This paper was presented at the conference:

Oxford eResearch 2008

11-13 September 2008

University of Oxford

Conference website:
http://www.oii.ox.ac.uk/microsites/eresearch08/index.cfm

Conference papers collection:
http://ora.ouls.ox.ac.uk/objects/uuid%3A64aa6f39-7e81-4d42-a008-ee2d7524bd67

Conference organisers:

Oxford Internet Institute
University of Oxford
1 St Giles, Oxford OX1 3JS
http://www.oii.ox.ac.uk/
email: enquiries@oii.ox.ac.uk

Oxford e-Research Centre
University of Oxford
7 Keble Road, Oxford OX1 3QG
http://www.oerc.ox.ac.uk/

Using Technology to Enhance Research Practice: Analysing the use of ICT and e-science by academic researchers

Nick Pearce, Centre for e-science, Lancaster University

n.pearce@lancaster.ac.uk

Abstract. This paper will discusses the relationship between disciplinary differences and the adoption of a wide range of Information and Communication Technologies (ICTs) at a mid-sized, regional university at the end of 2007. Disciplinary differences have been shown to affect the adoption and use of ICTs across higher education, in e-learning, publication and collaborative writing. An analysis of US data from 1999 painted a more mixed picture of the effects of disciplinary differences on the use of e-mail and websites to communicate with students. The data presented here suggests that academic researchers use a wide variety of methods to communicate and collaborate with colleagues and that the choice of method varies significantly across faculty. In addition to this the use of wikis and blogs appears to be strongly related to the faculty in which a researcher is based. This might be due to substantially different cultural norms and values which might favour the adoption of one tool over another. The implications of this for the future adoption of e-infrastructure is discussed.

Keywords: ICT, Web 2.0., e-Science, e-Research, disciplinary differences

Introduction

Universities have been early adopters of key Information and Communication Technologies (ICTs) such as the desktop PC and internet but here has been a complex interdependent relationship between ICT and universities. The internet was initially sustained and developed through the involvement of the university sector, the World Wide Web was developed at CERN and many computing developments originated as university research. Similarly universities have used their early adoption of ICTs in order to prepare their students for an increasingly technological workplace.

Successive developments in ICTs have impacted upon academic practice since the first development of mainframe computers or the first incarnations of the internet. Word processors and e-mail have changed the nature of much employment and have eventually led to substantial productivity gains, although these took decades to take shape as the technological developments had to be accompanied by a social re-organization to maximise the benefits (David 1990; Brynjolfsson and Hitt 1998).

Since the 1980s similar revolutionary promises have been made about the impact of widespread adoption of ICT by academics and whilst there can be little doubt that academic practice has changed as a result of the adoption of the word processor and e-mail the extent of this change, and whether it constitutes a revolution are debatable.

Over the 1980s in particular the widespread adoption of individual workstations for staff and students promised to radically alter research and teaching, indeed some of the claims made in 1983 bear a striking resemblance to contemporary promises made of future e-infrastructure developments as these improvements would lead to:

> "1. Integrated methods for creating, accessing, filtering, synthesising, and manipulating information.
>
> 2. More efficient processes and tools for … research.
>
> 3. Enhanced group interactions with more sharing of work and more joint exploration of ideas" (cited in Shields 1995)

This is not necessarily surprising given the fundamental nature of academic work, but this does highlight the continuity in technological development in academia over time, and the importance of placing current revolutionary claims in a critical historical context. The adoption of new technologies does not necessarily change the underlying work practices, and can in fact solidify and reinforce retrograde practices rather than foster newer ones (for a discussion of this in HE learning see Privateer 1999). The adoption of new tools for research will not necessarily change, let along revolutionise the nature of research.

Established technologies such as the word processor are widely adopted across disciplines and have undoubtedly enhanced academic practice, although the fundamental nature of academic publishing (currently) remains relatively unchanged in most disciplines. These tools were not developed with the academic researcher in mind, but nonetheless have gained widespread adoption, although alternatives exist. Whilst free to the individual user institution level licences for proprietary packages such as Microsoft Word are a significant investment.

More recently two contrasting technological developments have had specific implications for the ways in which research is carried out. Developments in distributed computing such as the grid (Berman, Fox et al. 2003) and video conferencing such the Access Grid[1] have been part of a wider programme of e-science, where large scale, centrally funded technical projects have been adopted by researchers in the natural sciences in order to work in large collaborations dealing with enormous amounts of data. This programme has received significant funding from national funding bodies, such as £98mn for the first phase of the UK e-science programme (we are currently in the 3rd phase)[2].

The showcase for this approach has again been at CERN, where the Large Hadron Collider will produce 10 Petabytes of potentially interesting data annually. The challenge of analysing these quantities of data has led to technological developments which it is hoped will lead to a significant step change in the research output of particle physics (Britton, Cass et al. 2005). Having invested significant amounts in these technological developments there is now a drive to diffuse the benefits to other fields, such as the social sciences, arts, and humanities in what has started to be called e-research.

The Access Grid project has seen the establishment, mainly within academic institutions, of an international network of 'nodes'. These nodes are dedicated rooms set up to facilitate high quality, high bandwidth video conferencing, with shared desktop features. The purpose of this

---

1 http://www.accessgrid.org/

2 http://www.rcuk.ac.uk/escience/news/firstphase.htm

project is to help facilitate national and international collaborations. These nodes are expensive to set up and maintain and are not provided by individual researchers.

In contrast to, and approximately concurrent to, the centrally developed and deployed e-science/ e-research programme there has been the emergence of a rhetoric of web 2.0 (O'Reilly 2006). Web 2.0 has been used as a label for a wide variety of web based tools, mostly characterised by the extent to which they allow for the sharing of user generated data (such as YouTube, Facebook, Flickr). The impact of web 2.0 on learning has been widely discussed (for example see Downes 2005) and the potential impact of web 2.0 tools on research has begun to be investigated, characterised as Academia 2.0, or Research 2.0.

Tools such as blogs and wikis can help communication and collaboration amongst academics and a wider community that might be interested in their work. Whilst not specifically developed to enhance academic research they certainly hold the prospect of improving the speed with which research results are disseminated and commented upon, and the ease with which geographically distant collaborators can work, and write, together.

At the level of the individual researcher the reasons for adopting either e-science or web 2.0 tools are not clear. Technologies adopted at an institutional level may be ignored, resisted or subverted. An example of new developments being ignored might be senior professors who do not use their e-mail account, resistance might come in the form of Apple Mac users in a windows environment and subversion might take the shape of critical gossip propagated through e-mail lists.

The adoption of ICTs might improve productivity through increases in output (Meyer and Xu 2007) although the evidence of a correlation between research outputs and use of technology may be due to more productive staff being more likely to adopt technologies touted as ‘time saving’. As in the LHC case above new technologies might enable the large scale collaborations required by increasing amounts of data. Similarly ICTs might develop community and identity in academic departments through the establishment of web based communities (Chu and Hernandez-Carrion 2006) where technologies such as wikis can reinforce face-to-face relationships within a department.

Whereas e-science has had a reasonably clearly defined trajectory through the disciplines from the natural sciences, through the social sciences and on to the arts and humanities the take up of web 2.0 tools by researchers has been less coherent and is less well documented. Rather than attempt to understand the ICT use of all researchers, this paper discusses some research that attempted to document the use of technology by academic researchers across a broad range of disciplines at a mid-sized, regional university at the end of 2007.

There is a review of some of the literature on the relationship between disciplinary culture and the adoption of ICT in a variety of Higher Education (HE) contexts. Following this the results of an online survey on the uptake of ICT at Lancaster University will be discussed. The relevance of this for the future adoption of an expanded e-infrastructure will be discussed.

Technological change, disciplinary cultures and research practice

The rate and diffusion of technological change across academia is affected by a wide variety of factors, including the disciplinary culture within which the adoption of research technologies takes place. The disciplinary cultures are affected by the epistemological nature of the disciplines themselves (Becher 1994; Becher and Trowler 2001). Studies have looked at the influence of disciplinary differences on the development of electronic publication (Stephen and Harrison 2002; Sparks 2005), collaborative writing (Rosenzweig 2007) and the use of digital resources in teaching (Kemp and Jones 2007) to name a few relevant areas.

The influence of disciplinary culture on the uptake of ICT for research has only started to be investigated. Jenny Fry has specifically looked at how the organization and culture of disciplines has affected the use of ICTs (Fry 2004) including the shaping of digital resources (Fry and Talja 2007). These studies suggest that fundamental differences in the nature of disciplines, such as the degree to which there is a low level of task uncertainty and mutual dependence, lead to radically different patterns of adoption of key technologies such as mailing lists.

Xu and Meyer have analysed data from the National Study of Postsecondary Faculty, a large scale dataset of US universities, to uncover the institutional and individual factors influencing technology use (Meyer and Xu 2007; Xu and Meyer 2007). Unfortunately this dataset only has quite restricted data on technology use, asking respondents whether they use websites to disseminate class information, and whether they use e-mail for the same purpose. Despite this limited notion of technological uptake and the date of the survey (1999) the sample size (n=4,293) and wide range of descriptive data gathered about the individuals and their institutions make this a significant study.

They examined a wide range of possible predictor variables including demographic, professional, contextual and productivity measures for their influence on the use of web and e-mail. Demographic variables included age, gender and ethnicity, professional measures included academic rank and seniority, contextual measures included disciplinary differences, and the measures of productivity included data about teaching and research workload and output.

The results were complex, and I will only briefly summarise them here, but there are a number of findings which are relevant to the study I outline below. Firstly the factors explaining e-mail and web use were significantly different, which suggests that different tools are used by different people for different reasons. This is a simple enough conclusion but one which might question the notion of a single technological solution for the problems of all researchers.

Disciplinary differences were a significant explanatory variable of both e-mail and web use. There was a significant negative affect of age on technology use, which might be expected. Gender and ethnicity were not strong explanatory variables, although there was some evidence to suggest that women were using e-mail more than men at some institutions, whilst men were more likely to use the web (Xu and Meyer 2007).

Significantly in relation to the earlier discussion Xu and Meyer also investigated the relationship between technology use and productivity and found a strong correlation, although no evidence to suggest the direction of causality.

This brief review of relevant literature suggests a need to further explore the individual and disciplinary factors which have affected the uptake of antecedent technologies and might be expected to affect the uptake of future technological developments. It is clear that there are

strong grounds for supposing that disciplinary differences might affect the uptake of specific tools.

The Data

This paper presents the results of a survey of 194 academic staff at Lancaster University, a research orientated, mid-sized university based in the northwest of England, with around 16,000 students, and 2,500 staff, of whom 861 are academic. The precise definition of academic staff is by no means straightforward and all research staff were invited to participate, but the focus of the survey was on resource discovery, collaboration and publication. The figure of 861 came from collating the figures given for each faculty by senior administrators upon request.

The university is organised into three faculties: Arts and Social Sciences (hereafter FASS), Science and Technology (FST) and a Management School (MS). The survey also asked respondents about their sources of funding as another potential measure of disciplinarity but for the moment the ready division by faculty has provided the easiest measure. Eight staff respondents did not declare a faculty and their results were excluded from the analysis in this paper.

The survey was carried out entirely online through the software package SNAP, and was publicised through e-mail lists, newsletters and a project website[3]. This combined with the provision of an Apple iPod as a prize meant that researchers who use very little or no technology would be unlikely to respond although if this group are small this is unlikely to invalidate the conclusions.

Table 1. Response rate by faculty

Faculty	Research Staff	Responses	Response Rate (%)
FST	470	105	22.3
FASS	250	52	20.8
MS	141	37	26.2
Total	861	194	22.5

As can be seen from table 1 the overall response rate for academic staff was 22.5%, which was fairly evenly distributed across faculties with the highest rate of response from the Management School and the lowest from the Faculty of Arts and Social Sciences. The sample was broadly representative of the different contract types present amongst staff, but was skewed towards younger staff.

A series of questions focussed on the generic stages of the respondents' research work practices such as resource discovery and reference management. The results for resources discovery are presented in table 2 below.

Table 2. Distribution of methods for discovering relevant academic references (%)

	Traditional	Web 1	Web 2

[3] This is still available at http://redress.lancs.ac.uk/survey/

Faculty	Reading	Colleagues	Data base	Web search	Journal notifications	e-mail list	Google scholar	Wikipedia	RSS
FST	88	77	77	63	42	26	53	26	5
FASS	95	88	94	72	53	42	66	31	11
MS	91	78	81	59	57	28	57	12	3

I included options for non-technical means of resources discovery (such as manually following references in reading, and recommendations of colleagues) in order to allow for a comparison with newer methods, and to make the purpose of the question clearer.

The first thing to note from the table above is that there was widespread use of a variety of tools for this key academic task, the survey accepted multiple answers from respondents. This makes a comparison between faculties difficult as, for example, researchers in FASS were more likely to use every method for resource discovery than FST.

We can see that there is some variation across the faculties. Whereas the most popular method across the faculties was to discover relevant resources through reading there was some significant variation in the use of other methods.

Researchers in the FST were equally as likely to learn of new resources through colleagues or a database search (77%) but used these methods less than the other two faculties. Online databases were almost universally used (94%) in the arts and social sciences, compared to (77%) in the FST.

I also asked respondents about how they managed their references, another key generic part of the research cycle. The results of this are summarized in table 3 below.

Table 3. Methods used to manage references (%).

Faculty	Specialist Software	Cut and paste	Custom db	Paper methods
FST	50	34	20	40
FASS	53	51	12	24
MS	50	33	14	38

Once again we can see in the table above that a variety of methods are used to manage academic references although the level of use of specialist software packages, such as EndNote and Bibtex is broadly similar across faculties. Researchers in FASS were more likely to use cut and paste from previous documents than the other two faculties. Researchers in FST were more likely than those in the other two to build a custom database, and this faculty and the MS were more likely to use paper based methods than FASS.

Respondents were asked about their use of a variety of ICTs to collaborate with colleagues, such as e-mail, video-conferencing, instant messaging and various web 2.0 practices such as blogging and wikis. These were used to provide a more nuanced measure of overall technology use by researchers.

Table 4. Use of different information communication technologies by faculty (%)

Faculty	Instant Messaging	Conference calls	Desktop video conference	Access Grid (n=155)[4]
FST	30	25	9	10
FASS	23	25	6	9
MS	35	24	13	21

From Table 2 we can see that the, of the communication technologies shown, instant messaging (such as icq or MSN) was the most popular across the faculties, with the exception of FASS, where it was not as widely used as conference calls. Instant Messaging is a relatively recent communications tool, particularly in a work setting and research about its adoption and use is relatively sparse (Nardi, Whittaker et al. 2000; Cameron and Webster 2005). I have not found evidence of any studies of IM use in research collaborations.

Conference calls were the also relatively widely used for research collaboration, but were least popular in the Management School. This was followed by desktop videoconferencing (such as skype[5] or agora[6]).

Despite the presence of seven Access Grid Nodes on the Lancaster University campus awareness and use of this highly specified video conferencing tool was limited outside of the management school, although this could reflect a small number of heavy users, I have not been able to get data on the levels of usage of each node.

Some recent developments in ICT have been described as web 2.0, and these include wikis and blogs. Respondents were asked a number of questions about the academic projects that they were involved in, and this included one asking whether or not any of the projects had an associated blog or wiki. The results, cross tabulated by faculty, are presented in table 3 below.

Table 5. Presence of project website, blog or wiki (%)

Faculty	Website	Wiki	Blog
FST	38	15	2
FASS	44	12	12
MS	38	11	8

The data in table 3 only relates to whether any of the academic projects of which the respondent is a part uses website, blog or wiki, not whether or not the individual uses these tools. As such this data is of limited use in describing the uptake of these tools across these areas, although there is still evidence that wikis are more popular in Science and Technology projects than either the Management School of the Arts and Social Sciences. Websites were

[4] There was a separate series of questions about Access Grid, hence the difference in numbers of responses. The results have been included here for simplicity.

[5] http://www.skype.com/intl/en-gb/

[6] http://agora.lancs.ac.uk/

the most popular tool for projects, and were significantly more popular in the arts and social sciences.

A specific question on the level of individual use of wikis was not included in the survey, but questions about the levels of reading and writing of research related blogs were, as presented in table 4 below.

Table 6. Levels of blog readership and authorship (%) (n=192)

Faculty	Read	Write
FST	18	2
FASS	31	8
MS	8	3

Unsurprisingly in each case the numbers writing blogs were less than those reading them. There is clearly a large variation across faculties with the Arts and Social Sciences significantly more likely to read and write with blogs than the other faculties. This corresponds with the findings for project blogs in table 3.

Discussion

Even a brief review of the literature on the effect of disciplinary differences on the uptake of ICT has suggested that values and norms of a discipline can have a significant effect, even if the extent of this varies.

Despite the faculties being a coarse grained level of analysis, masking many intra-faculty disciplinary differences, this survey has nonetheless suggested that there is clearly some considerable variation across the faculties in the uptake and use of ICTs in the research process. A wide variety of tools are being used, by individuals and across faculties. Even where tools have a very high uptake (e.g. 94% use of databases for finding resources in FASS) this is not at the exclusion of other tools that perform a similar task.

For resource discovery (table 2) we can see that academics use a variety of methods, both technical and nontechnical, with newer methods supplementing rather than replacing older established methods. Similarly a variety of methods of managing references was uncovered in table 3 with researchers in the FST more likely to use a custom database to store their references than cutting and pasting from previous work, which was popular with social scientists.

The results from table 4 suggest that researchers in the Management School were more likely to use instant messaging, desktop videoconferencing and the Access Grid than researchers in other faculties. They use a wide variety of tools to collaborate with colleagues which may be due to the needs to commercial collaboration as part of their research.

Many of the tools that have been adopted by researchers were not initially developed with academic research in mind. Telephone conferencing, VoIP and Instant Messenger were all developed commercially for general use and yet are widely adopted by researchers, whereas some tools developed specifically for academic researchers, such as the Access Grids nodes, are far less well known and used.

The data in tables 5 and 6 also suggested a significant difference in the use of wikis and blogs by faculty. Wikis were more likely to be used by researchers in the faculty of science and

technology and this might be due to a number of factors. The nature of larger scale collaboration in the sciences may make wikis the best way of collaborating, as well as norms around co-authorship where large numbers of 'authors' produce papers (Becher 1994; Becher and Trowler 2001). In addition to this scientists' comfort in dealing with coding schemas, similar to their preference to build a database to store references, might make them more willing to engage with a wiki interface.

The popularity of more user friendly blogs might fit in better with the culture of "possessive individualism" (Rosenzweig 2007) found in the humanities and social sciences, where comments and ideas are expected to be clearly and visibly attributable, by single authors, whereas in the natural sciences published works can have dozens of co-authors with little indication of the distribution of work.

The persistence of older tools and methods across the faculties also undermines the revolutionary claims made for each new technological wave. Far from replacing and radically altering work practices in many cases new technologies supplement and support established working practices, indeed this may be a precondition for adoption in some cases.

In addition to this the widespread adoption of a variety of free to use tools that have not been developed with academic research in mind but which are nonetheless being used to enhance research practice suggests the future technological landscape of academic landscape will be varied, not so much supported by an e-infrastructure than e-infrastructures. The enhanced researcher will be a bricoleur, selecting and dropping tools as they meet specific needs.

It is all too tempting to look for evidence of a progression, from technologically sophisticated large scale collaborations of natural scientists through to more traditional, lone humanities scholars but there may well be other explanations for the different patterns of technological usage. The age and establishment of a discipline may have an impact over and above the intrinsic culture, such that new emerging fields, without established working patterns might be quicker to adopt new technologies than fields where deeply entrenched work patters make innovation more difficult.

In conclusion there are limits to the extent to which centrally funded large scale projects will be adopted within academic research, although this is not to dismiss their impact. In specific disciplinary instances they are having a dramatic effect, and more broadly projects such as the Access Grid are being used by a significant minority of academics. The extent to which the benefits of the e-science programme will be limited not by the technology, or even by the resistance of individual researchers, but by the degree to which the projects, developed within once disciplinary culture, translate across cultural differences.

Web 2.0 type tools have achieved more broad adoption across faculties, although not universally so. Different tools have found a home in different cultural settings, without national or institutional backing or support. Academics are free to chose to adopt whichever tools they feel might help them research better, but similarly they are free to drop them as quickly. The survey asked how many had written a research related blog, but not how many continue to do so. Future surveys may find that the current hyperbole around web 2.0 has led to a short lived spike in adoption with limited long term impact.

Whilst this survey has found evidence of technological innovation amongst academic researchers this does not need imply that they are similarly innovative in their work practices. Technological change is a necessary but not sufficient condition for changing and enhancing

work practices. The establishment of an e-science programme, and the emergence of web 2.0 tools may make possible the formation of an enhanced researcher, but will not guarantee it.

Acknowledgments

The research on which this discussion is based was funded through the Lancaster University Alumni Friends Programme. I would also like to thank Leslie Humphreys and Alistair Robertson for useful comments as this work has taken shape.

References

Becher, T. (1994). "The Significance of Disciplinary Differences." Studies in Higher Education **19**(2): 151-162.

Becher, T. and P. R. Trowler (2001). Academic Tribes and Territories: Intellectual enquiry and the culture of disciplines. Buckingham, Open University Press.

Berman, F., G. C. Fox, et al., Eds. (2003). Grid Computing: Making the Global Infrastructure a Reality, Wiley.

Britton, D., A. J. Cass, et al. (2005). GridPP: Meeting the Particle Physics Computing Challenge. All Hands Meeting.

Brynjolfsson, E. and L. M. Hitt (1998). "Beyond the Productivity Paradox: Computers are the catalyst for bigger changes." Communications of the ACM **41**(8): 49-55.

Cameron, A. F. and J. Webster (2005). "Unintended consequences of emerging communication technologies: Instant Messaging in the workplace." Computers in Human Behaviour **21**(1): 85-103.

Chu, C. M. and J. R. Hernandez-Carrion (2006). "Harnessing ICT to develop community and identity: a model for academic departments." International Journal of Web Based Communities **2**(1): 70-80.

David, P. A. (1990). "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox." The American Economic Review **80**(2): 355-361.

Downes, S. (2005). E-learning 2.0, ACM. **2005:** 1.

Fry, J. (2004). "The Cultural Shaping of ICTs within Academic Fields: Corpus-based Linguistics as a Case Study." Literary and Linguistic Computing **19**(3): 303-319.

Fry, J. and S. Talja (2007). "The intellectual and social organization of academic fields and the shaping of digital resources." Journal of Information Science **33**(2): 115-33.

Kemp, B. and C. Jones (2007). "Academic Use of Digital Resources: Disciplinary Differences and the Issue of Progression revisited." Educational Technology & Society **10**(1): 52-60.

Meyer, K. A. and Y. Xu (2007). "A Bayesian analysis of the institutional and individual factors influencing faculty technology use." Internet and Higher Education **10**: 184-195.

Nardi, B. A., S. Whittaker, et al. (2000). Interaction and outeraction: instant messaging in action. ACM Conference on Computer Supported Cooperative Work, Philadelphia, Pennsylvania

O'Reilly, T. (2006). Web 2.0 Principles and Best Practices. O'Reilly Radar Reports.

Privateer, P. M. (1999). "Academic Technology and the Future of Higher Education: Strategic Paths Taken and Not Taken." The Journal of Higher Education **70**(1): 60-79.

Rosenzweig, R. (2007). "Can History Be Open Source? Wikipedia and the Future of the Past." Journal of American History **93**(1).

Shields, M. A. (1995). The Legitimation of Academic Computing in the 1980s. Work and Technology in Higher Education: the social construction of academic computing. M. A. Shields. Hove, Lawrence Erlbaum Associates**:** 161-187.

Sparks, S. (2005). JISC Disciplinary Differences Report. London, Rightscom.

Stephen, T. and T. M. Harrison (2002). "Building Systems Responsive to Intellectual Tradition and Scholarly Culture." The Journal of Electronic Publishing **8**(1).

Xu, Y. and K. A. Meyer (2007). "Factors explaining faculty technology use and productivity." Internet and Higher Education **10**: 41-52.