Using electronic tools to support a large development and research project: a case study

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In this paper we describe how the 'Learning How to Learn' project of the ESRC Teaching and Learning Research Programme has employed a range of electronic tools to enable communication, collaboration, and project management. Underpinning these developments has been a commitment to what we term 'responsive' design of software, in which project needs are continually re-evaluated and electronic tools and environments adapted in response. A set of consistently applied principles has allowed evolving ‘use-cases’ to be addressed. We describe some of the themes and issues which emerged in the course of the project's developing relationship with new technologies. These have proved successful and have been more widely applied across other education research projects in the Teaching and Learning Research Programme.

Keywords: Research Design, Project Management, Dissemination And Impact, Information Technology

Introduction: The Learning How to Learn Project

‘Learning How to Learn – in classrooms, schools and networks’ was a four year (2001-2005) development and research project\textsuperscript{2} within the ESRC Teaching and Learning Research Programme (TLRP). It sought to develop understandings of the organizational conditions of schools, and across networks, in which teachers are successful in developing pupils' knowledge and practices in learning and in learning how to learn through assessment for learning. This reflected our aspiration to bring insights from classroom-level and school-level research into closer alignment with one another. James et al. (2003) argue that such alignment offers our best chance of furthering understanding of effective learning, its nature, the teaching practices that promote it, and the kinds of professional learning and institutional conditions that help teachers to adopt new practices. These avenues of investigation constitute an enormous range of inquiry and, since earlier reviews of research (Black and Wiliam, 1998) indicate a 'poverty of practice', there was a perceived need to stimulate and support innovation through development. For these reasons, it was necessary to bring together a large team of

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\textsuperscript{2} The Project (ref: L139 25 1020) was directed by Mary James (University of Cambridge until December 2004, then at the Institute of Education, University of London) and co-directed, from 2002, by Robert McCormick (Open University). Other members of the research team were Patrick Carmichael, Mary-Jane Drummond, John MacBeath, David Pedder, Richard Procter and Sue Swaffield (University of Cambridge), Paul Black and Bethan Marshall (King’s College London), Leslie Honour (University of Reading) and Alison Fox (Open University). Past members of the team were Geoff Southworth, University of Reading (until March 2002), Colin Conner and David Frost, University of Cambridge (until April 2003 and April 2004 respectively) and Dylan Wiliam and Joanna Swann, King’s College London (until August 2003 and January 2005 respectively). Carmel Casey-Morley and Nichola Daily were project administrators. Further details are available at \url{http://www.learntolearn.ac.uk}.
academics and researchers with different areas of substantive and methodological expertise and willingness to take on a variety of roles.

Previous research on assessment for learning had been relatively small scale, so another area of interest was to investigate the sustainability of innovations, which were developed in authentic settings with modest levels of support, as they were adapted and spread across teachers and schools. This required the team to recruit a sizeable sample of schools and to work in partnership with head teachers, school co-ordinators, ‘focal’ teachers who were identified for detailed study, and Local Education Authority (LEA) advisers. By the time of its conclusion, the project had involved 17 academics and researchers from five HEIs and 40 infants, primary and secondary schools in five LEAs and one Virtual Education Action Zone. The project was also supported by an Advisory Group, mainly of representatives of ‘user’ groups. This number and range of participants, and the scope and locations of project activities, presented the project team with a number of challenges, not least the need to develop and maintain internal and external communications for various purposes.

Not only was it important to ensure that team members was aware of project progress in all its dimensions, in order to avoid fragmentation, omission and duplication of effort, but the highly integrated design required that different researchers in different sites for different purposes would need access to a centralised ‘data pool’. Alongside these internal requirements there were also the usual demands for information about the project, and its outputs, from external audiences. The project team never underestimated the value of face-to-face contact in distributed teams in order to develop both intellectual and social capital (see James, 2006) so monthly whole team meetings, twice yearly advisory group meetings and regular sub-group meetings were the norm. As time progressed so dissemination talks to potential ‘user’ groups also increased. However, the sheer number of communications and the quantity of the data meant that this was a prime case for use of electronic tools. Moreover, the fact that the project had a substantive interest in researching networks, including electronic networks, had ensured that it had built relevant expertise into project planning. This enabled us to exploit these resources both to study school networks and to create the electronic tools to support our own project network. What follows is an account of how these tools were developed and used, responsively, as the project progressed.

The Project Website

The most obvious of the electronic tools used by the project is the extensive website at http://www.learntolearn.ac.uk which has evolved over the life of the project to fulfil a number of roles including:

- the provision of information about the nature and scope of the project to both participants and the wider public;
- provision of classroom and staff development materials for use by LEA and school coordinators involved in the project;
- data collection, storage and analysis
- provision of project management and data analysis tools for use by the research team;
- sharing exemplification of developing practice in classroom assessment.

Central to these roles is an innovative content management system that builds web pages and other types of outputs from data components held on a web server: a typical page viewed by a user might actually represent
many small components embedded in a template. These components represent the basic units of communication within the project; the largest are characteristically documents constructed in other applications (such as Microsoft Word documents and PowerPoint presentations) with the smallest being single bibliographical references, dates and times or email addresses.

The use of the website and associated tools to address a range of project needs has increasingly led to a view of electronic networks not simply as a means of information dissemination but rather as an environment across which data, analytical tools and users are distributed. The purpose of the electronic tools we have used and developed, then, was first to replicate the existing patterns of interaction required by the day-today practicalities of the project and demanded by the research design (James, Pedder, Black, Wiliam and McCormick, 2003, 2006) but also to enable and encourage new patterns of interaction within the developing research community. In this respect it closely resembles the relationship between technology and community described by Verwijs et al. (2002; p. 60-61) in which they argue that while initially at least “technology support should match the primary activities of the community, its size, goals, and the preferences of community members”, the availability of new technologies “may inspire [community members] to explore new interaction styles, thus improving the performance or efficiency of the community”. As the project has come towards the end of its funding period, the commitment to ‘leave something behind’ has been manifest in the publication on the website of research instruments, development activities and other supporting materials for use by a wider audience. This integrates the website with a handbook for teachers (James et al., 2006a forthcoming).

While the project website is the most obvious public expression of the project's commitment to use electronic tools, the focus of this article is the process by which it evolved as the project progressed. This itself is a reflection of the iterative, participatory approaches employed across the project as a whole.

**Participatory and Responsive Design**

The Learning how to Learn project team was made up of members from first three, later four and finally five different universities, some were very experienced researchers with records of participation in many major projects; for others this was their first opportunity to work in a multi-site, multi-disciplinary environment. Levels of expertise and engagement with electronic tools varied widely across the team and were largely independent of other experience of involvement in education research activities (see Procter, 2004, for further details). Amongst the team, however, were several individuals (including the authors) with experience in software design. Prior to joining the project Carmichael had been working on software development within participatory research projects in the NGO sector, and Procter was completing a Master's degree in IT and Education in the course of which they had been developing web applications and other software.

The presence of members with experience both of education research and of software development allowed the development of electronic tools that were responsive to project needs and – in some cases – contributed positively to project management, to communication between project participants and to user engagement and impact. As the project developed, new ‘use cases’ (see Carmichael, 2003, for a discussion of the role of ‘use case analysis’ in the development of educational software) became apparent; initial needs to publicize the project and to disseminate project materials to participating schools gave way to needs to support the collection and analysis of data. Latterly the need to securely archive project data and other resources, and to maximize the reach and impact of the project beyond the initial participants have become priorities.
Participatory approaches are now becoming widespread in software design (Gottesdiener, 2002). Our central roles in the project, and our involvement in the full range of project activity (rather than, for example, being employed to develop software on a consultancy or contract basis) allowed a much closer association between the project design and its realization, on the one hand, and our development of software to support it. Rather than working to develop software in response to a specification document or from a project plan, we were party to and frequently involved in the discussions that generated them; when we encountered problems or decisions had to be made, we were able to consult project members, either individually or collectively. As the role of electronic tools became more central to the project, they – and the process by which they had been developed - were also subject to the scrutiny of the project’s advisory group. This combination of iteration, flexibility and accountability goes further than most participatory design processes and allowed us to develop a process of what we now characterize as ‘responsive design’ – responsive not only to immediate needs of the ‘users’ but also to their often domain-specific concerns, approaches and theoretical frameworks.

Our Design Principles

Underpinning our approaches - and borrowing from prior work as mentioned previously – were a number of design principles which allowed us to respond to specific and in some cases very detailed demands and specifications. Without going into too much technical detail we will outline these, together with the rationale for their adoption and some of the benefits they have brought in the course of our project work.

**Design Principle 1: Small is Beautiful**

In short, small components can be assembled in lots of interesting ways, some of which may not have thought of when project team members, or someone else, (a) first created them or (b) first started assembling them. From the outset, we recognized that managing the data resources of the project would involve a great many small elements, so a key task was trying to identify what these might be. Some are familiar: the personal profile of each participant; the contact details for a school or university; the bibliographical entry for a single publication; and so on. What was more difficult was breaking down into meaningful ‘chunks’ more complex items. When we wanted to collect diary entries from participants, did it make more sense to store the whole diary as a single entity, or to subdivide it into weekly sections or individual entries? In many cases a fine balance had to be struck between maintaining meaningful units of analysis and allowing small components to be rearranged in new ways. This dilemma will be familiar to anyone who has undertaken computer-based qualitative data analysis, where a major concern is how to filter, sort and rearrange text excerpts while retaining some oversight of their broader context.

This componentisation was achieved through the use of Extensible Markup Language (XML) and Resource Description Framework (RDF) (Miller, 1998). The use of these technologies gave us the ability to describe each of the parts of the research project in their smallest possible components. Thus with the information about a research project divided into its smallest descriptive components, software tools can be developed to organize, arrange, sort, search and display these components in a number of different ways. For this to be fully realized, we had to adhere to a second design principle.

**Design Principle 2: Embedded Markup Considered Harmful**

The rigorous separation of data from metadata (descriptive information about the data) and structural and formatting information allows data to be combined and presented in a wide variety of forms. In many
conventional websites the content and formatting information are inextricably linked within the same files. There have been many arguments advanced for their separation (see for example, Nelson, 1997) but in most cases these are related to ease of maintenance and data exchange. In our case, however, the flexibility gained by adherence to this design principle allowed us to address the evolving needs of the project, developing management and user engagement tools in parallel.

For example, the individual user diary entries mentioned above could be incorporated into individual diaries, per-school reports or cross-project reviews. The same data and metadata were presented through alternative ‘templates’, which altered the structure and formatting with which they were presented to users. What appeared to be whole new sets of functions, or significant changes within the website, were, in fact, relatively quick and simple to achieve.

**Design Principle 3: Reduce, Reuse, Recycle**

One of the enduring problems of the World Wide Web is the storage of a great deal of redundant information. So, for example, an individual may have a home page, a ‘departmental profile’, any number of ‘project pages’ and countless references on other web pages. One of our intentions (‘reduction’) was to avoid further duplication of information, and wherever possible to point to existing resources. This was the reason for our adoption of Resource Definition Format (RDF), as this is an XML specification from the World Wide Web Consortium (W3C) designed to allow the expression of relationships between resources themselves identified by URI’s (Uniform Resource Identifiers). So, for example, once we have completed this paper and lodged it in the TLRP Digital Repository, an RDF record of the its relationships would take the form:

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[This Paper’s URI] \rightarrow [authored by] \rightarrow [Richard Procter’s Home Page URI]
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In fact, the relationships (such as 'authored by') are themselves expressed as URI’s: bibliographical information is commonly expressed using the Dublin Core vocabulary and the Common European Research Interchange Format (CERIF) provides a range of useful descriptors for project roles, outcomes and management functions. So, in fact, the database could hold an authoritative set of relationship information linking publications, individuals, projects, organisational affiliations and other data. This strategy not only encourages reuse, but also reduction in the data related to this particular resource. If the author wished to have a list of publications on their personal web page, it would simply have to link to the URI of the digital repository, from which it would collect publication details, abstract and other data.

We also applied the principles of reuse and recycling to elements of program code. Once we had established a range of core functions (‘find everything about this resource’, ‘find me all the resources related to X’, ‘sort all X according to Y’) we found that these could be reused across the project website. Our use of modular programming architecture (with programs being assembled from small units) allowed this, as did our use of ‘Open Source’ software, principally the Perl programming language. Perl users have access to the Comprehensive Perl Archive Network (CPAN) where members of the Perl community share their work with the rest of the community in the form of Perl “modules”. We have made considerable use of Perl modules for data handling and storage, text processing, sorting and searching, and program development; the availability

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3 http://www.w3c.org
4 http://www.dublincore.org
5 http://www.cordis.lu/cerif
6 http://www.perl.com
7 http://www.cpan.org
of these tools has reduced development time by a huge extent. The reusable software tools we have developed from scratch and using CPAN modules have had applications across the Teaching and Learning Research Programme (beyond the Learning How to Learn project) and our ultimate intention is to ‘give back’ some of the tools we have developed to the wider community through open-source releases.

Design Principle 4: Conformance with International Standards

Throughout our development work we have adhered to standards established by the World Wide Web Consortium. The W3C develops standards not only for ‘browser conformance’ and website accessibility but also for data interchange (RDF is a W3C Standard). The use of other standards such as that developed by the Open Archive Initiative (OAI) (Tansley et al., 2003) also allow the exposure of metadata so that they may be ‘harvested’ by web crawling ‘robots’ or through other interfaces. This conformance means that not only are our applications capable of accessing other resources, but also that the data and metadata we generate can, where appropriate, be made accessible to a wider (even global) audience. This clearly has implications for research projects wishing to engage with the widest possible audience (see Carmichael and Procter (2004) for further details of this aspect of our software development work in the context of the Teaching and Learning Research Programme as a whole).

Responsive Design in Action

The ‘responsive’ approach and the principles outlined above allowed us to address (or at least raise) a range of further issues relating not only to technical support but also to project concerns more generally. With the underpinning principles in place, we found it easier to address the ‘use-cases’ which the users of the website raised; they were not a substitute for involving project team members, but rather provided a basis upon which we could plan responses to (sometimes surprising) requests and suggestions. As project members themselves became more familiar with the principles underpinning our designs, they couched their requests in terms of rearranging components or providing different ‘views' of them.

In retrospect, we were surprised by the extent to which the approaches we developed were not just useful in terms of rapid software development but also became a focus for project-wide discussions that took place and threw some aspects of project design into high relief. Asking what seemed like a straightforward question relating to website content (“Where should this go?” “Who should be allowed to see this?” “What is the relationship between X and Y?”) was often the starting point for broader discussions about project roles and responsibilities, user engagement, collaboration and analysis. The following are some examples of these broader issues to which we had to ‘respond’ and where the associated discourse had wider benefits across the project.

Communication within the Project

One of the key expectations was the engagement of key staff in participating schools both with and in the ideas and development activities of the project. To this end, each school had an assigned member of the HE-based team whose role was to provide ‘critical friendship’ (Stenhouse, 1975; Costa and Kallick, 1993). This meant that we as a project we needed to develop strategies to support a triangular relationship involving project researchers, critical friends and school-based participants.

Our response to this was to develop a web-based ‘log’ to which school and Local Education Authority coordinators within the project and Project members based in Higher Education institutions could contribute
reports and reflections on the progress of the project in the settings in which they worked. This was initially conceived of as being an online equivalent to (and replacement for) paper or word-processed logs that would be completed as the project developed and which would intermittently be collected for analysis by researchers, but also aimed to provide a means by which feedback and advice could be provided to school-based participants. By reading through the logs before any meeting with a school coordinator, the critical friend would be prepared and ‘brought up to speed’ about school-based initiatives or research activities in that school, allowing coordination of the development and research aspects of the project.

In addition to providing data about the progress of the project, these were also designed to allow reflection and dialogue on the part of the participants. A set of management tools were also built so that any of the participants could gain a quick overview of progress to date (including which parts of the project intervention had taken place, what data had been collected and dates of future visits and meetings), and project managers could obtain an oversight of project progress across a whole Local Education Authority or across the project as a whole. For a complete account of the role of the logging tool and the data gathered using it, see Carmichael, Procter & Honour (2003).

The design of the logging tool reflected our design principles; log entries were stored as small components for aggregation (principle 1) which were devoid of any formatting information (principle 2). The log entries could be viewed individually, as part of a developing school record, or to help project managers maintain an overview of project progress as a whole. When data analysis began, the school logs could be output in formats suitable for qualitative data analysis using packages such as Atlas/ti (principle 3). Log entry data was stored using well-established standards such as vCalendar (for date information) and Dublin Core (for broader descriptive information) and web pages produced were W3C compliant, in accordance with principle 4.

Project Management and Informed Decision-Making

The collection and storage of small data and metadata components allowed their aggregation in novel ways, some of the most interesting of which related to project management issues and informed decision-making. For example, at the mid-point in the project, and in response to concerns about workload and sustainability, the project team needed to select approximately half of the schools for full data collection and as possible case-study sites. This selection process involved classifying schools according to the likelihood that we would be able to gather near-complete data sets from them, based both on their record of involvement up to that point, and the views of researchers and critical friends. We were able to rapidly adapt the school ‘log’ tool, but rather than using it to produce a web page per participating school, a large organizational chart (rather like a project-specific GANTT chart) was generated. This was then used – together with other data – to inform the selection process, James (2006b, forthcoming).

Access to Tacit Knowledge and Context

The website architecture we developed separated data (documents, datasets, diary entries etc) from metadata (descriptive and contextual information), and it was this metadata that provided much of the content of web pages within the site; a lack of metadata led to unappealing “no information about this resource” messages. This meant that when project members submitted content to the site, they could be prompted (within reason!) to provide some additional information; so for example, a document would be located in a set or sequence, related to other resources, or its relevance or provenance more fully explained. This also meant that when visitors to the web site conducted searches, they would find a greater range of relevant resources, as our search engine was able to search this descriptive text rather than simply file names.
Reflecting Concerns about Privacy and Confidentiality

The issue of ‘who’ should see ‘what’ on the Learning How to Learn website was initially conceived in terms of differential access for members of the project team, school-based participants and ‘the public’. It soon became apparent, however, that this did not provide sufficiently ‘fine grained’ distinctions between users, nor did it allow complex patterns of access to be expressed. A key example related to the level of access Local Education Authority representatives on the project would have to individual school records. Once this issue had been raised, a meeting of Local Education Authority staff and teacher members of the advisory group established a confidentiality framework. Our component-based approach allowed us to define (in the metadata of each component) who should see not whole data sets, but specific elements within them. This allowed the confidentiality framework to be applied almost immediately across the web site. In another development, a decision to publish a large set of project resources to schools other than those participating in the project was reflected on the website in a matter of minutes and without any large-scale reorganization.

Analysis and Archiving

As collection and analysis of data continued within the Learning How to Learn project, the need for secure data storage was also addressed through application of our design principles within the web site. Dialogue between researchers and developers continued as how best to structure, store and describe datasets, and particular requirements (such as the ability of researchers to retrieve data either by instrument or by research site) were addressed by our component-based approach. The definition of ‘component’ was also extended to include transcripts, analytical accounts and summaries; ‘code books’ and ‘heuristic units’ for qualitative data analysis, images, quantitative data files and bibliographic references, as diverse data were uploaded to the website. This now extends to over 800 resources each of which is, where appropriate, accompanied by a descriptive metadata file. The facility to output selected (or complete) data sets for archiving at other sites such as the Economic and Social Data Service\(^8\) is also available.

Further Technical Developments

A number of the approaches we have used and tools we have developed clearly had currency beyond the specific project in which we were involved. The Teaching and Learning Research Programme as a whole, other projects within it, and the education research sector as a whole have many of the same concerns, such as inter- and intra-project communication, archiving, user engagement, sustainability (highlighted in Dyson and Desforges, 2002; and McINTyre & McINTyre, 2000). As of 2003, our brief was extended to cover the development of tools for use across the Teaching and Learning Research Programme, including the enhancement and extension of the programme’s web site and community tools (Carmichael & Procter, 2004).

At this level, our responsive design approach is probably best exemplified by the extended use of the D-Space digital repository. 'D-Space' is a digital repository platform developed jointly by MIT Libraries and Hewlett-Packard (Smith et. al, 2003); a D-Space repository may contain a range of digital materials including text, images and video and audio, which are described during a structured ‘ingress’ process. Each item can be described in terms of its author, originating project, format and type, relevant educational sectors and on keywords from an established vocabulary. D-Space provides a number of ways to gain access to the assets within its repository: the standard web interface that comes with the D-Space package allows users to search the archive by a free text search and to browse the repository by authors, titles and date.

\(^8\) http://www.esds.ac.uk
In order to increase the reach and impact of the D-Space repository, we worked with the TLRP directors' team to establish a number of use cases. In the realisation of these, we employed our design principles once again, even though in this case we were working with a pre-existing resource. D-Space provides an Open Archive Initiative (OAI) interface (Tansley et. al, 2003), which generates a data stream containing the metadata of each item in the repository or in a ‘collection’ within it (as long as this is designed to be discoverable and machine-readable). This also allows the metadata describing the contents of multiple archives to be ‘harvested’, aggregated and searched.

Two applications of the OAI interface to D-Space are particularly noteworthy. On the individual project pages on the programme website, a custom search returns details of all the current publications produced by that project. This list can then be returned to the user in a number of formats: as normal web pages, as 'EndNote' export files for use with bibliographical software or as 'raw' metadata format should they wish to import the records into a database of their own. More complex queries (searching on type and sector, for example) can be constructed for use on individual project websites. Additionally, small programmatic components (the queries themselves) have become reusable components, which may be embedded within users' web pages and reused across projects and the programme as a whole.

A second application of the D-Space repository is the generation of RSS ('Really Simple Syndication' or 'RDF Site Summary') 'news feeds'. These can be ‘syndicated’ by users with websites and ‘portals’ on which they wish to aggregate relevant content. The programme already generates ‘news feeds’ relating to programme news and project events, but the use of this technology to regularly updated information about project and programme publications represents a novel use of RSS to provide the kind of ‘contents alerting’ functions such as the SARA service already offered by publishers of journals. In both these instances, small, format-free components are being reused and presented in a variety of ways to maximize their impact and value to users (for a more complete discussion of these services see Carmichael and Procter, 2005).

**Better, though Difficult, the Right Way to Go?**

In its search for improvement in the rigour, accessibility and relevance of educational research, the TLRP, perhaps more than any other similar programme, has put emphasis on the authentic engagement of research users at every stage in the research process. Pollard (2002), the Programme Director, expresses the rationale for this in the following terms:

> ...we should aim to transform research knowledge into accessible forms, to present it in ways that enable users to appropriate it, and then to ‘give it away’. We cannot sustain it. It must become owned by others, promoted by others and, in due course, incorporated into the routine practices and common-sense thinking of others.

For that, we need partnerships and user engagement at every stage. In particular, projects should have strong user engagement in local sites of research to enhance relevance, authenticity and validity, combined with strong links and alliances with national organisations offering high-leverage systems of dissemination and mechanisms for maximising impact. (pp. 8-9)

And again:
Alongside the imperative of conducting robust research, we have to build social capital. This rests on developing relationships and networks, and on sharing perspectives and building alliances with present and future stake-holders. To do this effectively requires an organisational infrastructure - which we are beginning to construct. (Pollard, 2002, p. 10)

As James (2006 forthcoming) makes clear in the context of the Learning How to Learn Project, turning this ideal into reality is both challenging and time-consuming, and requires problem-solving capacity in situ and ‘on the hoof’, as it were. Although some eventualities can be planned for, others need to be responded to opportunistically. The best tools are those that can save time, promote order, allow creative response to the unexpected, enhance collaboration and access, and permit adaptation and flexible use. By creating electronic tools on the basis of the four design principles set out in this article, it was possible to contribute to the development of an organisational infrastructure, at the level of both project and programme, which has supported communication, collaboration and management. But the real beauty of the solution lies in its capacity to facilitate responses to needs and uses as yet unimagined.

References


