



Diversity in the e-journal use and information-seeking behaviour of UK researchers

E-journal use of
UK researchers

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Abstract

Purpose – The purpose of this paper is to present some of the results of the project “Evaluating the usage and impact of e-journals in the UK”. The particular research reported here evaluated the use of the ScienceDirect journals database with regard to Life Sciences, Economics, Chemistry, Earth & Environmental Sciences and Physics by ten major UK research institutions. The aim of the study is to investigate researchers’ digital behaviour, and to ascertain whether their use and behaviours varied by subjects and disciplines, or in relation to the institutions in which they worked.

Design/methodology/approach – Raw logs for ScienceDirect were obtained for the period January to April 2007, were subject to deep log techniques and analysed using the Software Package for Social Sciences (SPSS).

Findings – Typically, 5 per cent of the ScienceDirect journals viewed accounted for a third to half of all use. A high proportion of researchers entered the ScienceDirect site via a third-party site, and this was especially so in the case of the Life Sciences and in the highest-ranked research institutions. There were significant institutional and subject differences in information-seeking behaviour. In the most research-intensive institutions, per capita journal use was highest and their users spent much less time on each visit. There were significant differences of the order of 100-300 per cent in the age of material viewed between subjects and institutions. Just four months after ScienceDirect content was opened to Google indexing, a third of traffic to the site’s Physics journals came via that route.

Originality/value – The research is one of the very few studies to investigate subject and institutional differences with regard to the information seeking and use of UK researchers, something UK academic librarians should particularly welcome.

Keywords Information research, Consumer behaviour, Electronic journals, United Kingdom

Paper type Research paper



Introduction

Numerous studies testify to the fact that increased and enhanced online access to the journals literature has led to high volumes of usage and information seeking (King *et al.*, 2003; Tenopir *et al.*, 2003; Voorbij and Ongering, 2006). However, little is known about the particular experience of UK researchers and the extent to which this varies

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from subject to subject and institution to institution. The Research Information Network funded project "Evaluating the usage and impact of e-journals in the UK"[1] set out to correct the deficiency and selected findings from the first, quantitative, stage of the project are reported here[2]. The second, qualitative stage, which seeks to obtain an explanation for the usage and behavioural patterns identified by the logs in the first stage, will be completed in 2010.

Aims and objectives

The aims of the study were to:

- investigate UK researchers' behaviour, in terms of levels and patterns of usage, content viewed, navigational preferences, routes used to access e-journal content and titles used; and
- ascertain whether UK researchers' use and behaviours vary by subjects and disciplines, or in relation to the institutions in which they work.

While a number of studies (see, e.g. Tomney and Burton, 1998; Rusch-Feja and Siebeky, 1999; Brockman *et al.*, 2001, Nelson, 2001; Tenopir and King, 2002; Smith, 2003; Talja and Maula, 2003; Tenopir, 2003, Sparks, 2005, Research Information Network, 2006) have commented upon the subject differences in information seeking behaviour of researchers and scholars most of them have employed self-report methods, like questionnaires and interviews. Surprisingly, very few studies have investigated subject diversity through an evidence-based approach, like log analysis, which clearly offers an important, different and complementary approach to the topic. Nor, despite the undoubted interest among practitioners, have we been able to identify many studies that have explored diversity in an institutional context. Log studies offer much in respect to the investigation of diversity because they enable differences to be measured in some considerable detail and greater specificity. There is a real need for researchers to move on from some of the very broad and generalisations that have characterised the literature for so long and are still being made. Statements such as "Virtually all researchers (99.5 per cent) rely on journal article [sic] as a key resource . . ." and "Ranked by importance, journal articles are by far the most important resource, listed in the top three by 71 per cent of all those interviewed" (Research Information Network, 2006, p. 7).

The prime focus of the study was UK researchers because this is where the funding body's (RIN) policy interests lie and where gaps in the knowledge had been identified. Clearly it was not possible to study all e-journal activity on the part of all UK researchers within the confines of a ten-month research project (January 2008 – October 2008), and therefore a case study approach was adopted with ten institutions and five subjects being selected on the basis of their representativeness. The journal usage and behaviour of the researchers involved, thought to number at least 3,000, and probably a great deal more, was investigated in respect to their use of ScienceDirect during the period January to April 2007. More details of the selection criteria used can be found in the Methods section of this paper.

Literature review

Past studies (e.g. Covi and Kling, 1996; Kling and McKim, 1999; Eason *et al.*, 2000; Tenopir, 2003) show that user's discipline and institutional context affects the use of electronic resources. However, the real nature and the extent of these differences, especially the institutional ones, are generally not well-researched. Vakkari (2006)

investigated subject differences of users of the Finland Electronic Library (FinELib) and found that while the proportion of those using mainly electronic material had grown in the humanities (7 per cent) and social sciences (17 per cent) during 2000-2005, the growth in other disciplines varied between 38 per cent and 53 per cent. While the difference between the humanities and social sciences and other disciplines in 2000 was about 10-20 per cent in terms of e-users, it was in 2005 already 45-60 per cent. Humanists were less frequent users, social scientists and economists formed a middle group and scientists were the most frequent users. The study did not present details on the nature of use or on the information seeking behaviour of users, although it did reveal disciplinary differences. The main conclusion was that the availability of resources in a discipline was significantly stronger predictor of the use than users' discipline. After all you can only use what is there.

Another study that conducted institutional comparison was the MaxData project (Nicholas *et al.*, 2007). What the MaxData study had in common with the present study was that whilst it was a log study of USA scholars (both students and faculty) it did conduct institutional comparisons. The most interesting finding was the differences found between information seeking and use in teaching and research universities, which was largely a function of research activity and the size of the respective academic communities. The study was confined to 4 universities in Ohio which used the OhioLINK journals database. The two research active universities in the sample recorded the shortest session times and their busy sessions were the lightest (viewing the fewest pages); their behaviour also appeared to be much more focussed – relatively low use of abstracts, fewer journals viewed in a session and search pages support this connection. The most research intensive university also recorded the highest per centage of:

- views to current journals;
- browsing sessions; and
- sessions which saw the advanced search facility used.

Analyses were also undertaken for five subjects that were roughly equivalent to the present study's case study fields:

- (1) Business and economics;
- (2) Chemistry;
- (3) Earth sciences;
- (4) Life sciences; and
- (5) Physics.

Relevant and important findings were the fact that users of Physics journals conducted the most active sessions – well over a third session saw 11 or more pages viewed. Business and Economics (28 per cent) recorded the highest proportion of bouncers – visitors who only used a single page. The equivalent figure for Physics was 13 per cent. Physics journals were also viewed for a relatively long time, 30 per cent of sessions lasted over 15 minutes. Physics recorded the highest average (median) page view time of 25 seconds. In terms of articles Chemistry and Life Sciences recorded the longest viewing times, respect and Business and Economics saw some of the shortest viewing times. With regard to type of journal content viewed physicists were proportionately more likely just to view abstracts (CIBER, 2007; Nicholas *et al.*, 2007).

Few studies appear to have investigated subject or institutional differences in the use of e-journals by UK researchers. The Research Information Network study (2006), Researchers and Discovery services, was a relatively small scale qualitative study of less than 500 UK researchers. Most of the data came from telephone interviews. Inevitably, a study ranging so widely and employing these methods could only come up with very general findings, the most relevant of which are:

- articles were the most relied upon source for research – 96 per cent of interviewees looked for journal articles during the course of research, with 71 per cent ranking them as the important resource;
- life and physical sciences researchers made more use of general search engines and less use of library browsing; arts and humanities researchers made less use of services such as citation indexes and bibliographic/A&I databases; and
- social science researchers shared some of the traits of both sciences and arts and humanities researchers – they were users of citation indexes and bibliographic services, and also of library services and facilities.

The only log study of information seeking behaviour that has included UK researchers was another study of ScienceDirect users (Nicholas *et al.*, 2008a) conducted in 2006. The study is of special relevance because it also undertook subject comparisons. The logs of 750 authors were studied, about a quarter of whom were British. Marked differences were found between the information seeking behaviour of authors in regard to their subject and five of the subjects were also covered by the current study. The key findings with regard to life scientists were that they undertook the:

- highest number of article views;
- lowest views to articles in print;
- highest rate of sessions recording one page views and the highest proportion of sessions recording over 20 views; and
- highest proportion of sessions recording an abandoned search.

Chemists searching stood out even more and they recorded the:

- lowest use of search pages;
- lowest rate of abstract views;
- highest rate of PDF views;
- lowest rate of views to current articles;
- lowest rate of dropped searches; and
- highest rate of searches with 51+ returned hits.

Physicists were characterised by the:

- lowest rate of full-text views;
- lowest views to current articles and the highest views to old articles; and
- highest number of searches with ten to 50 returned hits.

Earth and Environmental Sciences recorded the:

- highest views to old articles;

- lowest number of sessions where one page was viewed;
- lowest number of cases where searches were dropped; and
- highest average number of articles viewed in a session.

Economists also stood out with the:

- highest abstract views;
- highest views to current articles;
- the highest number of sessions with over 20 views;
- the highest number of searches with zero hits returned; and
- the lowest average number of article viewed.

Methods and working definitions

Raw logs for Elsevier's ScienceDirect (Figure 1) were obtained for the period January to April 2007 and were analysed using the Software Package for Social Sciences (SPSS) to generate fine-grained insights into the use and information-seeking behaviour of scholars from a representative range of university and government laboratories in six subjects. More details about the procedures involved can be found in Nicholas *et al.* (2000, 2008a).

Figure 2 shows an example of a ScienceDirect log. The first field (134.5.159.61, 143915) provides the IP address. This is an anonymous machine-to-machine address number used by computers to send and receive data over the internet. The second field

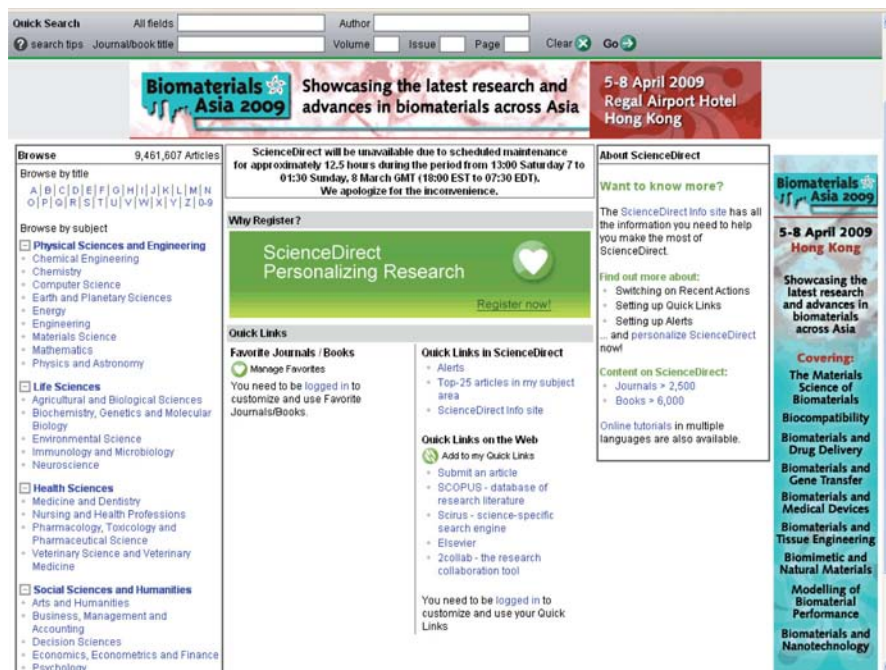


Figure 1.
ScienceDirect homepage

(143915) is a cookie and is used by the server to recognise a computer that has requested information previously. The third field (fc0f2bc6-b9e5-11d9-975c-8a0c5905aa77143915) is a session cookie and is a number the server uses to track transactions within that session. The fourth and fifth field (05/01/05, 02:09:57) provide the date, time and time record of the transaction. The sixth field (C000061700) is the users' account number. No information is supplied that enabled user account details to be linked to the database. The seventh field (blank in this example) records the previous site visited immediately prior to accessing ScienceDirect; frequently this will be a gateway such as PubMed. The eighth field (SearchQuick_Search) records the event identifier. The ninth field (2) records the functional area descriptor. The tenth field (n) is the session event snr. The 11th field (Media Searched) records the attribute type name. The 12th field (allinprod) records the attribute value description.

Working definitions

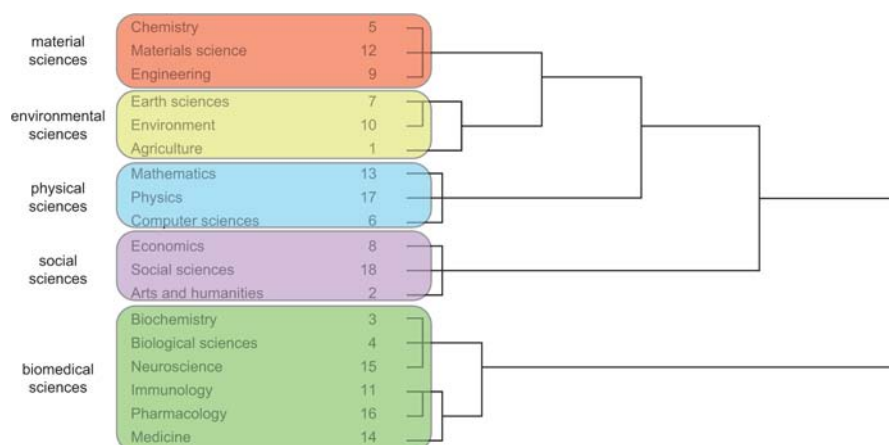
Researchers. Filtering out student teaching use from the logs is really only possible if student computers can be identified through sub-network identification. For this to work universities need to employ persistent, meaningful and specific sub-network labels. However, an exploratory investigation showed that this could not be undertaken with any degree of accuracy for the case study institutions. Of course, the choice of scholarly journals as the information resource to be investigated partly meant that a student and teaching information seeking filter was being introduced by default. Elsevier also believe that ScienceDirect's key constituency was researchers and this was confirmed by an exploratory sub-network analysis conducted at the University of Manchester, where, for instance, student halls of residence could be identified, and this showed student usage to be relatively low. It was not possible to distinguish between journal usage associated with teaching and research in the case of university staff. However, it should be noted that log analysis is based on IPs, and each IP does not necessarily represent a single user and an IP can be used by more than user. This is among the limitations of log analysis method.

Subject (department). Decisions about which subjects to include in the study were critically important if the findings were to prove representative of UK research. A technique called "subject fingerprinting" that applies clustering techniques to large collections of scholarly behavioural and attitudinal data was employed. This dataset included information obtained from Elsevier, ISI and CIBER. The five main clusters derived (Figure 3) were statistically very distinct: within each group, there is much less variation in behaviour and attitudes across a wide spectrum, from the importance attached to speed of publication to sympathy for open access. However, differences in scholarly behaviour and attitudes between the groups are huge. It therefore made sense to sample one subject from each of the main clusters.

A further consideration was that there was a requirement to select disciplines that mapped relatively easily on to existing research institutes and university departmental structures. Similarly, there was a need to select subjects that mapped on to Thomson Scientific ISI subject classifications, which would enable comparisons with citation and

Figure 2.
Example of a
ScienceDirect log

134.5.159.61, 143915, fc0f2bc6-b9e5-11d9-975c-8a0c5905aa77143915, 05/01/05,
02:09:57, C000061700, , 298789480, SearchQuick_Search, 2, n, Media_Searched,
allinprod



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Figure 3.
Automatic subject
categorisation

publication outcomes (another strand of the project). The subjects selected for the ScienceDirect investigation were:

- Life sciences;
- Chemistry;
- Physics;
- Earth sciences and environmental sciences; and
- Economics.

Case study subjects were defined by the subject category of the journal used, rather than by department name. This was because:

- it was not possible to identify departments accurately from the logs;
- it would allow for the existence of documentary scatter, whereby a good proportion of departmental publications appear in journals outside the subject of the researcher's home department because of widespread collaborative and problem-driven research; and
- the subject scatter of usage would be allowed for – this scatter arises from the blurring of disciplines; partly for the reason stated above, that the nature of research is changing, partly as a result of the primacy of multi-disciplinary information platforms like OJ.

Research institutions. The focus was on universities and Government research laboratories. In respect to the universities, because researchers were the object of the study, it was the research active ones that we were interested in. Research active was defined as having a department covering a case study subject with a rating of 4 or more according to RAE 2001.

Case studies. Taking together the institutional and subject requirements of the project, the following institutions were selected for investigation:

- (1) Centre for Ecology and Hydrology;
- (2) Rothamsted Research;

- (3) University College London;
- (4) University of Aberdeen;
- (5) University of Bangor;
- (6) University of Cambridge;
- (7) University of Edinburgh;
- (8) University of Manchester;
- (9) University of Strathclyde; and
- (10) University of Swansea.

Results

Logs have few peers when it comes to detailing use and information seeking behaviour in the virtual scholarly space. As will be demonstrated it is possible to research aspects of use and behaviour simply not open to surveys and interviews, like, for instance, exactly (to the second) when usage took place, how long it lasted and the exact number of times the advanced search function was used. ScienceDirect log analyses are presented in two parts: first a subject comparison is provided and this is followed by an investigation of institutional diversity within two contrasting subject fields (Life Sciences and Economics). The format for each part is exactly the same, first a usage analysis is presented; this is followed by analyses by method of access and form of navigation, type of content viewed and the journals used.

There is no way of knowing how many researchers are covered by the following analyses and this will become clearer once the second stage has been completed, but according to information obtained from the individual laboratories and the RAE 2008 for the subject fields covered staff researchers numbered 2,700. This has to be regarded as a minimum number to which has to be added research assistants, higher degree students and the researchers from non-case study subjects that have had occasion to use the journals of case study subjects.

Usage

There is no single "right" or "accurate" measure of use and as a consequence a variety of metrics have been utilised to provide a comprehensive and robust picture:

- (1) *page views*, which is a general and bald activity indicator covering searching, browsing, navigating and viewing/reading;
- (2) *full-text views*, which is generally seen as a consumption indicator and one that points more closely to satisfaction and positive outcome;
- (3) *PDF views*, a metric which, possibly, is a better measure of relevance and satisfaction, as people might view first in HTML and only if they like what they see then view or download the document as a PDF;
- (4) *sessions or visits conducted*, the vehicle for information seeking behaviour analyses; and
- (5) *time spent online*, either viewing a page or on a session, which is a potential interest metric.

Whatever the metric adopted it is plain that a large volume of use took place at the case study institutions in the space of just four months. Over half a million ScienceDirect

sessions were undertaken and more than a million and a half pages viewed across the ten research institutions in the five subject fields.

Life Sciences is very well represented in ScienceDirect (Table I, column 14) and not surprisingly proved to be the subject which attracted most use, accounting for half of all the sessions conducted and 44 per cent of page views (Table I, respectively, columns 12 and 3). Levels of use generally related to the size of the journal population, however, even so Life Sciences and Physics attracted high levels of use that might have been expected. This was true for all use indices with the exception of length of sessions. Thus Life Sciences sessions were about half the duration of those for the other subjects. Indeed, generally, all the high volume subjects recorded short session times and this can partly be ascribed to the number of gateway accesses undertaken, via Pub Med for instance (see Table II). In these cases users have probably already conducted some of their searching at a third party site.

Economics, unsurprisingly – it was represented by the fewest journals and was the only social science subject, recorded the lowest levels of use according to all metrics. Another interesting feature of Table I is the relative preferences shown for PDF/HTML full-text formats. Life Sciences showed a strong preference for displaying articles in HTML (55 per cent of full-text views were of this type) while Economics exhibited a preference for PDF (75 per cent were of this type).

Logs are unique in that they provide very detailed information on when people search and use digital information. In terms of day of the week, use was generally very even from Mondays to Thursdays; it fell a little on Friday and then dropped to around a third of weekday use over the weekends. Nevertheless, weekends still accounted for significant (15 per cent) levels of ScienceDirect use. Economists were the most active over a weekend with about 17 per cent of their use occurring then; this compared to just 10 per cent of weekend use for Chemists. The most popular period of the day for using ScienceDirect proved to be between 12 and 2 p.m., when 28 per cent of all use occurred. Nearly a quarter (24 per cent) of use occurred outside the “traditional” 9-5 working day, and it was Economists who were most likely to use the service “out of office hours”, with 30 per cent of their use being recorded then.

Access and navigation

Logs provide a comprehensive and detailed account of how researchers access a site and, once there, how they navigate through it. In this regard they provide us with two types of important information about the:

- (1) *Method of access*, which describes:
 - where they were and what they might have been doing prior to arriving at ScienceDirect, something which enhances our knowledge of the broader Web session of which the ScienceDirect visit is probably only a part; and
 - where they arrived in the site and what kind of view of the ScienceDirect content they obtained as a consequence, something which in turn might influence what they use.
- (2) *Form of navigation adopted when arriving at the site* – searching and browsing behaviour.

Method of access. Researchers arrived at ScienceDirect via a wide variety of routes (Table II, 3-6 columns). They often arrived by way of a “gateway” site[3] (Column 3) and, if so, accessed ScienceDirect articles (occasionally abstracts) directly by activating

Table I.
Subject usage metrics

Subject	Total page views		Total full-text views		Total HTML views		Total PDF views		Sessions		Journal sample		
	n	%	n	%	n	%	n	%	Ave. in secs	n	%	n	%
Life sciences	602,340	44	372,900	46	205,751	56	167,149	38	68	229,986	50	539	40
Chemistry	208,706	15	115,314	14	43,849	12	71,465	16	105	65,988	14	199	15
Earth Sci	276,684	20	155,406	19	56,799	16	98,607	22	192	72,566	16	256	19
Economics	120,167	9	50,858	6	10,888	3	39,970	9	149	29,626	6	132	10
Physics	170,473	12	108,458	14	46,990	13	61,468	14	126	57,861	13	209	16
All case study subjects	1,378,370	100	372,900	46	364,277	100	438,659	100	95	456,027	100	1,330	100

Notes: All page view counts include views to abstracts, an article or a menu (e.g. Table of contents); Because of duplicate PDF and HTML views totals will add up to more than total article views; Journal sample is the number of journals for each subject that were included in our ScienceDirect data

Subject	All gateway access		Method of access		Form of navigation			
	<i>n</i>	%	Google access	Google Scholar	PubMed access	Menu use	Advanced search	Basic search
Life sciences	149,021	64.80	1,378	123	52,183	77,581	350	3,472
			0.80	0.10	30.70	33.7	0.20	1.50
Chemistry	31,963	48.40	4,060	380	1,919	35,032	183	2,800
			9.40	0.90	4.50	53.1	0.30	4.20
Earth sciences	29,924	41.20	5,353	948	1,302	41,833	172	3,032
			11.60	2.10	2.80	57.6	0.20	4.20
Economics	5,579	18.80	369	30	46	19,353	60	915
			1.80	0.10	0.20	65.3	0.20	3.10
Physics	33,487	57.90	14,655	1,424	264	24,988	125	2,714
			35.60	3.50	0.60	43.2	0.20	4.70
All case study subjects	249,974	55.70	25,815	2,905	55,714	198,787	890	12,933
			8.10	0.90	18.10	41.8	0.20	2.30

Notes: Gateway access here (and in similar tables following) includes Google, Google Scholar and PubMed figures; Low levels of Google access were due to the fact that Elsevier only started opening the site to Google indexing during the period of investigation; percentages are based on all sessions featuring this form of access and navigation

Table II.
Method of access and navigation (sessions)

a link, bypassing homepages, menus and (sometimes) abstracts. Thus anyone accessing the ScienceDirect via a gateway site will have undertaken some of their searching and navigating in the gateway site and arrived at ScienceDirect mainly to pick-up content. Therefore, for a high per centage of “users” – 56 per cent in the case of ScienceDirect – only a proportion of their searching has been captured.

Pub Med is perhaps the best known example of a gateway site and its use has been highlighted its use in our analyses (Column 6). Users may also have come into the site via a citation link within an e-journal, for example, Scirus provides such links. Furthermore, researchers may have arrived via ExLibrisSFX and CrossRef, which are electronic services linking online library resources by providing hyperlinks to articles from references and abstracts (these accesses form part of the all gateway figure in column 1). Indeed, Google, too, can be thought of as a gateway and because of its enormous popularity and the fact that ScienceDirect opened up its site to Google indexing in 2007 – the impact of which was clearly worth studying, it has been singled out for analysis as well (Column 6).

Researchers may also have arrived via a referrer link and in these cases they are taken to the site, rather than a document; meaning they were one or two links away from content, as would be researchers using a bookmark or “Googling” for ScienceDirect. In the main these links were from library or university pages and there were hundreds of them (too many to list). Overall, 22 per cent of sessions arose from such a referral.

For most subjects gateway access accounted for around half of all ScienceDirect accesses, but there were large differences between subjects. Thus, for Life Sciences nearly two thirds of the traffic came via gateways, and this compared to just 19 per cent for Economics, where gateways are clearly not as numerous or popular.

As mentioned previously the use of gateways inevitably meant that all information seeking behaviour associated with the queries that prompted the ScienceDirect visits was not captured. As will be seen this shows up in short session times (Table I), lower use of menus (Table II) and a smaller number of pages viewed (Table III) for subjects that make extensive use of gateways, although, interestingly, it did not impact much on abstract viewing, which might have been expected.

Google access was artificially low because ScienceDirect only opened its contents to Google during 2007. For the period surveyed just 324 journals benefited from Google indexing. Of these journals, 58 were from Physics, 22 Life sciences, 16 Earth sciences and 11 Chemistry. This has clearly impacted upon the number of Google searches undertaken in each subject. Thus, 36 per cent of ScienecDirect sessions arose from a Google search in Physics, whereas the equivalent figure for Economics was, unsurprisingly, less than 2 per cent. The Google traffic is not necessarily new traffic, probably just people finding the Google search a better or more convenient method of location. There is a need for future studies to distinguish between use of Google search engine and Google Scholar, when examining researchers’ information behaviour.

As might have been expected it was in the Life sciences that Pub Med had a real impact, with around one-third of traffic coming into the site via this route.

Form of navigation. The use of the advanced search was universally low, being utilised in less than 0.2 per cent of sessions conducted. In fact the raw numbers tell a more potent story: for Physics the advanced search was utilised just 125 times by ten institutions over a period of four months. An earlier CIBER study has also shown that scholars do not tend to use advanced facilities on databases (Nicholas *et al.*, 2007). Low use is probably due to a combination of factors – the belief that searching is easy, convenience, gateway use (where much searching is conducted off-site) and the fact that top researchers know exactly what they were looking for (Jamali, 2008). While the

Subject	Ave. no. of pages viewed	Volume Ave. no. of articles viewed	Ave. no. of journals viewed	Form % viewing an abstract	Ave. age of article viewed (days)	Age/currency Alerts (%)	% viewing an AIP	Ave. impact factor of journal viewed	Relative impact factor
Life sciences	2.1	1.5	1.2	19.30	859	0.1	7.1	4.4	1.15
Chemistry	3.6	1.9	1.5	23.30	1,176	0.1	8.2	2.5	1.15
Earth sciences	3.8	2.0	1.5	22.50	1,078	0.1	9.3	2.1	1.17
Economics	3.9	1.5	1.2	30.20	1,552	0.1	5.9	1.4	1.24
Physics	2.6	1.7	1.4	20.10	1,157	0.1	7.4	1.6	0.97
All case study subjects	2.4	1.5	1.2	20.30	1,022	0.1	6.7	2.9	

Table III.
Content viewed (sessions)

basic search facility was used more times, it was still relatively lightly used. Even for the subject where it was used the most (Physics) it was employed in less than one in 20 sessions. Furthermore this cannot wholly be put down to gateway use as Economics, a subject with low gateway use, exhibited even lower levels of basic searching – just one in 30 sessions saw the facility being used. ScienceDirect also had a facility called quick search, a more abbreviated search, but even this only attracted just over 700 uses over the four-month survey period. Low levels of use of internal search engines have been found elsewhere (Nicholas *et al.*, 2008b); it appears that while researchers use web search engines with alacrity, this does not translate into the use of their less effective (or less well known) internal cousins.

With regard to browsing and searching the data shows that viewing menus (tables of content, lists of journals etc.) were by far the most popular means of navigating toward content, between one third (Life Sciences) and two-thirds (Economics) of sessions recorded a view to a menu.

Content viewed. There was clear water between subjects in regard to session “busyness”, the amount of activity (page views) recorded in a session (Table III). Thus, in terms of the number of pages viewed, Life Sciences recorded just two a session (probably the gateway influence at work again) yet Economics recorded twice that number (nearly 4). Life Sciences also viewed the fewest articles and journals in a session (respectively 1.4 and 1.1), with Earth sciences recording the most (1.8 and 1.4). The relatively low number of page views is not unexpected given the relatively short session times described earlier in the paper.

There were considerable differences in abstract viewing, with nearly one in three Economics’ sessions recording a view to an abstract as compared to one in five sessions for Life Sciences (again, the latter figure is probably explained by the influence of gateway searching). Life Sciences viewed the most recent articles, with an average age of 862 days (about 2.4 years old) and Economists the oldest, 1,648 days or 4.5 years.

Use of e-mail alerts were at a very low level (0.1 per cent of sessions saw them used) but the viewing of articles in press (AIPs), a possible currency indicator, proved more popular, especially with Physicists – 9.5 per cent of their sessions saw AIPs viewed. As might have been expected Economics, the sole social science, not only viewed the oldest articles but also used AIPs the least (in 5.9 per cent of sessions).

In terms of the rank of the journals viewed (ISI impact factor), on average Life scientists viewed higher ranked ones (average impact factor 4.92), but this might well be a reflection of the higher scores of journals that is prevalent in this field. Earth sciences saw the lowest ranked journals viewed (1.18). It can be dangerous comparing across subject and therefore the data have been normalized for better comparison. According to the CIBER-generated relative impact factor Physics viewed the lowest ranked journals and Earth sciences the highest.

Journals used. The highest concentration of article use was found in Economics, where nearly 47 per cent of use was accounted for by just 5 per cent of journals. By marked contrast the equivalent figure for Physics was nearly 27 per cent. The highest number of unique journal titles was viewed in Life Sciences, which of course had the most journals in the first place (539). Almost every journal in a subject field was used, 97 per cent in the case of Earth Sciences and 100 per cent in the case of Economics, a testament to the success of large digital collections like ScienceDirect. This supports the OhioLINK data which also showed that, even in the case of the biggest of the big deals (around 6,000 journals); all journals end up being used (Nicholas *et al.*, 2007).

Key subjects comparisons

The subject analyses have conclusively demonstrated that researchers in different subjects behave very differently and, for ease of comparison, Table IV summarises the key differences.

Institutional diversity within subject fields

Two diverse subject fields have been chosen to illustrate institutional diversity, a science, Life Sciences, and a social science, Economics. Institutional diversity data for all the case study subjects can be found in CIBER (2009).

Table V gives the number of researchers entered for the two subjects in RAE 2008, which provides a very rough idea of the size of the research populations for each participating university and these data are particularly important in understanding volume of use (see Figures 4 and 5 in particular).

Life sciences

Usage. Of the ten institutions the three biggest users were Cambridge, Manchester and UCL (Table VI). Cambridge ranked first in the case of all the usage metrics – 20 per cent of page viewed, 21 per cent of PDF articles viewed and nearly 20 per cent of sessions conducted. Again, the heaviest users had the shortest session times; with Cambridge recording the shortest sessions of all (74 seconds) and Bangor (one of the smallest users) the longest ones (293 seconds). The OhioLINK study also showed that research-intensive institutions were characterised by short session times (Nicholas *et al.*, 2008a). As will be

	Number of journal titles viewed	Top 5 per cent of journals accounted for (per cent of use)	Average number of page views per session	Percentage of sessions featuring a view to an abstract	Gateways (per cent page views resulting from visits from a gateway)
Chemistry	196	39.5	3.2	23.3	49.2
Earth and environment science	248	29.6	3.6	22.7	41.4
Economics	132	46.9	3.8	30.4	19.0
Life sciences	531	38.1	2.0	19.5	65.9
Physics	204	26.6	2.5	20.1	57.8

Table IV.
Key usage and information-seeking subject differences

	Economics	Life sciences (inc. agricultural and veterinary)
Aberdeen	14	67
Bangor	n/a	52
Cambridge	38	253
Edinburgh	18	230
Manchester	35	107
Swansea	18	16
Strathclyde	n/a	n/a
UCL	32	79
Total	155	804

Table V.
Number of researchers entered for the two case study subjects in RAE 2008

Figure 4.
Life sciences use
compared with researcher
population

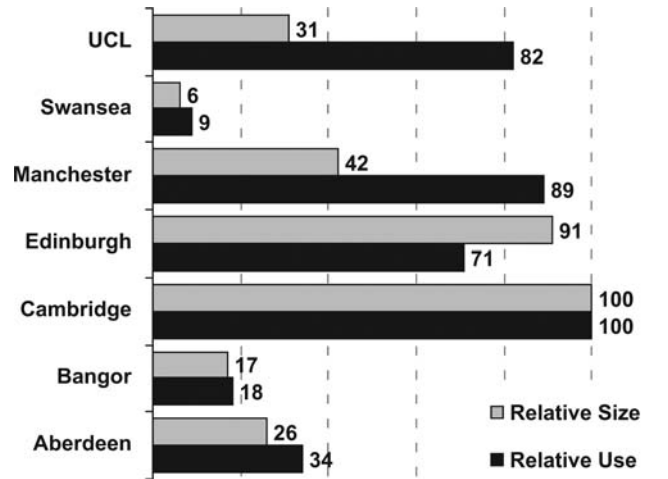
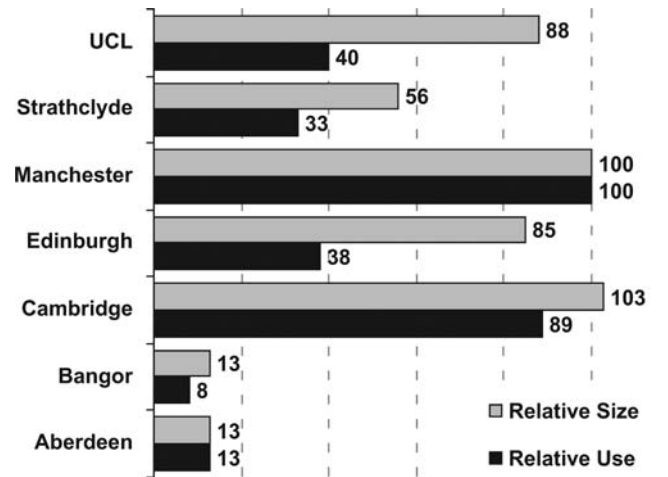


Figure 5.
Economics use compared
with researcher population



discovered later, Cambridge researchers employed gateways the most and Bangor the least and this partly accounts for the time differences between them.

Figure 4 compares use (page views) with the size of subject discipline (as indicated by numbers of staff FTEs submitted to the 2008 Research Assessment Exercise[4]). The data are indexed to the institution with the largest number of research-active staff in that subject. It shows that use at UCL and Manchester was much higher than might have been expected given the size of the potential population of researchers and the very opposite was true in the case of Edinburgh.

Really big differences emerged in weekly patterns of use. Researchers in universities and government laboratories behaved very, very differently, especially in regard to weekend searching. Typically, in the case of university researchers, 14-15 per cent of ScienceDirect use took place over a weekend; however, for the two laboratories, it was less than half of that. In regard to the time of day when use occurred, CEH stood

Table VI.
Life sciences usage
metrics

Institution	Total page views		Total full-text views		Total HTML views		Total PDF views		Session numbers		Session time Ave. in seconds
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Aberdeen	47,030	7	28,947	7	14,748	6	14,199	6	15,322	5.7	154
Bangor	25,118	4	13,533	3	5,188	2	8,345	3	7,255	2.7	293
Cambridge	140,243	20	92,565	21	55,340	23	37,225	21	56,271	20.9	74
Edinburgh	100,134	14	57,867	13	31,212	13	26,655	13	37,483	13.9	81
Manchester	124,225	18	82,560	19	45,098	19	37,462	19	48,817	18.2	84
Strathclyde	23,907	3	15,453	3	6,958	3	8,495	3	7,834	2.9	272
Swansea	13,427	2	8,427	2	3,764	2	4,663	2	4,371	1.6	281
UCL	114,998	16	67,628	15	40,474	17	27,154	15	46,622	17.3	61
CEH	4,424	1	1,795	0	595	0	1,200	0	1,306	.5	122
Rothamsted	8,834	1	4,125	1	2,457	1	1,751	1	3,032	1.1	89

out with virtually no use having occurred in the night or early morning. By marked contrast 13 per cent of Strathclyde searching was undertaken then. Indeed, it appears that Scottish researchers generally search well into the night.

Method of access. Cambridge researchers made most use of gateways, with nearly three-quarters of views accounted for by gateway visitors and Bangor researchers the least with less than half using gateways (Table VII). Only a small percentage (4 per cent) of Life Sciences titles were available to Google searchers during the survey period, so Google traffic levels were bound to be low, and they were. Swansea researchers used Google the most to access ScienceDirect Life Science content. Nearly 4 per cent of their sessions originated from a Google search. UCL and Cambridge users showed the strongest preference for coming via Pub Med, with more than one third of sessions emanating from this route. Cambridge and UCL have medical schools and that will predispose them to using Pub Med. In contrast at Bangor just 6.4 per cent of sessions originated from a Pub Med visitor.

Navigation. CEH researchers exhibited the strongest preference for browsing - over two thirds of their sessions featured a view to a menu, and this might be explained by a strong current awareness need. By contrast, Cambridge researchers viewed a menu in one in four sessions. Advanced searching was generally very unpopular throughout Life Sciences, and researchers from the laboratories never used the facility at all. Proportionally speaking, Swansea researchers used the facility the most, in 0.6 per cent of sessions, but this still only constituted 28 uses in four months. The "use" of advanced searching appears not to be related to research performance. Basic searching proved most popular at Swansea where over 5 per cent of sessions saw the facility used and least popular at Cambridge and UCL, where just 0.7 per cent of sessions featured its use, tiny levels really and quite at odds with what some survey studies have found. Thus questionnaire surveys have found a tendency among online journals' users toward searching rather than browsing (e.g. Eason *et al.*, 2000; Sathe *et al.*, 2002; Talja and Maula, 2003; Boyce *et al.*, 2004). One explanation could be that researchers behave differently from general population of scholars; another could be that researchers conduct their searching on gateway sites and most of the activities on the publisher sites are related to browsing. Other log studies support this scenario. Thus, an analysis of referral logs of the use of chemical journals showed that library catalogues and

		Gateway access	Google access	PubMed access	Menu use	Advanced search	Basic search
Aberdeen	<i>n</i>	10,105	63	2,396	5,706	35	356
	% ^a	65.8	0.6	21.6	37.2	0.2	2.3
Bangor	<i>n</i>	3230	31	322	4,068	14	289
	%	44.4	0.6	6.4	56.0	0.2	4.0
Cambridge	<i>n</i>	41,370	437	15,703	15,069	112	373
	% ^a	72.9	1.0	35.0	26.5	0.2	0.7
Edinburgh	<i>n</i>	23,507	207	9,094	13,638	34	559
	%	62.3	0.8	34.8	36.1	0.1	1.5
Manchester	<i>n</i>	31,856	252	9,530	15,405	75	990
	%	64.8	0.7	27.1	31.3	0.2	2.0
Strathclyde	<i>n</i>	3,630	53	1,205	4,248	24	306
	%	46.2	0.9	21.4	54.1	0.3	3.9
Swansea	<i>n</i>	1,774	115	376	2,569	28	228
	%	40.5	3.9	12.7	58.7	0.6	5.2
UCL	<i>n</i>	31,333	182	13,189	14,678	28	325
	%	66.6	0.5	36.3	31.2	0.1	0.7
CEH	<i>n</i>	399	18	150	894	0	22
	%	30.5	2.0	17.0	68.4	0	1.7
Rothamsted	<i>n</i>	1,817	20	218	1,306	0	24
	%	59.3	1.4	15.2	42.6	0	0.8

Table VII.
Method of access and navigation (sessions)

Note: ^a Percentage of all sessions for that subject

bibliographic databases, which are both set-up for searching, were the top two sources that led users to journals (Davis, 2004).

Content viewed. Bangor recorded the most “active” sessions with, on average, 4.2 pages and 2 articles viewed; in contrast the figures for Cambridge were meager, the figures being, respectively, 2 and 1.5 (Table VIII). The least active sessions generally

Subject	Volume		Ave. no. of journals viewed	Form Per cent viewing an abstract	Age/currency		Per cent viewing an AIP	Impact Relative impact factor
	Ave. no. of pages viewed	Ave. no. of articles viewed			Ave. age of article viewed (days)	Alerts (%)		
Aberdeen	3.1	1.9	1.4	25.4	579	0.1	6.5	1.2
Bangor	4.2	2.0	1.6	27.4	1,007	0.1	7.6	0.9
Cambridge	2.0	1.5	1.2	17.2	722	0.1	6.5	2.0
Edinburgh	2.1	1.4	1.2	18.1	788	0.1	6.9	1.5
Manchester	2.1	1.5	1.3	20.1	828	0.1	6.9	1.6
Strathclyde	3.6	1.9	1.5	22.9	900	0.2	10.4	1.1
Swansea	3.8	1.9	1.5	26.9	737	0.2	10.2	1.0
UCL	2.0	1.3	1.1	17.3	507	0	7.3	1.7
CEH	3.4	1.3	1.3	17.4	309	0	11.1	1.0
Rothamsted	2.3	1.2	1.3	18.7	477	0.1	8.4	1.0

Table VIII.
Content viewed (sessions)

were those of the research-intensive universities. Bangor also viewed the most journals in a session (1.6), although it was UCL, not Cambridge, this time which viewed the least (1.1). Swansea recorded the highest levels of abstract viewing – over one in four sessions viewed an abstract; for Cambridge the equivalent figure was more like one in six. The research-intensive universities (and the greatest users of gateways) used abstracts the least.

There were large differences in terms of the age of the Life science articles viewed. Bangor viewed the oldest articles (1007 days old) and CEH the most recent (309). Part of the explanation might lie in the fact that non-academic researchers at CEH are plainly more focused on currency than their academic colleagues. There appears also to be a difference between the research intensive universities and teaching-oriented ones. Thus UCL and Cambridge viewed the newest material and Bangor and Strathclyde the oldest. However, Swansea was an exception to the rule. The differences could arise from the fact that within Life Sciences there are very different “styles” of research, from interdisciplinary to basic and from big teams to individuals. Or another explanation could be that there is a wide range of topics and intensity differences within Life Sciences.

E-mail alerts were rarely used; although they were a little more popular at Strathclyde and Swansea (in both cases 0.2 per cent of sessions featured their use). It might be that these researchers are not so well connected as their colleagues in Manchester or Cambridge. CEH, clearly an institution where currency is very important, made most use of articles in press: 11 per cent of sessions saw an AIP viewed. Interestingly this is another area of behaviour where the major research universities were the lowest users of the facility.

The higher the institutions research ranking, the higher the ISI rank of the journal viewed. Thus Cambridge’s average relative factor was 2.0, whereas that for Bangor was 0.9. The difference may be due to a Big Science effect where the top researchers are undertaking more basic science, whereas at Bangor research is more applied.

Journals used. In the case of three institutions (Bangor, Cambridge and CEH) just 5 per cent of the available journals accounted for more than 50 per cent of all use, high-levels of concentration indeed. At Aberdeen and UCL use was spread more evenly, where 5 per cent of journals accounted for one-third of use. Manchester viewed the highest number of unique journals (517) and CEH the least (209). Generally, the more research active the university the greater the number of titles viewed. Cell and Current Biology proved to be the most used journals; both were ranked in the top five lists at seven of the ten institutions. In fact, in the case of Cambridge, Cell accounted for 13 per cent of all Life Science use.

Economics

Usage. Economics followed a similar usage pattern to those of the scientific subjects, with the top institution (Manchester) accounting for a third of all use. Manchester, which has a business school, accounted for around a third of all use, whatever the metric adopted (Table IX). Cambridge, which actually submitted most economic researchers to RAE 2008, conducted the shortest sessions, 119 seconds, and Bangor the longest ones (403 seconds).

A good deal of use occurred over the weekends and, in the case of Aberdeen, this accounted for 17 per cent of all use. Similarly, a good deal of use occurred outside of normal office hours (9-6); in fact, for Bangor the figure exceeded 50 per cent. A check showed that this could not be attributed to robots.

Institution	Total page views		Total full-text views		Total HTML views		Total PDF views		Session numbers		Session time Ave. in seconds ^a
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Aberdeen	4,966	4	2,078	4	820	7	1,258	3	1,403	4.5	168
Bangor	7,325	6	4,079	8	600	5	3,479	8	1,208	3.9	403
Cambridge	23,540	19	8,922	17	1,517	13	7,405	18	5,958	19.1	119
Edinburgh	15,494	12	5,865	11	1,111	9	4,754	11	3,478	11.2	169
Manchester	40,880	33	18,015	34	3,917	34	14,098	34	10,202	32.8	149
Strathclyde	12,108	10	6,146	12	1,301	11	4,845	11	2,938	9.4	267
Swansea	2,976	2	1,305	2	422	3	883	2	814	2.6	196
UCL	12,844	10	4,433	8	1,193	10	3,240	8	3,574	11.5	111
CEH	12	0	2	0	2	0	0	0	7	0	251
Rothamsted	22	0	13	0	5	0	8	0	9	0	326

Table IX. Economics usage metrics **Note:** ^aHuber's M-Estimator

Figure 5 compares use (page views) with the size of subject discipline (as indicated by numbers of staff FTEs submitted to the 2008 Research Assessment Exercise[4]). The data are indexed to the institution with the largest number of research-active staff in that subject. It shows that aside from Manchester and Aberdeen' use figures were below what might have been expected given the size of their research populations.

Method of access. Unsurprisingly, the levels of gateway access were considerably down on what has been recorded previously for the scientific subjects, attaining just a quarter of sessions in the case of Aberdeen (Table X). Swansea again recorded the greatest use of Google – it was used in 5 per cent of sessions.

Navigation. Menu use was generally high, and very high at Edinburgh where menus were viewed in three quarters of all sessions. Swansea used the advanced search facility the most. Bangor recorded the highest levels of basic searching with around 5 per cent of sessions seeing it employed.

Content viewed. Bangor recorded the busiest sessions, which averaged 5.1 page and 2.4 articles viewed (Table XI). (The CEH data were too low to count). Edinburgh though viewed the most unique journals in a session (2.4 on average). In regard to the universities, abstract viewing was greatest at Aberdeen where more than a third of sessions saw an abstract viewed and lowest at Edinburgh and Bangor, where abstracts were viewed in fewer than a quarter of sessions. Cambridge, Edinburgh, Manchester and Strathclyde all viewed articles aged 1,700 days or older. Bangor and Swansea recorded the highest proportions of sessions viewing an AIP; around 1 in 10 sessions did so. Generally, the ISI impact factor of the journals viewed were on the low side, with the relative factor dropping below the key 1.0 mark for Cambridge and Swansea. The high score for Strathclyde stands out (1.4) and is unexplained.

Journals used. High levels of concentration were found at Bangor where two thirds of use was accounted for by 5 per cent of journals. There was quite a different picture at Swansea where 5 per cent of journals accounted for just 40 per cent of use. Excluding the laboratories, where figures were too small to have any real significance, the highest number of journals were viewed at Manchester (127) and lowest at Swansea (83). World development was clearly the most popular journal in the field, ranked first by six of the 11 institutions.

		Gateway access	Google access	PubMed access	Menu use	Advanced search	Basic search
Aberdeen	<i>n</i>	494	22	12	857	2	39
	% ^a	25.2	2.8	1.5	61.0	0.1	2.8
Bangor	<i>n</i>	170	8	1	896	2	63
	%	14.0	0.8	0.1	74.0	0.2	5.2
Cambridge	<i>n</i>	740	156	8	3675	7	108
	%	12.4	3.3	0.2	61.6	0.1	1.8
Edinburgh	<i>n</i>	474	30	10	2636	11	108
	%	13.6	1.5	0.5	75.8	0.3	3.1
Manchester	<i>n</i>	2,198	38	6	6,480	20	338
	%	21.5	0.5	0.1	63.4	0.2	3.3
Strathclyde	<i>n</i>	560	17	0	2050	6	134
	%	19.1	0.8	0	69.8	0.2	4.6
Swansea	<i>n</i>	175	31	3	562	9	37
	%	21.5	5.7	0.6	69.0	1.1	4.5
UCL	<i>n</i>	763	67	6	2,186	3	86
	%	21.8	2.7	0.2	61.1	0.1	2.4
CEH	<i>n</i>	2	0	0	5	0	1
	%	28.6	0	0	71.4	0	14.3
Rothamsted	<i>n</i>	3	0	0	6	0	1
	%	33.3	0	0	66.7	0	11.1

Note: ^a Percentage of all sessions for that subject

Table X.
Method of access and
navigation (sessions)

Subject	Ave. no. of pages viewed	Volume		Form Per cent viewing an abstract	Age/currency		Impact Relative impact factor	
		Ave. no. of articles viewed	Ave. no. of journals viewed		Ave. age of article viewed (days)	% Alerts viewing an AIP		
Aberdeen	3.9	1.6	1.4	35.9	1,049	0.1	7.7	1.0
Bangor	5.1	2.4	1.4	24.3	1,471	0	9.8	1.0
Cambridge	3.6	1.3	1.1	34.0	1,756	0.1	4.5	0.9
Edinburgh	4.4	1.6	1.2	24.9	1,736	0.1	5.9	1.1
Manchester	3.7	1.5	1.1	28.0	1,746	0	5.1	1.0
Strathclyde	4.4	1.8	1.3	32.5	1,731	0.1	8.9	1.4
Swansea	4.2	1.6	1.3	30.1	1,431	0.2	9.8	0.8
UCL	3.3	1.0	1.1	33.4	1,266	0	5.1	1.0
CEH	5.7	1.8	n/a	28.6	729	0	0	1.1
Rothamsted	5.3	3.6	n/a	44.4	1,011	0	22.0 ^a	0.5

Note: ^aBased on just four

Table XI.
Content viewed (sessions)

Conclusions

The paper had the following aims:

- (1) to investigate UK researchers' use and information seeking behaviour in regard to e-journals;
- (2) to ascertain whether UK researchers' use and behaviours varied by subject and institution; and
- (3) to generate questions for the second stage of the project, which is a qualitative study that sought to obtain explanations for the behaviour we have discovered in the logs.

With respect to the first aim the main findings were:

- (1) *E-journals proved to be very popular with UK researchers.* Over half a million ScienceDirect sessions were conducted in respect to the four case study subjects at ten institutions in the space of just four months. Furthermore, 98 per cent of the 1,400 ScienceDirect journals available to the case study institutions were used. British academics have shown a high uptake of e-journals since early 2000s (Urquhart *et al.*, 2003).
- (2) *Use was highly concentrated.* Thus, typically 5 per cent of journals accounted for a third to half of all page views – by any standards very high concentration levels. This is not surprising as the “80/20 rule”, or Pareto principle (Evans and Peters, 2005) normally applies to use of journals. This principle indicates that 80 per cent of the usage by all members coming from 20 per cent of the titles.
- (3) *Information seeking was fast and direct.* A high proportion of researchers entered ScienceDirect via a third-party site, such as PubMed, staying just long enough to pick up the full-text they had identified elsewhere. Partly as a result, most users visited ScienceDirect for only a few minutes, and viewed only a couple of pages during their visit. A previous study of ScienceDirect (Huntington *et al.*, 2007) also showed relative high use of gateways and the fact that those who enter the site via a gateway are likely to visit only one or two items in a session.
- (4) *Researchers by-passed carefully-crafted discovery systems.* Advanced search, basic search, e-mail alert facilities were hardly used at all. Not surprisingly then just four months after ScienceDirect content was opened to Google, a third of traffic to ScienceDirect's Physics journals (the first subject to be opened) came via that route. This effect is particularly notable since Physics is well known for being richly endowed with information systems and services.
- (5) *Researchers used e-journals well into the night and over the weekend.* Nearly a quarter of ScienceDirect use occurred outside the traditional 9-5 working day and weekends accounted for around 15 per cent of ScienceDirect use.

The main findings with respect to the second aim were:

- *Researchers did seek and use information in very different ways.* Users in research-intensive universities behaved very differently from those in less intensive ones: per capita use was highest in the most research intensive institutions; their users spent much less time on each visit; they forsook many of the online facilities provided on the publisher's platform; and they were much

more likely to enter via gateway sites. There were also marked differences between subject and between type of institution: User behaviour varied markedly by subject: for example, life scientists were much more likely to enter ScienceDirect via a gateway site than economists. Users in government laboratories and universities, even within the same subject and using exactly the same source, exhibited very different information behaviour and especially so in regard to the time when searching was conducted. Disciplinary differences have been well-established in the area of information needs and behaviour (Sparks, 2005).

- *Great diversity was evidenced with regard to the age of article viewed.* This was true in regard to both subject and institution. There were very large differences of the order of 100-300 per cent in the age of articles viewed. In subject terms the average age of an article viewed in life sciences was 859 days and 1,552 for economics. In diversity terms the average age of life science articles used at the Centre for Ecology and Hydrology was just 309 days, while at Bangor it was 1,007 days. These findings are in line with those of previous researchers. Two studies by Cunningham and Bocock (1995) and Guthrie (2000) showed that life science articles decay faster than those in economics. A study by Laarhoven and Fahmi of a Big Deal subscription to all Elsevier journals at the University of Groningen in 2005 showed that the use half-life of the whole Elsevier journal package was calculated at 387 days.

The usage and information seeking habits of researchers from identifiable institutions has been described in unparalleled detail on a scale not witnessed before. However, log data raises the important questions that need to be asked but does not provide any reasons for this behaviour. That is the role of the interviews, observation and questionnaires we are undertaking in the second stage of the project.

Notes

1. www.rin.ac.uk/use-ejournals
2. All project reports can be found at the RIN web site and available at: www.ucl.ac.uk/infostudies/research/ciber/
3. Gateway is an Elsevier term that refers to an access via a link that jumps direct to content. In these circumstances no ScienceDirect menus or non content resource pages are used. Most users linked via gateways like PubMed, some users surfed from paper to paper but they were in the minority.
4. Not all institutions submitted all their research-active staff, so this figure provides only a rough indication of relative size.

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