The Use of ICT in Education for Research and Development

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Introduction

The Technology-Enhanced Learning in Research-Led Institutions (TELRI) project was established at the Universities of Warwick and Oxford, funded by a Teaching and Learning Technology Project (TLTP) award from the Higher Education Funding Council for England (HEFCE). The project proposal sought to tackle two inter-related issues. The first is that in many universities the two main activities of research and teaching are not closely linked, and the former has higher status than the latter. The second is that the wider availability of powerful ICT tools brings with it the need to make sure that the tools are used in ways that best support students' learning. The project's proposers aimed to tackle both of these issues by assisting academic staff to develop research-based approaches to teaching, through the effective use of learning technologies.

The team was aware of the intense debate about supposed links between research and teaching, and aware also that, despite the generally inconclusive research evidence (see Hattie and Marsh, 1996 for a meta-analysis of 58 studies), a belief that research informs teaching persists. The team believed that research and teaching could beneficially be linked, with one enriching the other, if this was planned for. The alternative situation, in which students receive no direct benefit from lecturers' research, whilst academics feel pulled between two competing demands for their time, is obviously undesirable. Although the improvements in students' learning that the project sought to bring about do not require a research-led environment, it was believed that certain environments, of which research-led institutions are an example, offered particular opportunities for bringing research and teaching together in a productive relationship. The point was trenchantly made in the USA by the Boyer Commission report that criticised research-led universities for failing to make use of their natural advantages and urging that research and teaching should be brought closer together (Boyer Commission, 1996).

Several possible forms of linkage between research and teaching were identified. The **content** argument supposes that researchers can bring their own leading edge research into the curriculum, although it is also widely suggested that this can be problematic, particularly in the sciences (Feldman, 1987). Others, more pragmatically, take a **resources** approach, pointing out that research brings better libraries, better research tools and higher levels of resourcing generally. A third main area is in **learning processes**, since undergraduates and researchers are both engaged in learning.

In considering the potential value of ICT in these forms of linkage, the project proposers could see the usefulness of supporting staff to make more and earlier use of research tools, many of which are, of course, technology-based. Certainly the early

introduction of research tools – for simulations and textual analysis for example - offers another large area for development. However, the area of learning processes was thought to be a much more valuable – and challenging – area to work in, since it addresses such a central educational issue.

The focus of the TELRI project was therefore on what, ideally, researchers and undergraduates share - a culture of personal inquiry, the process of inquiry and learning (Light, 1999). It is reasonable to suppose that experienced researchers and others who apply a discipline professionally will have developed a range of higher level cognitive skills. Their intellectual processes and methods of working provide a useful model for their students' own learning. It would be of immense benefit to students if they could be helped to develop those skills through an appropriately delivered curriculum, so that the skills would then be available for further work both in the discipline and in other fields. The TELRI team was not claiming to have discovered a new idea. Clearly in all disciplines there are many existing examples of research and student learning being linked in this way. However, it was believed that without careful planning the benefits of academics' research expertise would not be fully realised. TELRI could be a prompt to thought and a source of guidance on appropriate tools and their use.

What are research capabilities?

Attempting to link research and teaching immediately suggests problems of the definition of those terms (Elton, 1986) and these may be discipline-related (Hattie and Marsh, 1996). However, across all disciplines one would expect a number of broad capabilities of a proficient researcher, including:

- being innovative
- working independently
- setting and solving problems
- analysing critically
- handling large quantities of information in a wide range of media

What these might mean in practice would clearly be very different from one discipline to another. Nevertheless they seem to be a reasonably robust set of terms which academic staff in any discipline would agree were desirable attributes, and this probably explains their repeated appearance in published lists of skills from many sources.

These capabilities require the presence of:

- a body of disciplinary knowledge
- techniques used within the discipline
- higher order cognitive skills

A focus on higher order cognitive skills

TELRI sought to identify and develop those aspects of expertise that have widest applicability within and beyond the discipline. For this reason the team's interest was at two levels: the broad research capabilities listed above and, more fundamentally, the cognitive skills that inform them. It was believed that, whilst disciplinary knowledge and techniques are vital and must be taken into consideration, they did not need reinforcement through the work of the project, since they are self-evidently important and are explicitly taught. In contrast, cognitive skills are rarely developed explicitly. The TELRI team therefore chose to focus on higher order cognitive skills. These skills include the abilities to:

- make meaning, by interpreting information, forming and applying concepts and principles, critical analysis, synthesis into coherent wholes,
- generate ideas, using innovative thought, creativity
- take decisions, using procedures, algorithms, strategies, heuristics and judgements about applicability
- reflect on own purposes and processes, including justifications for judgements and decisions, possibilities of transferability

Crucially for this discussion, the project team identified two essentially complimentary and mutually supportive learning methods. The first of them, adoptive learning, is a reproductive process and occurs when a situation has already been defined. It requires the application of well-understood knowledge, techniques and procedures. Adoptive learning is very useful: a great deal of any person's learning will be adoptive. However, there may be difficulties in transferability to new situations. Adaptive learning, on the other hand, is a generative process in which originality and creativity are involved and which requires higher cognitive skills. An accomplished researcher will be skilled in adaptive learning and potentially may be well placed to help others to develop similar expertise.

The importance of transfer

There has been much debate about the importance of skills – termed variously core, key and transferable skills. Throughout the discussion there is a concern to identify those central capabilities that are of use in many areas of life, whether vocational or otherwise, and to ensure that curricula enable students to develop them. Cognitive skills, it might be argued, are vitally important in transfer because they are not as context-dependent as other abilities and because they are themselves used to effect the transfer. Because of this they have been termed "skills of transfer" (Bridges, 1994).

Much discussion of skills is conceptually thin, as has been pointed out (Hyland, 1994) and there is an interesting tension between the clearly vocational drive of much skills development work and the fact that it restates what many have taken to be higher education's "traditional ideas of autonomy and breadth" (Barnett, 1994). However, as Barnett also points out, higher education has not always been particularly attentive to this mission, and has certainly not been in the habit of articulating its purposes.

The project's proposers saw the opportunity of using the project to encourage academic staff to pause and to analyse their teaching purposes in terms of the capabilities they were intending to develop, and the processes (rather than content) that would be likely to being these capabilities about. They saw the link with research as a strong motivator to engage with this really rather challenging area. Further, they sought at that point to invite staff to consider the ICT tools that were available to them and to consider which of them might be useful in developing those capabilities and how the tools could best be employed.

What this means for the curriculum

A curriculum should develop not only disciplinary knowledge and techniques but also the higher level cognitive skills that are essential for their development and use. The potential for the latter may be maximised if the curriculum is designed to provide appropriate course processes and assessment approaches that emulate the research environment.

The following were considered to be useful guides for the design of a curriculum to encourage the development of broad research capabilities and of cognitive skills:

- Activities should prompt the concentrated development and use of cognitive skills.

- Expertness, as distinct from competence, derives from the capacity to engage in novel thinking in complex and uncertain situations.
  Therefore:
  - Students should be encouraged to set as well as solve problems.
  - Open tasks are better than closed tasks
  - Problem-based learning is more beneficial if the student has a part in defining the problem.

- Students should he encouraged to reflect on their learning processes.

Assessment is of central importance. Assignments that require the presentation of well-established knowledge are adoptive in nature and will encourage students to take an adoptive approach to their learning. Instead, assignments should require more than a procedural or learned response. They should require judgements of value, likelihood and probability, together with innovation and creativity.

Reflection is also very important, since it is by reflecting on work in progress and learning to make judgements about its quality that students will gain insights into the natured of expertise in the field.

Again, there is nothing novel in TELRI approaches, which borrow from ideas about autonomy in learning (Boud, 1988), the creation of form (Kuhn, 1981), "deep" and "surface" learning (Marton and Saljo, 1976), transformative learning (Mezirow, 1997) and competence and expertise (Dreyfus and Dreyfus, 1986). The strength of the

TELRI approach is believed to be that it bases its work on the research expertise of academics and that it encourages a more thoughtful use of ICT tools within that context.

What learning technologies can contribute

It is easy to find examples of the use of learning technologies to make research tools, data and information available, thus contributing to students' disciplinary knowledge and techniques. However, learning technologies are less often used deliberately to develop higher cognitive skills, although they have considerable potential to do so. The Boyer Commission report makes this point strongly, asking for ICT that "enriches teaching rather than substitutes for it", and wanting students to have tools "with which they can discriminate, analyse and create rather than simply accumulate" (Boyer Commission, 1996).

There are many possible contributions. Creativity and originality are highly valued in researchers. Both are difficult to define, but it can safely be said that those who work in open situations, with the greatest autonomy, who are required to identify and set as well as solve problems, are most likely to be encouraged to be creative because of what they are required to bring to the situation themselves. Therefore TELRI was concerned with the integration of C&IT tools to support learning that takes place in "open" settings.

Researchers characteristically deal with large amounts of complex information, and require the skills of analysis, the ability to make and discern structure. Therefore ICT tools that require learners to give meaning and value to information are particularly useful. Research requires considerable precision. ICT tools that demand a high degree of focus, particularly on meaning, are therefore valuable. Finally, the ability critically to reflect on working processes is vital, and so tools that make apparent the processes of learning are useful. All of these tools are more effective when they offer immediate feedback to the learner. These links may be summarised thus:

Desired research capability	*What ICT should offer*
Ability to be original, creative, innovative	Tools that present and offer resources for open situations
Ability to deal with complexity	Tools that support the learner in evaluating, analysing, selecting and structuring
Ability to work with precision	Tools that permit a high degree of focus on a particular skill
Ability to reflect on working processes	Tools that make working purpose and processes transparent
Ability to form justified discipline-based judgements	Tools that enable discussion of reasoning, judgements and decisions

What this means across the disciplines

Discussion and debate enable the exploration of ideas and generation of meaning and are central to the development of research capabilities in the arts and humanities. ICT tools may assist these processes by making it possible to improve the amount and timeliness of tutorial support, particularly as group sizes increase. Where they enable students to submit, to view and to comment on their own and others' work, they may help them to develop skills of critical analysis, to explore matters of form and style and to learn from seeing – and perhaps participating collaboratively in - work in progress. Modern languages tutors have found web publishing particularly useful in moving beyond basic skill acquisition and into critical thinking and understanding of related issues.

Discussion is equally important in the social sciences, where students must gather, evaluate and present evidence and construct arguments. The application and testing of theories and concepts is also central. Tutorial and small group work are very important in development of students' capabilities and, once again, ICT tools can offer the opportunity of more effective support. Case studies are very commonly used throughout the social sciences. ICT tools may enable the sharing of scarce case study material and offer access to "real" primary source materials that are more akin to the materials used by researchers. Indeed the work of researchers – including that of the tutor – may be more readily made available.

In the sciences, curricula may develop problem solving and reasoning skills. Activities may require that students identify, evaluate and make use of sources of data, employing a range of methods to reach reasoned conclusions and solve problems. Problems classes are a staple item in many science curricula, where prompt feedback is vital is learning is to be effective. Once again the potentially collaborative nature of ICT-based working can be useful, mirroring the ways in which scientists customarily work.

Choosing tools

TELRI approaches do not require the use of particular software. What is important is the nature of the task and the assessment that is designed: the tool is incidental. Any virtual learning environment that enables the sharing of documents and discussion – WebCT, Learning Space or COSE - may be used as a means of structuring case studies and encouraging student-student and staff-student interaction. Conferencing software such as FirstClass or WebBoard might also be appropriate.

Web publishing was seen to be particularly useful as a means of enabling students to see and contribute to work in progress and to evaluate it, thus offering them insights into approaches to and criteria for assessment. Early on in the project it was realised that many academic staff did not have ready access to the tools that were needed, so a simple web publishing tool was designed that enabled students to publish to the web and to comment on others' work. The tool is simple to use and free and has, therefore,

been very attractive to staff who wanted to work in this way without a requirement that either they or their students should develop sophisticated web publishing skills.

Support for staff

Working with TELRI did not necessarily mean changing one's educational purposes or, necessarily, one's approaches to teaching and assessing. The team offered a process of curriculum review (Roach, Blackmore and Dempster, 1999) that was intended to assist in translating the course's purpose into a transparent form. The process supports staff in being more analytical about what they are seeking to achieve through their teaching and more deliberate about how they set about it, making use of educational technologies where they can provide a clear benefit. The process includes clarification of the capabilities and cognitive skills that are to be the focus of attention; a review of existing approaches; development, in conjunction with the staff involved, of appropriate approaches to teaching and assessment; and the establishment and use of a means of evaluating the effectiveness of the intervention.

TELRI has employed this approach to support staff in thirteen departments within the universities of Warwick and Oxford in implementing technology-enhanced learning. The team produced case studies detailing the context, the technological tool and the capabilities and skills developed. A second phase extended the approach to further departments in several other research-led universities, including Durham, Birmingham and Southampton. A third phase provided staff development workshops and consultancy across the HE sector.

Conclusions

The work described here offers a means of bringing together research and teaching, by focusing on the process of learning, which is common to both. Part of the purpose is to ensure that research is not seen as an activity remote from other forms of learning. There are a number of potential benefits for, as has already been suggested, we believe that learners may thus become more capable in a range of activities in later life – including research. We believe also that academic staff find this linking of the two activities to be stimulating.

It is believed that making use of ICT tools to make links between research and student learning makes good sense. The substantial investment made in ICT in higher education, and the increasing use of ICT tools in undergraduate curricula make it vital that we are able to analyse the costs and benefits. If ICT tools are used unreflectively, delivering packaged learning to passive recipients, higher education may be considerably damaged. However, if ICT can be a means of engaging more closely with the development of those capabilities and cognitive skills that have traditionally been the concern of higher education, even though they have not always been articulated, the benefits will be immense.

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