct a compulsory four term research or consultancy project. The ‘project’ starts in year 3 and runs through the three terms of year 4. Projects are developed jointly by academic staff and industry practitioners and are based on some sustainable engineering problem with interdependencies between people, the environment and the economy embedded in technical solutions. Most projects are funded by industry partners, at little or no cost to the University. A particular aspect of the project is the inclusion of indigenous people's cultural engagement. In New Zealand, the Maori are the legally and culturally recognised guardians of the country's natural resources. As part of the project students take two full-day interactive workshops facilitated by a non-for-profit organisation to learn about the principles and implications of the Treaty.

Source: O’Sullivan and Cochrane (2009)

1.9 Simulating Research Using Electronic Laboratories at MIT and Purdue, USA

Online laboratories can support many students and often at many locations worldwide to carry out simulated research experiments. Such may not have the authentic value of working in a real laboratory, but can support such

real world experience and/or for institutions coping with large numbers provide an experience that in part gets close to authentic lab based research. Two such initiatives are:

i Labs at MIT. From their own computers at any time of the day or night, students in science and engineering can use these remote lab setups to conduct experiments, working remotely with instruments housed at MIT to complete course assignments with curriculum materials that combine remote experiments and Open Course Ware content.

Simulation-led Learning in Nanotechnology at Purdue. Founded in 2001 with support from the National Science Foundation, this Web portal features more than 50 high-performance, interactive tools let users input their own data and parameters to run complex experiments from their desktops. Much as the MIT iLabs Shared Architecture lowers the barrier of participation by providing students with access to instruments at remote locations.

Sources: Lombardi and Oblinger (2007); <https://wikis.mit.edu/confluence/display/ILAB2/Home>;
<http://nanohub.org/home>

1.10 Students work in multidisciplinary teams on both year-long engineering capstone projects for partnering corporate sponsors and two to three year-long entrepreneurial sustainable projects at Olin College, USA

Olin College (USA) is an innovative engineering institution with a curriculum from year one built around group project based entrepreneurial engineering design projects. Early projects are shaped by faculty but later projects are student designed with faculty support. Each year every student presents a project they have been working on at the Fall Project Expo. In the final year capstone, seniors work in multidisciplinary teams of 5-7 students on full-year engineering projects for partnering corporate sponsors. Olin works with companies and technology clients to develop SCOPE projects that are important to the sponsor while providing an important educational experience for the student. The corporate partner provides financial and organisational support. Olin provides a faculty advisor and dedicated work space and technical support and equipment. The teams deliver formal mid-year and final reports to the sponsors.

Partly drawing on the SCOPE experience, Olin with neighbouring Babson College (an entrepreneurial business college) has recently developed a linked course that starts in the junior year but can also serve as an alternative or additional capstone. 'Affordable Design and Entrepreneurship'. Student teams from Olin and Babson work on entrepreneurial, but sustainable projects around the world, including the USA in areas such as energy, water, health, agriculture, transportation and communication. An ideal student path would be to complete an internship with an initiative partner, take the course for two semesters, work for a mission-driven company or NGO as an intern, and be part of launching a new social venture. The plan is for projects to last 2-3 years, with dozens of students "getting on and off the (project) bus," as one course or one year is not enough time for the necessary technology and business model development.

Sources: Kearns *et al.* (2004); <http://www.youtube.com/watch?v=2wRj1G15eiE>;
<http://scope.olin.edu/about/>; <http://www.youtube.com/watch?v=pDitxrXeYnA>;
<http://design.olin.edu/courses/ade/course/description>; <http://design.olin.edu/courses/ade/>;
<http://nciia.org/node/1724>; <http://www.tornado-in-greensboro.info/>

1.11 PBL Civil Engineering at the University of Limerick, Ireland

Since 2009 the civil engineering programme at Limerick, uniquely in Ireland has PBL as the central pedagogy through the four years of the course. In year one a structured small scale problem introduces students to this curricula approach with a strong focus on group work. In subsequent years the problems become more complex and culminate in a final year independent project. The course timetable was reshaped to enable two PBL sessions per week of 2-3 hours with lectures interspersed between these sessions. The PBL sessions consist of 2 tutors or facilitators and between three and six student groups working on linked problem areas. The PBL approach is now established in a number of civil engineering programmes worldwide, notably at Aalborg in Denmark, New South Wales, University of Castilla, La Mancha, Spain and Monash University, Australia.

Sources: <http://www3.ul.ie/courses/CivilEngineering.php>; http://doras.dcu.ie/447/1/Butan_ISEE07.pdf;
<http://www.ul.ie/civileng/>

1.12 Research project-based teaching in engineering: a departmental strategy at Taylor's University, Malaysia

The curriculum in the School of Engineering had adopted a project-based learning approach where the students are required to take a Design module each semester for the first three years of their four-year study, and then a final-year capstone project. All the projects require students conducting a variety of inquiry-based, design and build activities in groups. Staff research groups are organised around the Grand Challenges themes identified by the (US) National Academy for Engineering (NAE) in 2008. Staff in these research groups are expected to perform the following duties:

1. adopt related core and elective modules. This includes developing, updating and teaching these modules. Staff members are encouraged to include aspects of their own research findings into the modules;
2. offer group design projects to the students in years one to three;
3. offer final-year research projects. Every fourth-year student is required to undertake a major research project and write a conference paper as a requirement for graduation. Their research findings are presented at the school's annual Engineering Undergraduate Research Catalyst Conference (EURECA).

This departmental strategy is now under consideration as an institution-wide strategy.

Distinctive, but generalisable features of this strategy are that: here research is broadly conceived to include staff consultancy and advanced professional practice; the staff research does clearly support students' research understanding and future employability; and there is an overall departmental vision to bring together the different aspects of the student and staff experience.

Sources: Al-Atabi et al. (2013); <http://www.taylors.edu.my/en/university/schools/engineering>;

http://www.taylors.edu.my/en/university/schools/engineering/why_taylors;

http://www.taylors.edu.my/en/university/schools/engineering/why_taylors;

<http://www.taylors.edu.my/EURECA/2013/>; <http://www.taylors.edu.my/en/university/schools/engineering/research>

1.13 Engineering Inspiration is a free Technical News resource for undergraduate science and engineering students developed at UCL, UK

We want our students to start engaging with research early in their careers, but there are real difficulties in achieving this. Specifically, technical papers are filled with jargon that first and second year undergraduates cannot reasonably be expected to handle, and require a deeper level of expertise than they have had time to develop.

Engineering Inspiration (ENGins) is a news site that tries to help students through this difficult period - where they are neither truly technical nor non-technical people - by giving them easy access to the popular science and technical trade press. Instead of wading through technical papers, they can read concise, user-friendly articles aimed at the educated public, technical management, and/or technical people who want to know what's going on outside of their narrow area of expertise. These articles are curated from hundreds of publications as diverse as *Wired*, *The Economist*, *Medical New Today*, *Physics World* (*Chemistry World*, *Laser Focus World* etc.), *Nanowerk*, *Gizmag*, and *IEEE Spectrum*. There are currently more than 30,000 articles on the site and more are being added daily.

Another advantage of the site is that it is customizable: students can see a front page that is tailored only to their own particular interests, and sign up for an RSS feed – with no duplicates – that also matches their preferences.

We are currently using the site as a research tool for undergraduate essays, as a showcase for student writing, and as a means of helping students find profiles of scientists and engineers to emulate. The site is open to all.

Further information: Sunny Bains (sunny.bains@ucl.ac.uk); <http://engins.org>

1.14 Tutorials enabling students to connect across year groups in Biomedical Engineering, UCL, UK

Tutorials provide an opportunity for students to reflect on their learning, make holistic connections between modules and see their subject in a broad context. We have restructured the tutorials in our Biomedical Engineering programme so that each tutorial group includes students from all years of the programme. The main reason for this change was to encourage students to connect between year groups so that newer students can learn from more experienced near peers and so that students reaching the end of their programme can recognise how much they have learned and matured. This approach gives practical help to newer students by involving established students in tackling the problems they face, allowing them to form their own support groups organically without the commitment required by a formal mentoring programme. Pedagogically, we aim to use tutorials to emphasise continuity throughout the

degree, enabling students to form connections between their learning year- by- year, and to see how their understanding and expertise develops through the programme.

An initial feedback questionnaire suggested that students in the later years of their degree felt that they would gain less from this scheme than new students. We have tackled this concern by scheduling tutorials to ensure that each session contains material relevant to all students and by retaining year- group tutorials in cases where there is material that is only relevant to one year group. An additional benefit is that the tutor's role increasingly becomes one of facilitating problem solving between students. This means that the tutor needs less programme- specific knowledge, allowing a broader range of staff to get involved in tutoring. We are reviewing the new tutorial system by monitoring students' feedback with questionnaires, which we will use to refine our approach as the programme develops.

Source: Fung (2017, 130-131) Vignette submitted by Adam Gibson, Professor of Medical Physics, UCL.

1.15 Reinforcing Learning in an Engineering Master's Degree Program: The Relevance of Research Training

Master students at our institute were graduating without acceptable research proficiency. We intervened by shifting our research training from teaching-centred to student-centred, and from research-related subject content to research-related processes. We performed a mixed methods study aimed to confirm there was improved research proficiency without a negative trade-off for our students' engineering skills. Results indicated improvements to research proficiency, which our students were able to transfer to engineering-related learning activities to increase their ability to achieve engineering synthesis. This outcome was potentially supported by our courses including several perspectives on scientific knowledge production. This implies that research training, rather than having a negative effect on engineering skills, can be helpful in learning diametrically opposing aspects of thinking required by current engineering. As engineering education evolves towards more cross-disciplinary cooperation, this implies the need to pursue the increased opportunities for students to learn about different perspectives on knowledge production.

Source: Fredrik Asplund (fasplund@kth.se) and Martin Edin Grimheden (mjb@kth.se) *International Journal of Engineering Education*, March 2019

1.16 Students have the opportunity to start up a software company or work with industry professionals on real world projects at ANU, Australia

TechLauncher is an ANU initiative which enable students from any discipline to develop the research and professional skills required to use technology to bring great ideas to life and have a positive impact on society. Students develop these skills by working closely with industry professionals, technology experts and entrepreneurs to complete projects addressing complex problems across a variety of disciplines and industries. Students are given the choice to create start-up software companies whilst guided by experienced industry mentors, or to work with industry professionals on real-world projects. In 2015 they had 120 3rd and 4th year students enrolled in the course which runs over two semesters. Many of the 3rd year students will continue with the program in their 4th year.

Participation in TechLauncher revolves around small teams of 4-6 students working on a broad range of project types. Traditional client projects are normally proposed by someone working in government or the private sector, or by university academics and professional staff. People who propose such projects normally become the project's client. Start-up projects are normally proposed by students wishing to take the start-up option. Each team is normally led by a 4th year software engineering student enrolled in [COMP4500](#). The remainder of each team normally comprises 3rd year students enrolled in various computing project courses. Some teams may also include students from other disciplines such as arts, law or commerce. These students will normally be enrolled in [COMP3710](#). Each team will have an experienced mentor who is independent of other project stakeholders including any clients. Assessment has three components:

- [Posters and Public Showcase](#) [10 marks]
- [Project Reviews](#) [60 marks]
- [Learning Portfolio](#) [30 marks]

There are several opportunities and competitions that are available to students, which may be linked to TechLauncher.

Further information: <http://cs.anu.edu.au/TechLauncher/>

B. Institutional Strategies to Mainstream Undergraduate Research and Inquiry

Amended extract from: Mick Healey and Alan Jenkins (2009) *Undergraduate research and inquiry* York: HE Academy. pp.80-101

http://www.heacademy.ac.uk/assets/York/documents/resources/publications/DevelopingUndergraduate_Final.pdf

A. Develop supportive institutional strategies and policies

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

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

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

C. Ensure institutional practices support undergraduate research and inquiry policies

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

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

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

A. Develop supportive institutional strategies and policies

Strategy 1: Embed in vision and teaching and learning and research strategies of university

Before undergraduate research and inquiry can be effectively mainstreamed, it is helpful for colleagues and students to discuss what they mean by the term (see section 2). This may well result in variations between different disciplines across the institution, but the understandings will then be owned by those who have to implement practice. Some institutions may choose to widen what counts as 'research' by students. This approach has been used by the University of Gloucestershire (see section 2). Griffith University, Australia has also expanded the definition to incorporate the concept of 'public scholarship' as a distinctive feature of the University's learning activities. They use the concept to refer to "the opportunity (for students) to work with real problems, and in doing so to place their knowledge at the service of our communities. This ... finds expression through our commitment to work-integrated learning and to research based learning" (Griffith University, 2007, 1).

Research-led Education Programme Requirements at Durham University, UK

In March 2011 Senate - the governing body of the University - required research-led education - understood "as in its broadest sense encompassing all four types of research-led education" (ie research-led, -oriented, -based and -informed, as in Griffiths, 2004) to be embedded within the curriculum of all programmes of study in a three year implementation plan. Other required curricula principles are employability and skills, and internationalisation. Specific requirements include:

- "Research-led education will be ... a coherent, progressive and explicit strand at all stages of a programme. The University will expect that this begins at Level 1 of undergraduate programmes (and Level 0 for those programmes incorporating a foundation year) and immediately in taught postgraduate programmes."
- "All degree programmes will include a major research project, dissertation or equivalent where students are able to demonstrate the development of their own research and independent study skills, as well as their expertise in their chosen field of study. This major research project will provide a 'capstone' to their Durham education that allows students to demonstrate their ability as independent learners and researchers."

Further information: <http://www.dur.ac.uk/learningandteaching.handbook/4/4/5/>
<http://www.dur.ac.uk/learningandteaching.handbook/10/10.2/>

Strategy 2: Develop supportive institutional curricula frameworks and structures

As we have argued at several points in this paper, the key way to mainstream undergraduate research and inquiry is to integrate it into the curriculum. Many of the case studies elsewhere in this paper illustrate this; for example, at Miami University, Ohio, they have instituted a Top 25 project in which over a four-year period the largest recruiting courses, mainly at first-year level, are being supported to convert to inquiry-based learning (case study 6.1), while McMaster University has optional inquiry courses (case study 1.2). Indiana University-Purdue University Indianapolis is another institution encouraging its first-year students to engage in undergraduate research and inquiry (see below).

One particular intervention is to rethink the overall institutional timetable; for example, by creating a particular period of the year when students can focus entirely on an undergraduate research project; this, in part, mimics the experience of faculty with a research project or sabbatical. This can readily be achieved outside the normal university calendar, as, for example, in the many undergraduate research Summer enrichment programmes and the practice in many fieldwork disciplines for week-long intensive field courses in vacations. At MIT the four weeks before the second semester is the Independent Activities Period (IAP), where "students are encouraged to set their own educational agendas, pursue independent projects ... (and) faculty are free to introduce innovative educational experiments as IAP activities" (MIT, n.d.).

The university curriculum timetable can also be changed to ensure *all* students have dedicated time for research; for example, by adjusting the timetable across the whole year or for a limited period. Thus instead of a one-hour block, the curriculum can be delivered over two- to four-hour blocks; such blocks of time both encourage and allow inquiry-based learning activities to take place (e.g. case study 1.2). There can also be a period of, say, one to two weeks where students can focus on one central investigation; for example, part of the final year can be solely devoted to the

dissertation or capstone. In some countries a whole term or semester or the whole of the fourth year may be given over to undertaking an Honours dissertation.

Experiential learning for all at Indiana University-Purdue University Indianapolis (IUPUI), US

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

Further information: Kathryn J. Wilson, Assistant Vice Chancellor for Research, Indiana University-Purdue University Indianapolis (IUPUI), posting to Council on Undergraduate Research web site 30 January 2009; <http://crl.iupui.edu/>

Block teaching and final two-year research project at Quest University, Canada

Quest University British Columbia, which held its inaugural class in 2007, is Canada's only private, secular non-profit university. In 2012 it had 425 students. The school was founded in 2002 by David Strangway, a geophysicist and former president of the University of British Columbia.

The curriculum emphasis is on student inquiry and research. Staff student ratios are high. Much teaching is seminar based with maximum class size of 20. There are no lecture theatres or lectures. Quest uses the block system, in which students take one course at a time for a month. In their second year, students spend an entire block, with 15 peers and a tutor, formulating a central question. Students spend their last two years focused on that question. Usually, it is answered in the form of a thesis but alternative research outputs are supported e.g. an original play or a graphic novel. Faculty are required to undertake standard discipline based research or pedagogic research.

In the 2011 National Survey of Student Engagement, in which most Canadian universities participated, for both first-year and senior students, Quest was first for year one and senior students in five key benchmark categories 1. Level of Academic Challenge; 2. Inclusion of Enriching Educational Experiences; 3. Intensity of Student-Faculty Interaction; 4. Use of Active and Collaborative Learning; and 5. Existence of a Supportive Campus Environment.

Further information : Miller (2012); <http://www.questu.ca/>; http://en.wikipedia.org/wiki/Quest_University
<http://www.youtube.com/user/questuniversity>; http://www.questu.ca/about_quest/a_quest_degree.php;
http://www.questu.ca/academics/concentration_program/index.php;
http://www.questu.ca/pdfs/uploads/content/quest_learning_outcomes.pdf;
http://www.questu.ca/admission/nsse_survey_results.php

Strategy 3: Link undergraduate research and inquiry to institutional policies for employability

It can be helpful not to envisage the development of undergraduate research and inquiry as a separate policy, but rather one that contributes to delivering other institutional policies, such as employability (see also departmental employability strategies in section 4). Northwest Missouri State University and the University of York, for example, have linked undergraduate research to their policies to encourage the employment of undergraduates on campus, as does the Universities of Warwick and York skills certificate. The emphasis by QAA Scotland and the Australian Learning and Teaching Council on linking research and teaching to deliver key graduate attributes also gives a focus on the benefits for employability of engaging students in undergraduate research and inquiry.

On campus undergraduate research employment: Northwest Missouri State University, US and the University of York, UK

Undergraduate students being employed in a variety of roles, including academic roles, on campus is an important feature of many US universities. The scheme at Northwest Missouri State University is a strong example of such structured programmes – with approximately 40% of University employees (over 540) being students. Some have roles of considerable responsibility and their employment is an integral part of their learning experience. In the UK

and elsewhere there is strong pressure from government to expand and link employment and higher education. The University of York, through its careers service and supported by a National Teaching Fellowship, aims to expand the breadth and number of part-time and temporary higher level employment opportunities available to its students – in part shaped by the Northwest Missouri State University example. The project involves scoping and prototyping a comprehensive on-campus student employment scheme, with a particular focus on higher skilled work, and to explore the application of this scheme with local businesses. The University of York is particularly interested in exploring how the scheme may be used to involve students in a variety of forms of undergraduate research.

Further information: DIUS (2008); catpages.nwmissouri.edu/m/lgmf/documents/

Institutional research skills certificate at the Universities of Warwick and York, UK

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

Further information: <http://www2.warwick.ac.uk/services/scs/skills/usp>;
<https://www.york.ac.uk/students/work-volunteering-careers/skills/york-award/>

Strategy 4: Link undergraduate research and inquiry to institutional policies for widening participation

By linking undergraduate research and inquiry to other appropriate institutional strategic priorities, wider support and greater embedding is likely. This approach could, of course, lead to different emphases being placed on the nature of undergraduate research and inquiry in different institutions. For example, the University of Michigan has devised special undergraduate research opportunity programmes for African-American students in years one and two in an attempt to reduce the relatively high drop-out rates from this group.

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

A number of Undergraduate Research Opportunities Programs (UROPs) focus on what in the UK would be called 'widening participation'. At the University of Michigan there is targeted support for largely African-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 years one and two to enhance their integration and academic success. There have since developed related projects to support transfer students into the University of Michigan from community colleges and four-year colleges. Research demonstrates significant positive impacts (Locks and Gregerman, 2008). In addition, linked to the University-wide UROP programme, a first-year residential programme for some 80 students is aimed at culturally and geographically diverse US students and international students. Research is conducted with selected faculty and supported by resident second- and third-year peer mentors.

Further information: Huggins *et al.* (2007a); Locks and Gregerman (2008)

Strategy 5: Link undergraduate research and inquiry to institutional policies for civic and community engagement

Yet another way of linking undergraduate research and inquiry to institutional policies is through civic and community engagement. In the US many institutions have developed a range of programmes and initiatives that connect the university with the wider and local communities in a scholarly way, often referred to as the 'scholarship of engagement' (Boyer, 1996). Some of these initiatives, as with the case study of Bates College, the University of Michigan and Penn State University below, are effectively, in part, undergraduate research programmes.

Undergraduate research and the scholarship of engagement at Bates College, the University of Michigan and Pennsylvania State University, US

At Bates College, the Harvard Center seeks to build long-term projects founded in community needs and student and faculty research interests that enable students and faculty to work with community partners within semester-based courses on issues of common concern. Thus, one project has local museum staff working with humanities students

and faculty to develop a travelling exhibit about Lewiston's mills and millworkers in the 20th century. This includes students learning and using oral history research methodologies to interview former millworkers.

At the University of Michigan, the Ginsberg Center is funded through central university funds and endowment income. At any one time it has a range of long-term projects developed through community needs and faculty, student or donor interests. These projects are then supported by a range of grants, credit frameworks in departments and student volunteering.

Penn State University has developed a 'Civic and Community Engagement Minor'. Although a central university initiative, the core courses are in the disciplines and departments, but are centrally recognised as 'public scholarship', e.g. a Summer field course in Geography where students research with a Philadelphia inner-city community issues of concern to that community. To be awarded a minor, students need to do one such field-based course – i.e. a capstone (similar to a dissertation and required for most programmes) that is community-based – and three courses from their discipline that have been recognised by the Public Scholarship minor committee as public scholarship.

Further information: Huggins *et al.* (2007a)

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

Strategy 6: Embed undergraduate research and inquiry from day students enter university

Rather than leaving the experience of doing research to the final-year dissertation or capstone project, it is more effective to engage students in a variety of research and inquiry projects from the beginning of their studies (see case studies 1.2). McMaster University has a set of optional inquiry-based courses in each faculty available in years one and two, which have proved effective in developing study skills at an early stage and hence helping students perform better in later courses.

Inquiry-based courses available across the curriculum at McMaster University, Canada

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

Further information: Centre for Leadership and Learning (n.d.); Knapper (2007);

Strategy 7: Raise students' awareness of research

Raising students' awareness, understanding and engagement in research is a critical part of bringing them into the research community of the university. Students in research-intensive universities generally have a greater awareness of research than students in teaching-focused institutions, which would be expected given the greater amount of research happening in the former. However, there is some research evidence that the level of engagement in doing research may not vary by institutional type (Turner *et al.*, 2008). To increase awareness of students of research, the research-intensive University of Alberta has an institution-wide project entitled 'Research Makes Sense for Students'.

Institution-wide project 'Research Makes Sense for Students' at the University of Alberta, Canada

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.

Further information: www.uofaweb.ualberta.ca/researchandstudents/;
<http://www.uofaweb.ualberta.ca/researchandstudents/nav01.cfm?nav01=19717>

Strategy 8: Provide opportunities for selected students to undertake undergraduate research and inquiry within and outside the curriculum

A growing number of universities are providing opportunities for *selected* undergraduates to engage in research either within or outside the curriculum. Selection is most commonly based on intellectual merit, aptitude and interest, such as in ANU's Advanced Studies course (see below), Utah State University's Undergraduate Research Fellowships (Kinkead, 2008) and the University of Warwick and Oxford Brookes University's Undergraduate Research Scholarship Scheme (www2.warwick.ac.uk/services/ldc/funding/urss/;
www2.warwick.ac.uk/fac/soc/sociology/rsw/undergrad/cetl/fundingopps/urssbrookes/). However, undergraduate research opportunities in some institutions are also used as part of their widening participation programmes, such as at the University of Michigan (see strategy 3).

A few courses are entirely built around research. For example, in the UK Anglia Ruskin University and the University of Bolton have a complete degree based around undergraduates undertaking action research in the workplace (see case study 4.6). Where a selected group of students gain the experience of undergraduate research, it is important that ways are found to communicate their achievements to the rest of the university community.

Advanced Study Courses at Australian National University (ANU)

In 2003 ANU established the Bachelor of Philosophy degree to provide a research based education for elite students. They undertake research at a high level from the beginning of their undergraduate degree through the inclusion of six or more research-led projects during years one to three of their degree (Wilson *et al.*, 2007, Newitt 2007; Wilson and Howitt 2012). These research projects replace lecture based courses and "may consist of a reading course with a world-leading scientist or joining a research team to assist in the advance of knowledge" (ANU, 2009). These students then take an Honours year which normally involves both course work and a substantial piece of original research. Those 'teaching' on the programme include specialist researchers from ANU's Institute of Advanced Studies. There is a university wide forum that supports spreading insights and resources from this programme to more 'mainstream' courses at ANU (Centre for Educational Development and Academic Methods, nd).

Further information: ANU (2009); Centre for Educational Development and Academic Methods (nd); Kiley *et al.* (2009); Newitt (2007); Strazdins (2007); Wilson *et al.* (2007); Wilson and Howitt (2012)
<http://studyat.anu.edu.au/courses/SCNC1101/details.html>

Strategy 9: Provide opportunities for all students to undertake undergraduate research and inquiry within and outside the curriculum

A few universities have gone for institution-wide approaches, which effectively provide opportunities for all students to engage in undergraduate research and inquiry. For example, at Roskilde University in Denmark half of the curriculum for all students is based around project work; while over 80% of students at MIT undertake at least one undergraduate research opportunity programme, mostly in addition to their studies.

Half of the work of all students is spent undertaking projects at Roskilde University, Denmark

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, 5). The first two years are interdisciplinary group projects; later projects tend to be within one discipline and sometimes may be undertaken individually.

Further information: Legge (1997); <http://www.ruc.dk/en/education/full-degree-graduate/interdisciplinarity-and-project-work/>

Undergraduate Research Opportunities Program at the Massachusetts Institute of Technology (MIT), US

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 working with the department of engineering at the University of Cambridge (UK) to develop an undergraduate research programme there. MIT conducts an audit of UROP participation among graduating seniors each year. For the class of 2004, 82% of graduating seniors had participated in UROP at least once during their undergraduate careers (Huggins *et al.*, 2007a). Further information: mit.edu/urop/; www.eng.cam.ac.uk/teaching/urops/

From problem based learning (PBL) to undergraduate research at Maastricht University, Netherlands

Problem Based Learning (PBL) has been central to all programmes at Maastricht since it was founded in 1976. Students work in small groups (10 to 13 students) on actual or simulated problems under the supervision of a staff member. While these experiences have an element of student research, the problems are generally ‘old problems’ and the inquiries are generally of two week duration. In 2010 Maastricht, through competitive national funding (Sirius) to support high ability students, established a programme – MARBL (Maastricht Research Based Learning) to support undergraduate research in all faculties. Two main differences with the well established PBL are the amount of time actually spent on just one research question – this can be five months; and that students are working on authentic problems, presented by external clients or as a part of a large research project at the university. Entry to such programmes is competitive. Most participants in the new programmes are in their third (final) year in the bachelor’s programme. On average 200 students (8 percent of the approximately 2,500 third-year students) participate in different research projects each academic year. Preliminary research is positive on the impact of the programme from both student and faculty perspective. In addition, MARBL is impacting on the mainstream curriculum for all students. Two faculties have revised their curricula, embedding more research elements. A third faculty has introduced a research-based curriculum for all students, with the undergraduate research project available for the top 20 percent of the students in their third year.

Further information: Bastiaens and Nijhuis (2012) <http://www.siriusprogramma.nl/>; <http://www.maastrichtuniversity.nl/web/Faculties/SBE/Theme/Education/MARBLEProgramme.htm>.

Strategy 10: Have students investigate issues that are of importance to the university or other students

A further way in which to engage students in undergraduate research and inquiry is to involve them in investigating issues that are of importance to the university or other students. A good example at department level is illustrated by selected Sociology students at the University of Warwick evaluate their peers’ experiences of teaching and learning. At the University of Exeter, students undertake action research into issues faced by other students in their programmes and act as agents of change. At Utah State University, students have investigated writing across the curriculum.

Students are engaged as partners in shaping and leading their own educational experiences through their 'students as change agents' initiative at the University of Exeter, UK

The key concept is that students themselves take responsibility for bringing about change, based on their own research on aspects of learning and teaching. The approach enables students to be actively engaged with the processes of change, often taking on a leadership role. They are engaged deeply with the institution and their subject areas, and the focus and direction is, to a greater extent, decided by students. The most important aspect is the focus on research, and building change on evidence-based foundations. Students from across the university have contributed to this initiative, carrying out a series of research projects on their learning and teaching environment, selecting concerns raised through student-staff liaison committees, and providing recommendations and solutions to improve their experience. A small amount of funding is available from the University’s learning and teaching budget to support this initiative. Students work as apprentice researchers; their research methods included focus groups,

informal interviews and questionnaire surveys. Outcomes are presented at a student-staff conference, which results in institutional engagement with key research findings. Each small project is also captured through a case study. Student research has driven organisational change, contributed to student engagement in shifts of policy and practice within the University, and supported students' graduate skills in the areas of research, project management and presentation of outcomes, leadership and understanding organisational development. For example, student projects in the Business School on the benefits students have gained from implementation of technologies in the classroom have contributed significantly to streamed video being now far more widespread, and 4000 voting handsets being distributed to undergraduate and Master's students.

Further information: Kay *et al.* (2010); Dunne and Zandstra (2011)

Strategy 11: Value the role that student organisations can play in supporting undergraduate research

Involving student unions and organisations in institutional interventions can ensure both that student concerns are central to such interventions and that student leaders have an informed understanding of undergraduate research to bring to institutional policy discussions. As we show in section 7, in Scotland, student organisations and institutional leaders have played a key role in institutional discussions on graduate research attributes.

Student Union involvement in institutional interventions at the University of East Anglia (UEA), UK

To support its commitment for the interaction between research and scholarship with teaching, UEA investigated the reality of University rhetoric about the relationship between research and teaching. The University's Centre for Applied Research in Education worked in co-operation with the UEA Student Union to recruit 12 student researchers to research the student experience of research at UEA. "Members of the Student Union played an active part in the management and execution of the project work" (Zamorski, 2000, 6), as well as in the subsequent policy decisions to ensure students benefited from, and were involved in, the University research environment.

Further information: Zamorski (2000, 2002)

Strategy 12: Celebrate undergraduate research and inquiry

We are rather diffident, in the UK at least, of celebrating the work of our students. Apart from the best final-year dissertations, which are usually put in the library, and the end-of-year shows, common in art and design courses, the only people who see most student work are the students themselves and their assessors. A number of institutional and discipline-based undergraduate research journals have been founded recently in the UK. As undergraduate research and inquiry become more common on this side of the Atlantic, more departments and institutions are introducing a range of ways of celebrating the work of their students. Student research conferences are growing in number, but we have yet to reach the level of embeddedness in some North American colleges and universities. Hunter *et al.* (2010) show that celebrating the work of undergraduate researchers may have powerful lasting effects.

Undergraduate research has become part of the institutional culture at the University of New Hampshire, US

In 2013 the University of New Hampshire celebrates its 14th undergraduate research conference; over 1000 students will participate over a fortnight. Parents, friends and students applying for entry to the University are invited to join in the events.

Further information: www.unh.edu/urc/

Strategy 13: Provide support and encouragement to students undertaking undergraduate research and inquiry

Undertaking research and inquiry is a new experience for most undergraduate students; hence, apart from financial awards, which are covered in strategy 8, they need support and encouragement if it is to be a successful experience. Often this will come from their tutors and members of academic staff responsible for the particular project, but where undergraduate research is well embedded a central office is often established to co-ordinate the research opportunities and administrate the process. Some institutions have undergraduate research advisory boards.

One group, who are too often forgotten when it comes to giving support, are other students. This may be informal support from peers going through the same experience, or more formal support by arranging for senior students who have previously undergone similar experiences to act as mentors. McMaster University has a peer tutor scheme where students who have been taught in inquiry mode can take a credit-bearing course that involves them peer tutoring in inquiry courses, while Hunter *et al.* (2010) document several examples of peer support in undergraduate research in the sciences and engineering. A specific example is the Chemistry Department at the University of Michigan, which has senior students supporting first-year inquiry courses.

Intergenerational student teams support first-year inquiry courses in Chemistry at the University of Michigan, US

Each year the Chemistry Department at the University of Michigan has approximately 100 students in term time or Summer involved in undergraduate research with the 40 or so 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 (approximately 1400 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 about 160 students in this first-year course self-select into a supplemental instruction programme 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 programme is a collaborative activity between the primary faculty member and a team of eight 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 two-hour sessions. These students are seen as potentially the next generation of teacher-researchers.

Further information: Coppola (2005)

C. Ensure institutional practices support undergraduate research and inquiry policies

Strategy 14: Ensure quality assurance, quality enhancement and institutional assessment processes and policies support students as researchers

If institutional initiatives for promoting and supporting undergraduate research and inquiry are to be sustainable they are best embedded in the university's quality assurance and enhancement and institutional assessment policies and procedures. For example, at Griffith University, Australia for a programme to contribute to meeting the University's strategic performance indicator for research-based learning, at least 20% of the student course enrolments are in courses identified as having significant elements of research-based learning. Course Convenors assess their courses against the following categories:

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

At Oxford Brookes University all undergraduate and taught postgraduate courses need to demonstrate how the linkages between research and teaching and learning are realised.

Building undergraduate research into the curriculum at Oxford Brookes University, UK

From 2007 all Schools and Departments have been required to develop a more structured approach to developing all students as researchers in all course programmes in years one and two, as well as through specialist pathways to

support those students who choose a more extended research curriculum. Such pathways may include a focus on community-based undergraduate research. The requirements build on a previous university-wide intervention. In the context of the move to semesters, in 2002-03 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.

Further information: Huggins *et al.* (2005, 2007b)

Strategy 15: Ensure appropriate learning spaces are available to support undergraduate research and inquiry

With the development of undergraduate research and inquiry activities the kind of learning spaces needed changes. There has been a growth in interest in the development of social learning spaces in higher education, which enhance collaborative learning (Joint Information Systems Committee, 2008). In the sciences different demands are made on the use of laboratory space as the following example from Vancouver Island University illustrates.

Building design to link research and teaching at Vancouver Island University (VIU), Canada

The institution is 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.

Strategy 16: Align student support from library, information and communication technology services, and laboratories with needs of students undertaking undergraduate research and inquiry

As well as appropriate learning spaces students undertaking undergraduate research and inquiry need different forms of support from staff working in the library, information and communication technology services and laboratories.

Library staff change the way that they support students undertaking inquiry-based projects at induction at the University of Gloucestershire, UK

Rather than the conventional library tour introducing new students to the facilities and services available in the Learning Centre, staff at the Francis Close Hall campus support the students undertaking inquiry projects during induction week by focusing on the resources and ways of accessing them relevant to the specific disciplinary projects in which they were involved. Such just-in-time support means that the students begin to develop information literacy skills relevant to their projects as and when they need them.

Further information: <http://insight.glos.ac.uk/tli/activities/activelearning/Documents/CeAL%20Self-evaluation%20Document.pdf>

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

Strategy 17: Increase academic staff awareness of undergraduate research and inquiry

Raising staff awareness of the role of undergraduate research and inquiry, both within and outside the curriculum, is just as important as raising the awareness of students. A few postgraduate certificates for new teaching staff in the UK, for example at the Universities of East Anglia, Northumbria and Plymouth, include specific modules on the relationships between teaching and research. The use of focus groups, swap shops and audits was mentioned in the last section as effective ways of raising awareness. Nottingham Trent University has a postgraduate diploma aimed at supporting staff, particularly those who come in from the professions, to supervise research projects.

Research Informed Teaching diploma at Nottingham Trent University (NTU)

NTU have introduced a Postgraduate Diploma 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.

Further information: <http://www.educaedu.co.uk/pgdip-research-informed-teaching-postgraduate-28250.html>

Strategy 18: Provide support to academic staff with regard to professional development so that they are encouraged to become engaged in undergraduate research and inquiry

Teaching certificates and diplomas in higher education are primarily aimed at new academics in UK and Australasia. For other academics, and for new faculty in North America, various forms of professional development, such as workshops and curriculum development support, may be provided by educational developers to inform, inspire and support staff to engage with undergraduate research and inquiry. Sometimes these sessions may be run by external academic developers (for example, the authors of this paper frequently run workshops on this topic in universities around the world); other times, academic staff may be sent on courses and conferences run by professional bodies, such as the Council on Undergraduate Research; and sometimes the support is provided internally (e.g. Spronken-Smith and Harland, 2009). A major source of professional support for lecturers in England is provided by the Centres for Excellence in Teaching and Learning, seven of which are particularly focused on undergraduate research and inquiry.

Seven Centres for Excellence in Teaching and Learning (CETLs) in England support undergraduate research and inquiry

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

1. Sheffield Hallam University, the Centre for Promoting Learner Autonomy (extra.shu.ac.uk/cetl/home.html).
2. University of Gloucestershire, the Centre for Active Learning (resources.glos.ac.uk/ceal/).
3. University of Manchester, Centre for Excellence in Enquiry-Based Learning (www.manchester.ac.uk/ceebl).
4. University of Reading, Centre for Excellence in Teaching & Learning in Applied Undergraduate Research Skills (www.reading.ac.uk/cetl-aurs/).
5. University of Sheffield, Centre for Inquiry-based Learning in the Arts and Social Sciences (CILASS) (www.shef.ac.uk/cilass/).
6. University of Surrey, Surrey Centre for Excellence in Professional Training and Education (SCEPTre) (www.surrey.ac.uk/sceptre/).
7. Universities of Warwick and Oxford Brookes, the Reinvention Centre for Undergraduate Research (www2.warwick.ac.uk/fac/soc/sociology/research/cetl/).

Further information: www.hefce.ac.uk/cetl

Strategy 19: Provide incentives and rewards for academic staff to support undergraduate research and inquiry, particularly through workload planning, institutional and departmental recruitment, criteria for appointment, performance review and promotion processes

Supporting academic staff involved with undergraduate research and inquiry is a good way of developing links between research and teaching. However, the reward system of most universities tends to treat these two areas separately. If Human Resource (HR) policies are to be aligned with policies to promote undergraduate research and inquiry, it is important that engagement in this area is recognised for workload planning purposes; for example, mentoring and supervising is counted when the students are undergraduates as well as graduates. HR policies also need include undergraduate research explicitly in performance review, merit pay and promotion processes. Including the expectation of involvement with undergraduate research in adverts for academic posts is one way of explicitly identifying the activity; encouraging research staff to engage with undergraduates is another. At the University of Queensland research staff are funded through central institutional funds to undertake teaching for up to a quarter of their time.

Research staff are funded to engage in teaching at the University of Queensland, Australia

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

- expose students to key researchers, who hopefully can convey the excitement of their field;
- improve the student to 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.”

Further information: www.uq.edu.au/teaching-learning/index.html?page=92623&pid=0; Correspondence with Deborah Terry, 30 Oct 2008

Vice Chancellor Award Medal for Teaching and Research Integration at University of Technology Sydney, Australia

As one of seven annual Vice Chancellor Awards for Research Excellence, this award recognises researcher(s) for the successful integration of research and teaching and learning as outlined in the UTS Strategic Plan. Nominations should address:

- Integration into the curricula – Demonstrate how research methods or outcomes have become embedded in subject/course and learning provision at UTS.
- Excellence in design and innovation in course design – Describe the methods used to apply the research methods/outcomes in the curricula and how they support key learning areas in the discipline.
- Student impact – Describe the benefit, or potential benefits, for students as a result of the influence of this research in teaching practices i.e. improved graduate attributes for their specific industry or workplace.

Further information: <http://www.research.uts.edu.au/awards/categories.html#teach>

Table 1: The Connected Curriculum in 20 Questions: Key questions for departments and programme teams

Core principle: Students learn through research and enquiry

1. Are students encountering specific questions addressed by researchers and learning to articulate their own research questions, at every level of study?
2. Can we adjust our teaching methods, student assessments and other aspects of departmental practice to prioritise engaging all students actively in research and critical enquiry?

Dimension 1: Students connect with researchers and with the institution's research

3. Do students have regular opportunities to learn about the institution's research and other current research relevant to their studies?
4. Are students meeting with researchers and engaging with their work, for example through group activities such as 'Meet the Researcher'?
5. Are students exploring the intellectual, policy- related, practical and ethical challenges associated with current research, and recognising their relevance to professional life more widely?

Dimension 2: A throughline of research activity is built into each programme

6. Is there a well designed core sequence of modules, units and/ or learning activities through which students steadily build their research skills and understandings, and is this explicit to students?
7. Are students explicitly challenged to make intellectual connections between different elements of their programme?
8. Can students have some flexibility and even take risks with their research-related activities, for example by working towards a Showcase Portfolio for which they can curate their best work?

Dimension 3: Students make connections across disciplines and out to the world

9. Is the programme of study structured so that students need to step outside their home discipline(s) and see through at least one other disciplinary lens?
10. Are students required to make explicit connections between disciplinary perspectives, for example by collaborating with students of other disciplines to analyse evidence and issues?
11. Through making interdisciplinary connections, are students challenged to address complex global challenges?

Dimension 4: Students connect academic learning with workplace learning

12. Are all students on the programme(s) able to analyse the ways in which their academic learning is relevant to the world of work?
13. Do students have explicit opportunities to prepare for the workplace, for example through meeting alumni, shadowing and work placements and, where appropriate, through critiquing the notions of work and professionalism in society?
14. Can students articulate effectively the skills and knowledge they have developed through their research-related activities and through their wider studies and experiences, and showcase these to future employers?

Dimension 5: Students learn to produce outputs – assessments directed at an audience

15. Are some student assessments outward-facing, directed at an audience, thereby enabling them to connect with local and/or wider communities (whether online or face-to-face)?
16. Are student assessments across the programme suitably varied, enabling them to develop a range of skills including expertise in digital practices and communications?
17. Are students required to revisit and use feedback on their tasks, both formative and summative, in order to improve their work?

Dimension 6: Students connect with each other, across phases and with alumni

18. Do students have frequent opportunities to meet and participate in collaborative enquiry with one another in diverse groups?
19. Are they building connections with students in other year groups, for example through events or mentoring schemes?
20. Can students meet and learn from diverse alumni and build a strong sense of belonging to an inclusive research and learning community?

Source: Fung (2017, pp.146-147)