INFORMATION BEHAVIOUR OF
THE RESEARCHER OF THE FUTURE

A British Library / JISC Study

TRENDS IN SCHOLARLY
INFORMATION BEHAVIOUR

Work Package I
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# CONTENTS

Scope of this work package 3

Changing contexts for scholarly production and use 3
   Changing research needs and practices 3
   The ‘Tragedy of the Commons’ 5

The digital transition 6
   Early studies 6
   Evolutionary processes 9
   Print vs electronic journals 13
   Electronic books 14
   The digital transition: some theoretical perspectives 17

Subject domains and information use 18

Changing user behaviour 21
   Writing and researching articles 21
   Finding articles 21
   Reading articles 25
   Using articles 27
   Ageing and obsolescence studies 29

Supporting Google Generation users 31

Summary of key findings 32

References 34
**Scope of this work package**

The aim of this work package is to identify and track some of the main trends in scholarly information behaviour over the critical period from 1995 (the beginnings of the impact of the internet) to the present. The materials examined are predominantly research-based articles in the international journals literature. The emphasis of this package inevitably tends towards electronic journals. This was not a deliberate editorial policy, it simply reflects the huge impact of this format on students, researchers, librarians and publishers over this period.

**Changing contexts for scholarly production and use**

This introductory section provides a general context for the materials that follow by examining some of the larger-scale trends that are shaping the research landscape and patterns of scholarly communication.

**Changing research needs and practices**

A study of research practices in the digital environment by Houghton, Steele and Henty (2003 and 2004) offers some useful insights into the ways that the self-reported behaviour of (Australian) researchers are changing in response to pressures bearing down on the academy. The main assertion of this study is that the context within which Australian research is conducted is being increasingly shaped by the needs of society and the national economy rather than being primarily driven by the natural curiosity of scientists. Using a framework developed at the Science Policy Research Unit (SPRU) in Sussex in the early 1990s, the authors find considerable evidence for a fundamental shift from basic Mode I (researcher-driven, tightly disciplinary bounded) to developmental and applied Mode II (funder- or problem-led, highly interdisciplinary) knowledge production.

As evidence, they cite survey findings that show:

- 56% of respondents said that their research was becoming ‘increasingly interdisciplinary’, 22% that it was ‘more applied’

- research is being conducted in a wider range of settings: 60% of respondents reported an increase in the locational diversity of their collaborators

- collaboration is spreading into the humanities, arts and social sciences, with more than 50% reporting an increase in team collaboration, the main reasons being access to specialist skills, intellectual property and equipment

- 74% said they now worked as part of a team

A 2002 paper by Liu provides further evidence of the increasingly collaborative nature of the research enterprise (Table 1) by means of a longitudinal analysis of three journals1, using a century’s worth of data, 1900-2000.

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1Journal of the American Chemical Society, American Journal of Mathematics, American Journal of Sociology
Table 1: Average numbers of authors per paper (after Liu, 2002)

<table>
<thead>
<tr>
<th>Year</th>
<th>Chemistry</th>
<th>Mathematics</th>
<th>Sociology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>1.36</td>
<td>1.04</td>
<td>1.00</td>
</tr>
<tr>
<td>2000</td>
<td>4.30</td>
<td>1.45</td>
<td>1.58</td>
</tr>
<tr>
<td>Increase</td>
<td>216%</td>
<td>38%</td>
<td>58%</td>
</tr>
</tbody>
</table>

Here is evidence of increasing author collaboration in three very different fields with a particularly dramatic increase in the case of chemistry\(^1\). Liu also presents some interesting new data on the growth of the journals literature in the three disciplines (Table 2) using numbers of journal pages produced per annum as the key metric.

Table 2: The growth of the journals literature (after Liu, 2002)

<table>
<thead>
<tr>
<th>Year</th>
<th>Chemistry</th>
<th>Mathematics</th>
<th>Sociology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>414</td>
<td>388</td>
<td>864</td>
</tr>
<tr>
<td>2000</td>
<td>13,040</td>
<td>1,308</td>
<td>1,840</td>
</tr>
<tr>
<td>Increase</td>
<td>3,050%</td>
<td>237%</td>
<td>113%</td>
</tr>
</tbody>
</table>

Houghton, Steele and Henty (2003) claim that, in spite of this growth, 82% of their respondents are making greater use of primary materials than before: in other words they are reading more articles. King et al. (2003) also note that the amount of academic reading has increased over the past 25 years, mostly from library collections as personal subscriptions decline and as the result of a large increase in bibliographic searching. They too argue that academics are reading across a wider range of sources, further evidence for which comes from Boyce et al. (2004) who show a growth in the range of journals consulted, from at least one article per year from 13 titles in the late 1970s to 18 in the mid-1990s to approximately 23 by the year 2001. This they attribute to greater awareness as the result of wider access to end-user search tools.

However, this may be a narrow interpretation since the transition from Mode I to Mode II knowledge production is not simply a matter of concern to the science policy analyst: these forces may be beginning to impact directly on information seeking behaviour as researchers engage in more transdisciplinary problem-oriented work (rather cruelly dismissed by Houghton, Steel and Henty as a shift from a shift from hypothesis testing to “suck-it-and-see science”).

“Online information search and access practices increasingly reflect the diverse needs of traditional disciplinary research and the needs of those engaged in an emerging new mode of knowledge production.” (Houghton, Steele and Henty, 2003, p. 53)

This argument develops from the observed popularity of generic web search engines and the relatively low use of subject gateways (except in areas where they tend to be problem oriented, e.g. medical and health, or where the discipline remains strong and retains essentially Mode I characteristics, e.g. mathematics). The popularity of databases of electronic journals is perhaps in part due to the opportunities they offer to cross disciplinary boundaries.

\(^1\) Note, however, that Price’s (1965) prediction of the death of the single-authored article is still some way off: 55% of 2000 articles in sociology, 57% in mathematics and 1.5% in chemistry were singletons.
The growth in the literature has profound implications for readers:

- lower attention per unit of information as faculty read more, and more widely, but spend less time per article (King and others, 2003 and Tenopir, King and Bush, 2004)

- since the absolute level of reading is pretty constant (King and Tenopir, 1999), researchers must inevitably be reading a smaller proportion of each year’s output

**The `Tragedy of the Commons`**

The other major context within which information seeking behaviour and use should be considered is the so-called ‘journals crisis’. A number of recent papers have examined the fundamental mistrust that has developed in certain quarters. McGrath (2002) and Miller and Harris (2004) offer clear, if rather general, overviews of the current crisis in scholarly communication, seen respectively through the eyes of scholars, editors, publishers and institutions. Like many other commentators, they see the problem as essentially an economic issue:

> “An understanding on the part of editors and their institutions of the extent to which they are subsidizing the scientific publishing enterprise is … growing” (Miller and Harris, 2004, p.86)

This is a good example (Houghton, Steele and Henty, 2003 is a more extreme example) of a kind of economic determinism: the inevitability of IT-based cost efficiencies and self-organisation by the academic community to cure the ills of the market.

A more thoughtful contribution is the paper by Davis (2003) based on the notion of the ‘Tragedy of the Commons’. This argues that authors, publishers and librarians are in conflict with what is in the best interest of the public good. Scholars rationally attempt to maximise their consumption of information, regardless of expense; publishers exploit the market for the highest prices it will bear and practice price discrimination; librarians attempt to build comprehensive collections and maintain free access rights for their users, real or potential. Davis argues that technology does not alter the basis of these incentives. His solution is for librarians to seize the opportunity to become guardians of the information commons by:

- selecting or rejecting information on the basis of its relevance, cost and utility, thus moving to an access model based on actual rather than potential use

- adopting a just-in-time business model, rather just-in-case

- adopting a cost-sharing model so that scholars become more aware of the true costs of their consumption

- developing a model that enhances the library’s ability to share with others

Despite the evident enthusiasm of users for electronic networked information, there are voices within the library community (see also the later section on Evolutionary Processes) that suggest that the shift to e-provision is simply a case of shuffling deck chairs on the deck of the Titanic:

> “Libraries cannot sustain a model involving purchasing print and licensing electronic copies of scholarly journals, particularly if there are expected to license multiple versions of the same journal title at ever increasing costs … If libraries are to go fully digital, all stakeholders—scientists,
publishers and librarians—must discuss not only the hot-button issues of archiving and access to current materials but also access to print-only materials—old and new.” (Vaughan, 2003, p. 1152)

Setting a strategic direction against a background of mistrust, misinformation and a lack of robust data is naturally very difficult.

Bjork (2004) offers a useful, open-minded, conceptual paper that explores the barriers hindering the proliferation of open access publishing, subject and institutional archiving in repositories. Bjork argues that a major barrier to change towards open access publishing is that author submission behaviour is highly conditioned by the academic reward system and that this is particularly explicit in the traditional journal system. Prestige counts for more than wide and rapid dissemination and easy access in this scenario.

He suggests that the success or failure of subject repositories has relatively little to do with the academic reward system, the motivations here are more efficient and faster dissemination. Thus, it follows logically that authors should be rewarded financially for archiving in an institutional repository and that this would be more effective in changing behaviour than mandatory approaches. His overall conclusion is that the barriers are formidable and insufficiently focused on author behaviour.

“Trying to get researchers to support the move towards open access, which most agree would be good for the advancement of science in principle, is like trying to get people to behave in a more ecological way. While most people recognise the need to save energy and recycle waste it takes much more than just awareness to get them to change their habits on a large scale” (Bjork, 2004, p.21).

The digital transition

In the period covered by this review, much of the published research is concerned with the issues thrown up by the transition from a largely print-based to a predominantly electronic journals environment. This throws up a number of concerns, some unexpected, which are organised in this section under three sub-headings: Evolutionary Processes, Print Versus Electronic Journals, and Theoretical Perspectives.

Early studies

Herman (2001) examines the transition from print to electronic information sources from research published between 1981 and 2000. Early studies focussed on the evolution of the digital library (Lancaster and Sandore 1997) and changes deriving from the development of electronic networks to support the growth in desktop access to the internet, bibliographic and full text databases and the significant use of email as a means of scholarly communication. (Adams and Bonk, 1995; Budd and Connaway, 1997) Disciplinary variations were noted, with the scientific community adopting electronic information sources more enthusiastically than those in the arts and humanities (Liebscher et al, 1997; Mehta and Young, 1995; Pullinger, 1999, Noble and Coughlin 1997; Lazinger et al, 1997; Milne, 1999). The Superjournal project (Eason et al 2000) identified social scientists as frequent users.

Barriers to acceptance of electronic resources contributed to low usage on the part of academics and researchers. These were often technological and factors such as a lack of reliability, incomplete content, imperfect search engines, shortcomings in hardware, software and network access from home and the workplace, authentication and lack of integrated access across systems, onscreen readability and reproduction (page integrity),
and a perceived lack of attention by publishers to readers’ needs, such as browsing (Adams and Bonk, 1995; McKnight 1997; Rowland and others 1997; Budd and Connaway, 1997; Zhang, 2001; Rusch-Feja and Siebecky 1999). Despite the popularity of electronic resources on the one hand, a reluctance to abandon print formats on the other was to some extent fuelled by the low regard in which electronic journals were held and a reluctance by promotion committees to recognise their value, with peer review and archiving being frequently cited as issues (Cronin 1995).

Herman (2001) identifies a trend throughout the 90s for younger academics to make greater use of electronic resources (Lazinger et al 1997; Milne 1999; Zhang 1999). Whitmire (2001) also provides evidence of increasing engagement with electronic resources during undergraduates’ academic careers.

Projects such as Superjournal (Eason et al 2000, Pullinger 1999), an e-Lib programme which investigated the use of electronic journals in UK academic libraries and TULIP (The University Licensing Project) (Borghuis 1997, Hunter 1996) a collaborative study between Elsevier Science and nine universities in the US, identified issues relating to technical matters, user behavior and organizational and economic questions. TULIP’s primary focus was on e-journal delivery and usability issues in Materials Science titles, and log file analysis yielded data showing that graduate students viewed more abstracts and searched electronic journals more actively and with a broader focus than faculty. While undergraduate usage was not examined in depth, log data also indicated a significant degree of activity by this group. (Borghuis 1997). Superjournal, which examined breadth and depth of use of e-journals, found variations according to subject discipline and user status and identified social scientists as enthusiastic users, partly due the ability to browse broadly (Eason 2000, p 493).

Tenopir (2003) undertook a comprehensive review of research into electronic library resource usage published between 1995 and 2003, which brings together major (Tier 1) and smaller-scale (Tier 2) studies. A highly selective approach identified Eight Tier 1 studies, or groups of studies, defined as large scale, multi faceted, and generating complex findings described in many publications by different authors. The studies use a variety of research methods which can introduce contradiction and limit the ability for cross study comparison. (Table 3). Tier 2 studies typically involve fewer subjects in a specific environment or are one-time projects of similar quality to those designated Tier 1 status The purpose of Tenopir’s review is to identify reliable research studies for librarians and analyse their findings although she acknowledges that research methods will influence the conclusions that can be drawn from each study. Martzoukou’s (2005) review of research methods also concludes that web information seeking studies suffer from the lack of a consistent methodological framework and suggests that multi faceted studies, which consider factors such as experience, information need, affective and cognitive characteristics, and socially and culturally determined traits are needed to allow cross-study comparison.
Table 3: Tier 1 studies (after Tenopir 2003)

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Participants</th>
<th>Methods</th>
<th>Questions</th>
<th>Findings</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superjournal</td>
<td>1999</td>
<td>Students and faculty</td>
<td>Logs/surveys/focus groups/interviews</td>
<td>Preference and reported behaviour</td>
<td>User level</td>
<td></td>
</tr>
<tr>
<td>DLR/CLIR/OUTSELL</td>
<td>2002</td>
<td>Students and faculty</td>
<td>Interviews</td>
<td>Preference and reported behaviour</td>
<td>User level</td>
<td></td>
</tr>
<tr>
<td>Highwire/ejust</td>
<td>2002</td>
<td>Scholars and clinicians</td>
<td>Surveys/interviews/logs</td>
<td>Preference and reported behaviour</td>
<td>User level</td>
<td></td>
</tr>
<tr>
<td>PEW/OCLC-Harris/Urban Libraries Council</td>
<td>2002</td>
<td>Middle, high, and college students and general public</td>
<td>Surveys/observation/focus groups/journal keeping</td>
<td>Preference and reported behaviour and observed</td>
<td>User level</td>
<td></td>
</tr>
<tr>
<td>OhioLInk</td>
<td>1999-2001</td>
<td>OhioLInk users</td>
<td>Logs</td>
<td>Log analysis</td>
<td>Group level</td>
<td></td>
</tr>
<tr>
<td>Tenopir and King</td>
<td>1997-2003</td>
<td>Scientist and social scientists (academic and non academic)</td>
<td>Surveys/critical incident</td>
<td>Critical incident, preference and reported behaviour</td>
<td>User and reading levels</td>
<td></td>
</tr>
<tr>
<td>LibQual +TM</td>
<td>2000-2002</td>
<td>Library users at HE institutions (students and faculty)</td>
<td>Surveys</td>
<td>Preference and reported behaviour</td>
<td>User level</td>
<td></td>
</tr>
<tr>
<td>JSTOR</td>
<td>1999</td>
<td>JSTOR users (mostly faculty)</td>
<td>Logs</td>
<td>Preference and reported behaviour and log analysis</td>
<td>User and group level</td>
<td></td>
</tr>
</tbody>
</table>

Tenopir’s study concludes that scientists, humanists and social scientists seek and use information differently, as do undergraduate and graduate students and faculty. In the social sciences, business and economics faculty have been early adopters of electronic information resources. Many findings of the Tier 1 studies are reflected in the Tier 2 studies, allowing consistent conclusions to be drawn. Some themes are unique to some studies, while others emerge consistently, but with contradictory results.
General themes are:

1. Differences in behaviour or preferences that can be explained by differences among users (e.g. disciplinarity, user status or workplace)
2. Information seeking behaviour and preferences including differences between print and electronic resources (e.g. browsing vs searching, awareness of electronic resources, print/electronic preferences, reasons for resource use)
3. Perceived advantages of electronic resources (e.g. time savings, improved workflows, currency and features of electronic systems)
4. Perceived disadvantages or concerns of electronic resources (e.g. technology, archiving, formats for reading, print vs electronic resources)
5. Library policy and financial issues.

While many of these themes are identified in Herman’s (2001) study, Tenopir’s review extends the findings into the new millennium, when research interests turned away from the technological aspects of digital libraries to those of the electronic library user and their interactions with electronic resources.

**Evolutionary processes**

Mahe (2003) and Boyce et al. (2004) identify three phases in the evolution of the electronic journal:

- an early, pre-1993, pre-Web, phase where electronic full texts were confined to CDROM and a few online services and article readings are almost entirely confined to print: this phase is characterised by low levels of electronic use, a preference for low technology resources, and a lack of recognition of e-journals which are anyway only accessible through limited experimental platforms.

- an evolving phase, beginning in the late 1990s and continuing into the present, marked by the availability of print and electronic alternatives: in this phase electronic use increases but fails to reach critical mass: research attention focuses on readers and on the socio-cognitive factors that enable or inhibit take-up (technical barriers, lack of knowledge, peer pressure, and the fact that prestige is still associated with print rather than virtual journals).

- an advanced phase, already arrived at in some disciplines, marked by sophisticated information systems designed specifically to enhance the way that scientists work (e.g. NASA’s Astrophysics Data System): research attention becomes increasingly user-focused as critical mass develops: knowledge on use becomes more specific and detailed and greater sensitivity is shown to differences between disciplines.

Brennan et al. (2002) employ a diffusion theory approach in their qualitative study of science faculty members’ use of and attitudes towards electronic resources. They conclude that the following characteristics of e-journals are key determinants in the adoption process:

**Content**

- critical mass of issues and volumes for a given title
- critical mass of titles in a subject collection
- full equivalence to print issues
• timeliness of appearance

Functionality

• searching facilities that support browsing, locating known articles and subject / author retrieval

• ease of navigation

• links to other articles

• high quality printing

• seamless movement among related resources

In 2005, of course, practically all these elements are in place. Based on a series of longitudinal surveys, Boyce et al. (2004) authors ask the question, “how have electronic journals changed patterns of use?” (see Table 4) and relates this to the three evolutionary phases noted earlier.

Table 4: Sources of articles read (Boyce and others, 2004)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal subscription</td>
<td>46.3</td>
<td>36.0</td>
<td>15.2</td>
</tr>
<tr>
<td>Print</td>
<td>[100.0]</td>
<td>[67.8]</td>
<td>[54.5]</td>
</tr>
<tr>
<td>Electronic</td>
<td>[0.0]</td>
<td>[32.2]</td>
<td>[45.5]</td>
</tr>
<tr>
<td>Library subscription</td>
<td>40.6</td>
<td>49.1</td>
<td>49.0</td>
</tr>
<tr>
<td>Print</td>
<td>[99.1]</td>
<td>[80.0]</td>
<td>[12.7]</td>
</tr>
<tr>
<td>Electronic</td>
<td>[0.9]</td>
<td>[20.0]</td>
<td>[87.3]</td>
</tr>
<tr>
<td>Separate copy</td>
<td>13.1</td>
<td>14.9</td>
<td>35.8</td>
</tr>
<tr>
<td>Preprint</td>
<td>0.2</td>
<td>1.5</td>
<td>18.5</td>
</tr>
<tr>
<td>Archive (ADS)</td>
<td>0.0</td>
<td>0.0</td>
<td>10.2</td>
</tr>
<tr>
<td>Colleague provided</td>
<td>9.2</td>
<td>9.2</td>
<td>4.5</td>
</tr>
<tr>
<td>ILL / document delivery</td>
<td>3.6</td>
<td>3.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Author website</td>
<td>0.0</td>
<td>0.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Other</td>
<td>0.1</td>
<td>0.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4 reveals the extent to which electronic formats have displaced print, and illustrate a significant shift from journals to separates, all in a remarkably short space of time. For Odlyzko (2002), as for many other writers, this is a sign of the electronic journal as a revolutionary, disruptive technology. What went before is history.
“The real issue is that, in this new electronic age, if it isn’t online, for many purposes it might as well not exist. Further, even if it is online, it might not matter if it is not easy to access or timely” 
(Odlyzko, 2002, p. 10)

With the use of e-scholarly resources growing at 50-100% pa and print use static or declining, Odlyzko predicts that electronic formats will become the completely dominant medium in less than a decade.

Flaxbart (2001) finds that electronic access has taken over more completely and more rapidly in chemistry than anyone in could have predicted in the mid-1990s, with faculty leading the way. Much less use being made of the physical library because of the convenience and time-savings that are possible:

“As a new generation of graduate students moves into the faculty, it is very possible that their attitudes, coupled with market forces, will virtually eliminate the traditional printed journal from the radar screens of most practicing chemists” (Flaxbart, 2001, p.24)

Obst (2003) compared print and electronic use of 270 matched journals in the context of a German academic medical sciences library using re-shelving statistics and online user metrics3. He found that:

• print usage declined dramatically between 1999-2001

• electronic journal usage accelerating rapidly (nearly tripling over the same period)

• journals published in both formats lost 30.4% of their print use within approximately two years (the total loss for print only titles was 45.8%)

“This result … appears to confirm that what is read or purchased is determined primarily by ease of access and that there is a steady tendency to reduce the multiplicity of access modes to a manageable few” (Obst, 2003, p. 28)

Table 5: Impact of e-journals on print use (Obst, 2003)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AP</td>
<td>63</td>
<td>2,960</td>
<td>2,913</td>
<td>-1.6%</td>
</tr>
<tr>
<td>Blackwell</td>
<td>52</td>
<td>2,085</td>
<td>1,331</td>
<td>-36.2%</td>
</tr>
<tr>
<td>Elsevier</td>
<td>57</td>
<td>4,692</td>
<td>3,489</td>
<td>-25.6%</td>
</tr>
<tr>
<td>HighWire</td>
<td>11</td>
<td>4,457</td>
<td>2,803</td>
<td>-37.1%</td>
</tr>
<tr>
<td>Springer</td>
<td>87</td>
<td>3,054</td>
<td>1,460</td>
<td>-52.2%</td>
</tr>
<tr>
<td>Total</td>
<td>270</td>
<td>17,248</td>
<td>11,996</td>
<td>-30.4%</td>
</tr>
</tbody>
</table>

Within two years of their introduction, electronic accesses were exceeding print uses for matched pairs of journals by a factor of nearly eight (although this figure disguises wide variation between different publishers, as can be seen in Table 5). Obst notes a strong correlation (0.6 for 1999-2001) between frequency of use of a journal title in both formats: in other words, journals that are heavily consulted in digital libraries are often the same

3 A major limitation of this study is that the use statistics are very difficult to interpret: they pre-date COUNTER compliance standards and the author admits that the interpretation of publisher-supplied usage data is exceedingly difficult.
titles as those most often consulted in print. Walter (1996) found that usage increases with frequency of publication: titles published irregularly or less than four times are year have distinctly lower levels of use.

In contradiction to these studies, Siebenberg, Galbraith and Brady, 2004 conclude that most print journals at Washington State University’s Owen Science and Engineering Library in 2003 were actually being used more than they were prior to the introduction of electronic journals. They argue that the availability of electronic formats has in fact greatly enhanced the total use of all titles⁴.

“The popular lore / common wisdom that people are changing from using print journals to electronic journals is not true across the board. This study suggests that users’ migration from paper to e-use is dependent on subject area... It may be worth noting that [other] studies reporting e-use as more than ten times the paper use were conducted at medical libraries where the timesensitive nature of many queries may have been a factor” (Siebenberg, Galbraith and Brady, 2004, p. 436).

Surveys of ARL academic library members in 1991, 1995, 1997 and 2001 by Tenopir and Ennis (2002) offer another insight into the impact of the transition to electronic journal formats from a library professional perspective. They found

• a big shift from mediated searches to self-service searching, with nearly 20% of libraries reporting that mediated services would be withdrawn within two years

• reference staff dependency on electronic materials to service patron’s requests is now “virtually total”.

and noted that these developments are more complex than might at first be recognised

“Ironically, Web versions of fee-based research services can create some confusion on the part of library patrons because they fail to differentiate between free Web resources with the fee-based content libraries subsidize” (Tenopir and Ennis, 2002, p. 270)

As most of the reported trends seem to point towards the imminent demise of print, Vaughan (2003) poses the research question: “in a hybrid print / electronic journal environment, what data are needed to decide when print is no longer needed?” and undertakes a study to look at the short-term effects of online availability (Elsevier ScienceDirect was introduced in February 2000) of journals on print use at Duke University Chemistry Library. He compares the use of three groups of journals: `Elsevier’ (44 journals available in print and online), `electronic’ (84 journals available in print and online before the introduction of ScienceDirect) and 125 print only titles. His key findings are presented as Table 6.

Table 6: Use of print journals in a chemistry library (Vaughan, 2003)

<table>
<thead>
<tr>
<th></th>
<th>1999/00</th>
<th>2000/01</th>
<th>2001/02</th>
<th>Overall change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elsevier</td>
<td>1,656</td>
<td>1,157</td>
<td>662</td>
<td>-60.9%</td>
</tr>
<tr>
<td>Electronic</td>
<td>4,528</td>
<td>3,330</td>
<td>2,363</td>
<td>-47.8%</td>
</tr>
<tr>
<td>Print only</td>
<td>1,437</td>
<td>1,318</td>
<td>1,018</td>
<td>-31.2%</td>
</tr>
</tbody>
</table>

⁴ This is a broadly similar argument to that employed when VHS technologies were introduced: rather than ‘killing’ cinema, home viewing created a new experience and expanded size and scope of the overall film distribution market.
Vaughan notes a big drop in print use across all categories, even among print-only titles (down by nearly a third). This finding is echoed by De Groote and Dorsch (2001) who also found that the introduction of online services impacted on the use of print-only subscriptions at the University of Chicago Health Sciences Library. They point out that library patrons may assume that all journals are available in both formats and that librarians may have an an important awareness-raising role to carry out.

In spite of the obvious convenience and attractiveness of electronic formats, these are disturbing findings and are

“clearly a source of concern to information specialists, especially in light of the recent research study at John Hopkins University where drug toxicity information available from print sources was not used, resulting in the death of a study subject” (Vaughan, 2003, p. 1151)

In what one imagines is an article designed to inflame the debate about the impact of electronic access, Odlyzko (2002) questions some fundamental assumptions at the heart of formal scholarly communication, especially the view of journals as the ‘minutes of science’.

“Authors like to think of their articles as precious resources that are absolutely unique and for which no substitutes can be found. Yet a more accurate picture is that any one article is just one item in a river of knowledge … substitutes exist for almost anything” (Odlyzko, 2002, p.12)

This is an extreme example of the convenience argument and one that finds some support in the self-reported views of authors in a CIBER survey (Rowlands, Nicholas and Huntington, 2004) and in the detailed analysis of web logs by Nicholas et al. (2003). Odlyzko’s position is certainly iconoclastic, especially in relation to his views on the non-unique, substitutable, nature of much that is currently published.

On a more positive note for publishers, Odlyzko does highlight the importance of ‘digital visibility’:

“Whether they like it or not, scholars are engaged in a `war for the eyeballs’ just as much as commercial outfits, and ease of access will be seen as vital” (Odlyzko, 2002, p. 18)

A point which finds much empirical support in the work of the CIBER Group at University College London (Nicholas, Huntington and Watkinson, 2003 and Nicholas and others, 2004 and 2005) and who develop parallels between scholarly information seeking and general consumerist behaviour:

“While we sought to shed light on the Big Deal users and what resulted from the greater choices open to them, probably the most interesting data to emerge concerns ‘trialists’. This clearly shows that user behaviour can be easily manipulated through the use of consumer incentives - incentives all consumers, online and online, are familiar with.” (Nicholas, Huntington and Watkinson, 2003, p. 108).

**Print vs electronic journals**

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1 It should be noted, however, that print use of Print/Online journals declined at a slightly faster rate than for Print Only journals.
A number of studies have reported on the relative advantages and disadvantages of electronic and print formats. For example, Bar-Ilan, Peritz and Wolman (2003) undertook a large-scale questionnaire survey of senior academic staff in eight Israeli universities, exploring their use of electronic journals and databases (2000/2001).

They found that e-journals and databases have found wide acceptance across the academy with more than three-quarters of faculty making regular use and reporting very high levels of satisfaction. There are major differences between broad disciplines, with life sciences and medicine the heaviest users, humanities the lightest. Age appears to be a big factor: older faculty are much less likely to use e-journals than their younger colleagues.

There are clearly dangers with self-reporting surveys of this kind:

“390 (85.2%) [of survey respondents] feel that they were either perfectly competent [in using the Web] or they manage with a little bit of help from time to time” (Bar-Ilan, Pertitz and Wolman, 2003, p. 351)

Yet further on we read that 62.3% are interested in further training!

Table 7: Advantages of electronic services (Bar-Ilan, Peritz and Wolman, 2003)

<table>
<thead>
<tr>
<th>Advantages of electronic networked services (n=197)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed and ease of access</td>
<td>57.9%</td>
</tr>
<tr>
<td>Searching capabilities</td>
<td>35.5%</td>
</tr>
<tr>
<td>No need to go to the library</td>
<td>27.9%</td>
</tr>
<tr>
<td>Downloading / printing / copying</td>
<td>21.8%</td>
</tr>
<tr>
<td>Access to wider range of materials than in library</td>
<td>21.3%</td>
</tr>
<tr>
<td>Fast update</td>
<td>12.2%</td>
</tr>
<tr>
<td>Added value (e.g. user profiles)</td>
<td>9.6%</td>
</tr>
<tr>
<td>Obvious</td>
<td>6.6%</td>
</tr>
<tr>
<td>Other</td>
<td>5.6%</td>
</tr>
</tbody>
</table>

Table 8: Disadvantages of electronic services (Bar-Ilan, Peritz and Wolman, 2003)

<table>
<thead>
<tr>
<th>Disadvantages of electronic networked services (n=166)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow / difficult access</td>
<td>21.7%</td>
</tr>
<tr>
<td>Not enough coverage</td>
<td>20.5%</td>
</tr>
<tr>
<td>Reading text from a screen</td>
<td>19.9%</td>
</tr>
<tr>
<td>Complicated / confusing interface</td>
<td>10.2%</td>
</tr>
<tr>
<td>Inefficient searching</td>
<td>9.0%</td>
</tr>
<tr>
<td>Problem with back issues</td>
<td>7.2%</td>
</tr>
<tr>
<td>Lack of knowledge / skills</td>
<td>6.0%</td>
</tr>
<tr>
<td>Not updated quickly enough</td>
<td>2.4%</td>
</tr>
<tr>
<td>Other</td>
<td>23.5%</td>
</tr>
</tbody>
</table>
General conclusions of the study were that print was the preferred medium for use in teaching and for catching up with developments in other fields. Most of the researchers who were interviewed held firmly to the view that electronic materials are supplementing print, not supplanting it (but note the relatively early date during which this research was carried out in terms of the format revolution).

The inherently conservative nature of many academics is reinforced by Houghton, Steele and Henty (2003) whose respondents also made the point that things had not changed very much, that they are doing the same kinds of things, only quicker.

A very interesting study by Wulff and Nixon (2004) compares shelf replacement data with electronic use for three major vendors of electronic journals: Ovid, ScienceDirect and IDEAL in the health sciences library at the University of Louisville.

**Electronic books**

Information seeking behaviour in a digital environment is not limited to the internet and use of scholarly journals. Electronic books are increasingly available, although studies of e-book usage using transaction log data are limited. Connaway and Snyder (2005) undertook an analysis of netLibrary logs for a specific day over each of three years. The primary aim of the study was to establish system loadings, but the logs also yielded data about the number of books and pages viewed. Social science, science and technology titles were most consistently accessed and users viewed, on a single day, an average of 14.1 unique pages per book in 2002,16.4 in 2003 and 18.1 in 2004. The average time per session was approximately 11 minutes, suggesting that e-books were used as a reference collection, rather than being read in their entirety. Downloading functions were not available.

A more recent survey carried out at the University of Strathclyde (Abdullah and Gibb, 2006) which investigated awareness of e-books amongst students, found that although usage and awareness of e-books was limited, textbooks were most commonly used, with the majority of users (94%) reading them on-screen despite the disadvantages of eyestrain. Printing was also popular with 35% of respondents. A study carried out at the Indian Institute of Science (Anuradha and Usha, 2006) also identified low usage levels, but found that students used e-books more than faculty members and staff and used mainly technical and reference material. Bennett and Landoni (2006) also found limited awareness and low usage of e-books amongst students.

A more detailed study was carried out by Roesnita and Zainab (2005) at the University of Malaysia, who found that students preferred to read e-books online (82%) , rather than in print format (16%), however reasons for non-use include preferring paper books and difficulties in browsing and reading. This confirms the tension identified by Abdulla and Gibb (2006) between use by enthusiastic readers who read on screen despite the disadvantages which deter non-users. As with other studies a low level of usage of e-books was identified, and promotion suggested to increase take-up. An analysis of subject specific e-book usage was undertaken by Hernon et al (2007), who examined undergraduate use in nursing, economics and literature. Participants in the study tended to look at tables of contents before proceeding to relevant chapters. Printing was preferred to downloading, although expense was a deterrent; an alternative strategy was to cut and paste relevant sections into a Word document.
Resistance to electronic books by faculty was also found by Palmer and Sandler (2003). The limited take up suggests that more promotion of e-books is necessary to increase awareness.
The digital transition: some theoretical perspectives

The transformation in scholarly communication has naturally attracted the attention of theorists as well as empirical researchers. Jacobs (2001) uses discourse analysis to characterise the utterances of researchers and librarians and finds that technological determinism is a deeply entrenched position in both cases.

Bohlin (2004) argues that the publication of research results serves three fundamental functions for scholars: quality control, distribution and archiving. These functions set it apart from informal communication. In this respect, his arguments are broadly similar to those of Mabe (2001), acting as an antidote to the excesses of the technology determinists by returning to the fundamental communicative and other functions of journals and how these need to be maintained in the digital universe, although his conclusions are very different.

Bohlin’s basic argument is that the changes taking place in journal publishing and use are much more significant than they currently appear and that the whole system is about to implode completely:

“The significance of the Internet to academic publishing is comparable with that of the printing press and the scholarly journal: in the course of the process thus set in motion, the nature of the learned journal, as well as of scholarly communication in general, may well be reconfigured altogether” (Bohlin, 2004, p. 366).

Like many on the Left, Bohlin appears to welcome such disruption as a way of returning control to scholars. Fyffe (2001) reviews the scholarly communications crisis from a social theoretic point of view, drawing on the work of Castells and Giddens and argues that we should understand the fragility of digital systems (his concerns are very much to do with issues of preservation and the continuity of the scholarly record) and the resulting possibility of cultural loss as:

“an intrinsic feature of digital information technology, not as an accidental limitation that will inevitably be overcome … some of the efforts currently under way to reform the scholarly communication system may increase that risk by increasing the instability of the … market” (Fyffe, 2001, p. 61)

Fyffe’s is essentially an alarmist argument that bewails the increasing dependence of scholarship on business, systems and networks, leaving academia potentially subject to massive disruptive change outside of their control. He therefore calls for libraries and administrators to engage in risk management planning NOW.

These arguments are largely informed by the idea that what is technologically possible will inevitably be realised in the social and economic sphere (“technological determinism”).

Kling and McKim (2000) offer a very different perspective in a conceptual paper that argues strongly against the proposition that we are in the early stages of a communications revolution in which it is only a matter of time before all academic fields converge on a stable set of electronic forums. Using a Social Shaping of Technology (SST) perspective, they argue that notions of trust and legitimate communication pull against this tendency to convergence and that communications plurality will both persist and indeed become more sharply

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6 Bohlin maintains that the establishment of priority derives from the archiving function and is thus at a lower level in the hierarchy.
defined. Using the examples of high-energy physics, molecular biology and information systems as examples, the authors note stark differences in communication patterns and preferences between disciplines, which they believe to be persistent features:

“We expect that considerations of trust will continue to shape the kinds of scholarly communication that are seen as legitimate in a specific field. The divide between fields where researchers share unrefereed articles quite freely (‘open flow fields’) and those where peer reviewing creates a kind of chastity belt (‘restricted flow fields’) is likely to change slowly, if at all. Thus, for example, Ginsparg’s unrefereed and (largely) unrestricted working article server includes some areas of physics, and a few cognate mathematical and chemical subfields … but we expect few biological or chemical specialties to join forces with this venture” (Kling and McKim, 2000, p.6)

They argue that the electronic publishing reform movement is being energised by a core group of highly vocal enthusiasts (Harnad, Ginsparg, Odlyzko) and that these activists promote a shared ideology (briefly that electronic materials are less expensive, distribution is easier and wider and that these aspects will in and of themselves speed up scientific communication). The tenets of inevitability and convergence to a common set of tools flow from these arguments. These homogenise the debate and leave contestable areas (like the fact that disciplines are different) as uncontested.

In a related study, Kling, McKim and King (2002) explore scholarly communication from a Socio-Technical Interaction Networks (STIN) perspective. They refer to a broad spectrum of Scholarly Communication Forums (SCFs) such as e-print servers, e-journals and collaboratories and argue that a regrettable tendency in scholarly communication is to try to understand it primarily in terms of information processing and rationality (thus higher speed networks, Internet access, etc., necessarily imply certain models). Instead they suggest that more emphasis should be given to issues like resources, incentive structures and stakeholder perspectives:

“… some scientists believe that the high-energy physics working article (e-print) server at the Los Alamos National Laboratory (now called arXiv.org) is the model of publishing that will sooner or later be followed by all of the sciences: it is ‘just a matter of time’ … [but] empirical research studies have found that ‘almost identical technologies’ are often configured very differently in practice, and that these configurational differences can influence their use and uses” (Kling, McKim and King, 2002, p.51)

**Subject domains and information use**

That disciplines vary widely in their communication habits and preferences has been a given in bibliometric studies for many years. What is new, perhaps, is the emergence of recent studies which try to model and explain this commonly observed if unexplained phenomenon. This strand of research might be coined the ‘Nordic School’ since the authors are largely of Danish and Finnish origin, no doubt inspired by the earlier conceptual work of Birger Hjorland at the Royal School of Librarianship at Copenhagen.

Fry and Talja (2004) observe that most studies of journal behaviour tend to focus on

- the use, usefulness and value of the articles read
- how scientists learn about the articles they read
- from where scientists obtain the articles they read
- the format of the articles obtained
• the age of the articles read

But this approach is of limited value, since it fails to explain the reasons underlying use and non-use, especially between disciplines. Most of the studies Fry and Talja cite in their argument are limited to a single institution or discipline or are comparative across very broad disciplinary groupings (e.g. physical sciences, health sciences). And they focus on use rather than non-use, thus skewing perceptions further.

Fry and Talja argue that we should embed journal use studies within a specific theoretical framework: we should be more aware of the organisational and cultural context of users and their domains, with specialties, preferably, or disciplines as the unit of analysis. Moreover, we should conceptualise the epistemic and social organisation of disciplines along two dimensions: the axes of `task uncertainty' and `mutual dependence' (see Table 8).

Mutual dependence refers to the degree to which a specialty depends on knowledge produced elsewhere (environmental studies would be a good example) and the extent to which researchers are required to show how their work is connected to others. This varies enormously.

Task uncertainty refers to the degree to which task outcomes and research processes are predictable, visible and clearly connected to general goals.

Table 9: A domain perspective on the journals literature (Fry and Talja, 2004)

<table>
<thead>
<tr>
<th>Features of the universe of documents</th>
<th>High mutual dependence and low task dependency</th>
<th>Low mutual uncertainty and high task uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature review</td>
<td>Formal: shows how the contribution fits with existing knowledge</td>
<td>Based on choice of theory and discourse communities: less need to</td>
</tr>
<tr>
<td>Density of relevant literature</td>
<td>Due to the relative stability of the research object, the density of topically relevant material is quite low</td>
<td>Due to the relative instability of the research object there is a greater density of potentially relevant material</td>
</tr>
<tr>
<td>Scatter</td>
<td>Relevant materials concentrated in core disciplinary resources</td>
<td>Relevant materials scattered across diverse fields</td>
</tr>
<tr>
<td>Primary relevance criterion</td>
<td>Topical relevance</td>
<td>Paradigmatic relevance</td>
</tr>
<tr>
<td>Primary search method</td>
<td>Directed reading, descriptor-based subject searches</td>
<td>Following up references, semi-directed browsing</td>
</tr>
<tr>
<td>Book versus article production</td>
<td>Predominant reliance on journal articles and centralised resources such as e-print servers, preference for e-journals</td>
<td>Books, articles, conference papers, grey literature and decentralised web resources; preference for print-based journals</td>
</tr>
</tbody>
</table>

This model reveals why, for example, `topic' and `systematic review' can be understood as almost entirely different concepts in different disciplines.

Talja and Maula (2003) also note major differences in use of electronic networked resources between disciplines and argue that these should be related to factors such as the size of the domain, the degree of literature scatter and domain-specific relevance criteria. This leads them to the following conjectures:

• research areas with high numbers of topically relevant materials are best searched by browsing

• research areas with middling numbers of topically relevant materials are best searched by directed subject searches
• areas with very sparse (‘needle in a haystack’) numbers of relevant items are best searched by linking (citation chaining from known documents)
• in high scatter domains, access to e-journal services and databases covering several domains helps in countering scatter
• e-journals and databases are likely to be used more heavily in fields in which topical relevance is the primary relevance criterion and less in fields where paradigmatic relevance is the primary relevance criterion

Further, issues such as professional orientation (e.g. teaching versus research, local versus international, basic versus applied) will have a major influence on information seeking strategies and journal use.

The implications of these issues for digital library design should be obvious and include the fact that the usefulness of e-journals and aggregated services may be limited in fields which are low in mutual dependence and high in respect of task uncertainty.

Domain differences offer a valuable corrective to the technologically determinist thinking of authors like Odzlyko (2002) who seem to assume that the ease, speed and seamless experience offered by electronic journals mean that all fields will eventually settle on a stable set of common electronic fora: preprint servers, discussion lists and e-journals. This is effectively projecting the physics arXiv model7 onto all disciplines as a technological inevitability, and is an example of thinking which is implicit in a whole range of debates, from open access publishing to institutional repositories.

While the domain perspective advocated by Fry, Talja and Malua (and, to be fair, as a general principle by many information science authors from Garfield onwards) are intellectually appealing, there are few empirical studies which explore disciplinary and organisational differences systematically. One exception, and a good example of trying to make these concepts work out in practice, is a study of disciplinary differences in the use of digital journal materials in the Finnish National Electronic Library (FinELib) by means of nationwide survey data by Torma and Vakkari (2004) and Kortelainen (2004). Discipline was the independent variable in their analysis: frequency of use and satisfaction were dependent variables scored on a Likert scale.

The key findings of Torma and Vakkari were that
• the perceived availability of relevant materials in the FinELib digital library was a better predictor of use than the users’ discipline
• regardless of discipline, a perception of the resources as being ‘good’ led to more frequent use
• satisfaction also did not vary with discipline, again, perceived relevance was the key predictor

If these results seem somewhat surprising in the context of this section on the primacy of domain differences, the authors are the first to admit that the six disciplinary categories they used (e.g. humanities, natural sciences) were simply too broad to be useful and that these

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categories mask substantial within-group variation. Here lies the real challenge: how to design studies at a meaningful (and definable) level of disciplinary aggregation?

**Changing user behaviour**

In this section, we are concerned with how users interact with journal collections: how they find articles, what they read and how they integrate journal materials into their working practices. Much of the research in this section stresses the need for studies in scholarly communication to provide insights into motivation and behaviour, not just to crunch performance indicators.

“We are finding that all aspects of human behaviour - affective, cognitive, and sensorimotor - have an influence on how people interact with information.” (Tenopir, 2003, p. 17)

**Writing and researching articles**

A major gap in the literature during the period under consideration relates to author behaviour in respect of how electronic tools are influencing writing practices: this is particularly surprising given the arrival of online manuscript submission and peer review mechanisms. The last major study appears to be that of McKnight and Price (1999), based on research at an early juncture in the evolution of the electronic journal, although Borgman covers a range of author-related issues in her 2000 article.

She sets out a research agenda for scholarly communication and digital libraries:

- studying how researchers disaggregate documents and re-aggregate them in different ways
- studying the `social life' of documents
- incorporating the criteria by which scholars choose publication outlets could better inform the design of digital libraries

She notes that:

“Scholarly publishing is inherently a social process, in which authors choose their publication outlet based on characteristics such as prestige, perceived quality of reviewing, ability to reach the intended audience and availability to the target readership” (Borgman, 2000, p. 419).

**Finding articles**

How do authors identify and retrieve the articles they want to read, especially in electronic networked environments?

Eason, Yu and Harker (2000) analyse the value to users of a range of functionality in electronic journals, arising out of insights from the SuperJournal project, and thus an early benchmark. Their key findings are that:

- the core (indispensable) functions of digital libraries are basic browsing, printing and search facilities
- directed searching is used less intensively than browsing features: researchers are not very good at searching.
- features such as alerting, saving, customising and communications functions are peripheral (i.e. dispensable) for most users.
An interesting observational study by Worel (2004) examined the form in which patrons presented specific bibliographic references to the reference desks at an academic health sciences library (University of Minnesota Bio-Med library) and a governmental library (the RN Barr Library at the Minnesota Department of Health).

Table 10: Where do users locate references? (Worel, 2004)

<table>
<thead>
<tr>
<th>Citation origin</th>
<th>Definition</th>
<th>Bio-Med n=200</th>
<th>RN Barr n=200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>Printout from a library database, e.g. PubMed</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Chaining</td>
<td>Citations found from the bibliography of another publication</td>
<td>14</td>
<td>24.5</td>
</tr>
<tr>
<td>Website</td>
<td>Print out from a non-index web site listing citation(s)</td>
<td>0.5</td>
<td>9</td>
</tr>
<tr>
<td>Typed list</td>
<td>Word processed lists, bibliographic management software, or course syllabi</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Handwritten</td>
<td>Citations handwritten on paper</td>
<td>28.5</td>
<td>13</td>
</tr>
<tr>
<td>Email</td>
<td>Citations from email correspondence or email discussion list</td>
<td>6.5</td>
<td>5</td>
</tr>
<tr>
<td>Memory</td>
<td>No visible source of citation</td>
<td>1.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Despite major differences in the size and orientation of the two libraries (one academic, one practitioner-focused) a very similar profile was found in both cases (see Table 10). This study provides evidence that library users seem to place considerable reliance on large databases like PubMed and on chaining from one document to earlier documents by following up references.

Table 11: Method of learning about article (Boyce and others, 2004)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Browsing</td>
<td>57.6</td>
<td>46.4</td>
<td>20.6</td>
</tr>
<tr>
<td>Print</td>
<td>[100.0]</td>
<td>[65.3]</td>
<td>[45.2]</td>
</tr>
<tr>
<td>Electronic</td>
<td>[0.0]</td>
<td>[34.7]</td>
<td>[54.8]</td>
</tr>
<tr>
<td>Online search</td>
<td>8.5</td>
<td>14.4</td>
<td>39.0</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colleagues</td>
<td>15.5</td>
<td>22.0</td>
<td>21.1</td>
</tr>
<tr>
<td>Citations</td>
<td>5.6</td>
<td>12.8</td>
<td>16.0</td>
</tr>
<tr>
<td>Other</td>
<td>12.8</td>
<td>4.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Returning to the work of Boyce et al. (2004) and their summary of survey data collected over a long period, we find (see Table 11) a very substantial shift over the past few years in favour of directed online searching and away from browsing behaviours. Note that the importance of colleagues as information gatekeepers and ‘following up the literature’ remain as important as ever, despite the massive technological advances.
In digital libraries, referral logs offer a very useful resource for helping us to understand how users navigate to the documents they deem worth downloading or printing (Nicholas and Huntington, 2003). A study by Davis (2004a) starts from the proposition that although we may think we know quite a lot about the information-seeking behaviour of chemists, the networked information environment throws up new challenges. Specifically, what pathways do researchers at Cornell take to get to American Chemical Society servers?

Davis’ findings (see Table 12) suggest that users employ a wide range of strategies to find chemistry articles.

Table 12: Types of referral (Davis, 2004a)

<table>
<thead>
<tr>
<th>Total referrals</th>
<th>% Total referrals</th>
<th>Unique IPs</th>
<th>Referrals per IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library catalog</td>
<td>2,482</td>
<td>24.9</td>
<td>552</td>
</tr>
<tr>
<td>Bib database</td>
<td>2,372</td>
<td>23.8</td>
<td>324</td>
</tr>
<tr>
<td>E-journal list</td>
<td>1,813</td>
<td>18.2</td>
<td>405</td>
</tr>
<tr>
<td>Web page</td>
<td>1,108</td>
<td>11.1</td>
<td>190</td>
</tr>
<tr>
<td>Web search</td>
<td>996</td>
<td>10.0</td>
<td>491</td>
</tr>
<tr>
<td>E-mail (Web based)</td>
<td>592</td>
<td>6.0</td>
<td>79</td>
</tr>
<tr>
<td>Article link</td>
<td>571</td>
<td>5.7</td>
<td>204</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
<td>0.2</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total referrals</strong></td>
<td><strong>9,949</strong></td>
<td><strong>100.0</strong></td>
<td><strong>1,591</strong></td>
</tr>
</tbody>
</table>

This Table aggregates the behaviour of a large number of individuals and is misleading in one very important respect: despite the range of strategies exhibited across a whole population, most individuals tend to rely consistently on a small sub-set of these methods. This has implications for librarians and publishers.

**Implications for librarians**

Redundancy should be encouraged: Davis’ findings support the view that it is not necessarily a duplication of librarians’ efforts to, for instance, maintain links to journal URLs from the library catalogue as well as having the same information on a University e-journal list.

**Implications for publishers**

“From the perspective of scientists, it is in their interest to have the electronic literature linked to as many types of information referral as possible. A publisher’s rationale for limiting direct linking from other databases and full-text products may be as much political as technical” (Davis, 2004a, p. 331)

The complexity of the issues, and the difficulty of making sweeping generalisations in this area are underlined by the work of Bontrhon et al. (2003). This was a small-scale investigation of 35 faculty and 500 students at Edinburgh University into their use of electronic journals. The starting premise was that the move to electronic formats is affecting serials management practices in libraries and it explores what this means for the ways that faculty and students incorporate electronic journal usage into their working patterns.
The study found that faculty made very little use of the library's electronic journals web page and its subject trees, preferring to go directly to (bookmarked) tools such as the Web of Science, Beilstein or PubMed to find relevant articles. Staff generally seemed to make very little use of the value-added features of electronic journals such as tables of contents or mailing features. Most got their articles by bookmarking internet sites or using links from databases such as the Web of Science. The library web page was used as a call of last resort.

Several studies underline the convenience of electronic journal services for off-site users. Jacoby and Laskowski (2004) found that the majority of use of e-journals at the University of Illinois, Urbana-Champaign, takes place off campus (69% in 2002, 83% in 2003) or on campus but not in the library (library use accounted for 7% and 4.5% respectively). At any time of the day, extramural usage is an order of magnitude greater than in the library: e-reserves were used more heavily off campus at 04h00 than at any time during the library's working day!

Further evidence of the popularity and convenience of electronic networked services comes from De Groote and Dorsch (2003) at the University of Chicago who found very high levels of electronic access among medical faculty and students. However, take-up varied enormously between different journal platforms, suggesting a lack of awareness of the richness of provision on offer: patrons strongly prefer to use services with which they are already familiar.

Both Davis (2002 and 2004a) and Ke et al. (2002) report on the highly asymmetric patterns of digital library use as reflected in their logs. In the case of the ScienceDirect On Site, Ke et al. report that nearly 50% of full text downloads come from the 100 most active IP addresses out of a total population of more than 30,000. In a later paper, Davis explored these patterns more systematically, using monthly COUNTER full text download reports from 16 HighWire participating institutions (Davis, 2004b). The other primary variable was the number of unique IP addresses (a surrogate for the number of users). Multiple regression methods were used to estimate the number of unique users across all titles. Scatter plots revealed a very strong linear relationship between \( \ln \) downloads and \( \ln \) unique IP addresses \( (R^2=0.96) \). Therefore Davis posits that article downloads are a good predictor of the number of unique reader proxies (IP addresses), constant across time and institutions.

Finally in this sub-section, Sandstrom (2001) offers some intriguing new thinking about information search behaviour. She uses the metaphor of animals foraging for food to explain some of the dynamics of information searching:

"Resource-selection decisions about where and how long to search, what to pursue and what to ignore, and whether to forage alone or in groups are similar, whether the decision-makers are animal subsistence foragers, human hunter-gatherers or scholarly information seekers … Scholars as subsistence foragers are constrained by the density and distribution of resources, which affect encounter rates, and by limits on skills, technology, knowledge of the environment, availability of foraging partners, opportunity costs and other factors that affect their decision making and processing abilities" (Sandstrom, 2001, p. 598)

"The study's findings show information foraging practices among human behavioural ecologists to vary according to their location within the core-periphery zones of a defined bibliographic environment. Core concerns are distinguishable from surrounding peripheral interests in terms of resource density and familiarity, searching strategies, information supply arrangements … the observed behavioural differences can be accounted for by principles of least-effort or maximisation"
models in which scholars behave like human or animal subsistence foragers.” (Sandstrom, 2001, p. 601).

This might be a highly appropriate new model for helping us to understand information seeking behaviour across multi-disciplinary journal platforms like ScienceDirect.

Reading articles

How is the reading behaviour of researchers changing in relation to electronic access and the ‘journals crisis’?

A good starting point for tackling this question is the work of Belefant-Miller and King (2003) who profiled reading behaviour at a medium-sized US university (the University of Tennessee at Knoxville). This was a re-examination of a 1993 study so it presents the situation at the cusp of the paper and electronic eras and is a useful benchmark for subsequent studies.

Belefant-Miller and Kind found that faculty

- read 384 documents per annum, of which 161 were journal articles
- had 4.2 personal journal subscriptions
- published three articles per annum

Tenopir et al. (2003) provides a rich synthesis of earlier surveys and literature on reading behaviour. Their key findings may be summarised as:

- the number of personal subscriptions per scientist has decreased steadily from 5.8 (1977) to 2.2 currently, signaling a shift from a journal economy to an article economy
- author web sites have not caught on, accounting for less than one percent of readings in both the early and advanced phases
- there has been a massive increase in electronic formats for reading
- the journal publisher makes a big contribution to knowledge creation: average readings per scientist have increased from 87 (1977) to 148 per annum, the large majority of which are readings supplied from library collections in print or digital form
- the usefulness of the articles read and indicators of their value suggest that information content has not changed much, but its overall value to the scientific community has increased as more articles are read and can be accessed more conveniently.

These data accord reasonably well with Mabe and Amin’s 2002 study which concluded that the average researcher reads 97 articles, 204 abstracts, 1,142 titles and gives 21 citations each year. Of course, disciplinary differences will be show considerable variation within these global figures. Jones et al. (2004) also make the point that there is a significant difference (within the context of British psychologists working in the NHS) in the median number of journals read annually between those with academic commitments and those without.

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8 Electronic separates may become even more popular due to the emergence of preprint servers and institutional repositories.
What role do electronic journals play in the weekly reading behaviour of researchers in the sciences and social sciences? Smith (2003) reports on a survey at the University of Georgia (2001), the key findings of which are summarised as Tables 13-15.

These self-reported data suggest that print plays a much higher profile in terms of weekly reading habits than might have been expected and that personal subscriptions are still an integral part of scholarly pursuits (Table 13).

Table 13: Weekly use of print and electronic journals (Smith, 2003)

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Science</th>
<th>Social science</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal subscriptions</td>
<td>91</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>Library subscriptions</td>
<td>73</td>
<td>74</td>
<td>70</td>
</tr>
<tr>
<td>Total print</td>
<td>95</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td>ELECTRONIC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal subscriptions</td>
<td>29</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>Library subscriptions</td>
<td>67</td>
<td>69</td>
<td>63</td>
</tr>
<tr>
<td>Total electronic</td>
<td>74</td>
<td>77</td>
<td>69</td>
</tr>
</tbody>
</table>

Interestingly, in this and the following Tables, the profiles of science and social science researchers are very similar (this may simply be because these disciplinary categories are too broad to be useful, disguising within-group variation). Print accounts for more than half of the articles read each week (Table 14).

Table 14: Articles read per week by type and format (Smith, 2003)

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Science</th>
<th>Social science</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal subscriptions</td>
<td>29</td>
<td>28</td>
<td>31</td>
</tr>
<tr>
<td>Library subscriptions</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Total print</td>
<td>54</td>
<td>53</td>
<td>56</td>
</tr>
<tr>
<td>ELECTRONIC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal subscriptions</td>
<td>10</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Library subscriptions</td>
<td>32</td>
<td>32</td>
<td>33</td>
</tr>
<tr>
<td>Total electronic</td>
<td>42</td>
<td>44</td>
<td>39</td>
</tr>
</tbody>
</table>

And personal collections of journals still play a vital role in researchers’ working practices (Table 15).
Table 15: First choice locations for full text (Smith, 2003)

<table>
<thead>
<tr>
<th>Location</th>
<th>All</th>
<th>Science</th>
<th>Social science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal collection</td>
<td>51</td>
<td>49</td>
<td>56</td>
</tr>
<tr>
<td>Bibliographic database with links to full text</td>
<td>22</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Full text electronic journal</td>
<td>19</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Smith is clearly of the view that print is alive and well:

“[Various authors] have predicted the end of traditional paper journals and embraced electronic journals as the panacea for the ills of scholarly communication. They foresaw this technology taking scholarly communication out of the hands of commercial publishers, and in doing so decreasing publication delays, eliminating editorial cronyism, and, perhaps most importantly, drastically reducing subscription costs. However, empirical research into electronic journal use revealed that the majority of faculty members were not as enthralled with the idea of a paperless society“ (Smith, 2003, p. 162)

Franklin and Plum (2004) make the point that print plays a really important role in the context of supporting funded research, even though electronic accesses are now used more.

**Using articles**

An emerging trend in the literature, albeit slight and from a low base, is an increase in bigger picture studies which attempt to capture something of the value of journals in increasing the efficiency and effectiveness of research. Drawing on experience and data from the pharmaceuticals sector, Koening (2001) advances the argument that research productivity is a direct function of organisational information culture. Environments characterised by openness, richness (of information resources and communication tools) and serendipity are more productive and creative places to work.

Many of the authors cited in this study have emphasised the convenience that attaches to electronic desktop access. Indeed, it is easy to overlook the frustrations and sometimes harsh realities of using printed journal collections. Shaw-Kokot and de la Varre (2001) offer one of a surprisingly low number of journal availability studies in a print-based collection, the context being an academic health sciences library at the University of North Carolina. They show that user groups found locating journal articles to be problematic: finding and photocopying items takes a long time out of busy schedules:

“If we have to get [print journal] materials from HSL, we have to budget at least an hour. Finding things and photocopying takes time.” (Clinical nursing tutor quoted in Shaw-Kokot and de la Varre, 2001, p. 22).

User errors (bad citations, lack of understanding of the way journals are shelved) or bibliographic error and local issues (reshelving, binding, missing issues, articles in use) simply compound the problem.

Sathe, Grady and Giuse (2002) studied the impact of print versus electronic journals on research processes at the Vanderbilt University Medical Center. Do researchers use print and electronic formats for the same purposes? (see Table 16).
Table 16: How researchers use journals (Sathe, Grady and Giuse, 2002)

<table>
<thead>
<tr>
<th>Use</th>
<th>Electronic-use survey respondents (%)</th>
<th>Print-use survey respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Browsed</td>
<td>39</td>
<td>72</td>
</tr>
<tr>
<td>Checked references</td>
<td>41</td>
<td>22</td>
</tr>
<tr>
<td>Printed or photocopied articles</td>
<td>58</td>
<td>36</td>
</tr>
<tr>
<td>Read articles</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>Read entire journal</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Read instructions to authors</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Read job advertisements</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Read tables of contents</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>Other use</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

They found that faculty tended to prefer print over electronic formats: possibly an age-related phenomenon, possibly later adopters of the new technology. Some of the differences in the ways that print and electronic journals are used are significant:

• print was favoured over electronic sources for browsing (p<0.001)
• electronic sources were favoured over print for checking references (p < 0.05)
• print was favoured over electronic sources for reading tables of contents (p < 0.001)
• electronic sources were favoured over print for printing or photocopying (p < 0.005)

“… our data regarding patrons’ preference for ands use of electronic journals confirms the idea that patrons may limit their research to easily available electronic journals simply because of their convenience and regardless of whether other sources would better suit their information needs” (Sathe, Grady and Giuse, 2002, p. 242).

This is an oldish study (reporting 1999 data) but it is an interesting approach.

What value do researchers extract from journals? Tenopir, King and Bush (2004) surveyed medical faculty at the University of Tennessee regarding their use of journals and the values they attach to these readings (Table 17).

Table 17: The value of medical journals (Tenopir, King and Bush, 2004)

<table>
<thead>
<tr>
<th>Principal purpose for reading</th>
<th>Proportion of readings (%)</th>
<th>Average ratings of importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary research</td>
<td>29.9</td>
<td>5.1</td>
</tr>
<tr>
<td>Background research</td>
<td>6.5</td>
<td>4.2</td>
</tr>
<tr>
<td>Current awareness</td>
<td>22.1</td>
<td>4.6</td>
</tr>
<tr>
<td>Teaching</td>
<td>16.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Writing</td>
<td>11.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Consulting</td>
<td>3.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Other purposes</td>
<td>9.0</td>
<td>4.3</td>
</tr>
<tr>
<td>All</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

*Importance ratings: 1=Not at all important to 7=Absolutely essential
The critical value of journals in underpinning and supporting primary research and in delivering front-line health care is well illustrated by these figures.

According to Brennan et al. (2002), access to electronic journals is changing research habits since as well as being more convenient, electronic access allows for greater opportunities to follow up on relevant cited articles, thus facilitating a more comprehensive treatment of the literature.

A fundamental shift in attitudes to the body of knowledge may be taking place. One respondent observed that he does not “need to retain knowledge as long as access is maintained” and that his attitudes are now changing to reflect the fact that “the aggregation of knowledge is now paramount” (Brennan and others, 2002, quoted on p. 523). Another respondent mentioned the explosion of meta-analyses in the last couple of years: a research form that was previously so cumbersome as to be impractical.

Finally, a really important question: can we translate the convenience offered by electronic information services into a financial value? Kurtz et al. (2000) in a study of the NASA Astrophysics Data Service (ADS), an abstracts service with links to full text documents, offer one of the very few attempts to place a value on the impact of an information platform on a whole discipline. Use of ADS is clearly very intensive: in a typical month (March 1999), each scientist makes, on average, 29 searches, reads 20 abstracts and 5.5 articles. What difference does this make?

“We will assign to each of several ADS functions a time which is our estimate of the increase in research time which accrues to the researcher by virtue of using that function. Our fundamental measure will be the time saved in obtaining an article via the ADS, which we estimate from the time it takes to go to the library, find the volume, photocopy the article, and return to the office as 15 minutes. We then estimate that reading an abstract, a reference list or a citation history saves one-third of the full article time, or 5 minutes, and we arbitrarily assign a one minute time saving to each query” (p.57)… “we find that the ADS increases the efficiency of astronomical research by 333 full-time equivalent research years per year” (Kurtz and others, 2000, p.41)

This approach: placing a financial value on the contribution that electronic journal access makes to the greater efficiency of the science base is interesting and one that could have major policy ramifications.

**Ageing and obsolescence studies**

There are some interesting and important questions to be asked about ageing and obsolescence processes in digital libraries. Does use follow the same patterns of temporal decline that we see in the citations universe? What implications would flow from a better understanding of obsolescence as seen through the eyes of readers as opposed to authors?

In an early, print-only study using 835 medical journals as a test-bed, Tsay (1999) began with the working hypothesis that there is no difference between the age distributions of use (as measured by re-shelving statistics) and citation.

Tsay’s findings showed that:

- use decays exponentially, with maximum use in year one

- citation shows a sharp initial rise from a low base to years 3 or 4, then an exponential decay
a comparison of the two curves shows that there is a very dramatic difference in year 1, the two curves intersect between years 2 and 3, after that the citation curve exceeds the one for use age, though both curves fall off exponentially beyond this point.

Tsay used Kolmogorov-Smirnov two-sample tests to show that the working hypothesis had to be rejected and that the ageing profiles of use and citation are indeed significantly different, at least for print titles in medicine.

As we move from Tsay’s study into an increasingly electronic environment, what impact, if any, will ease of access have on the age profile of use? Boyce et al. (2004) suggest little change in reading patterns as a function of the age of the material the profiles of use before and after the introduction of electronic access (see Table 18).

Table 18: The age of articles read (Boyce and others, 2004)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.5</td>
<td>65.2</td>
<td>68.8</td>
<td>63.8</td>
</tr>
<tr>
<td>2</td>
<td>13.3</td>
<td>14.5</td>
<td>10.2</td>
<td>9.9</td>
</tr>
<tr>
<td>3</td>
<td>2.6</td>
<td>2.6</td>
<td>5.2</td>
<td>5.5</td>
</tr>
<tr>
<td>4-5</td>
<td>8.4</td>
<td>5.7</td>
<td>5.4</td>
<td>7.8</td>
</tr>
<tr>
<td>6-10</td>
<td>10.2</td>
<td>4.2</td>
<td>5.2</td>
<td>5.7</td>
</tr>
<tr>
<td>11-15</td>
<td>1.7</td>
<td>2.6</td>
<td>1.7</td>
<td>2.8</td>
</tr>
<tr>
<td>&gt;15</td>
<td>2.3</td>
<td>5.1</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

However, Liu (2002) conjectures that since older papers now have a much lower visibility in the digital age, both reading and citation habits may change to accommodate the ease of accessibility of digital materials, a point also made by (Houghton, Steele and Henty, 2004). A further point is what will happen to readings for articles that pre-date the digital archive, given the drastic fall-off in print readings noted earlier in this report?

A systematic study of the NASA Astronomy Data Service (ADS) by Kurtz et al. (2000) found that

- articles 4-22 years old account for 2.5 reads per month.
- articles less than 4 years old account for 5 reads per month.
- very old articles (back to 1849) account for 0.025 reads per month.

Kurtz et al. also find that papers that are frequently cited tend to be frequently read (echoing the findings of Wulff and Nixo, 2004 and Obst, 2003), although the correlation is not very strong.
Supporting Google Generation users

Studies of internet usage by younger generations are indicators of future information seeking behaviour and provide insights into the mental models scholars of the future acquire at an early age. Williams (1999) studied the behaviour in 10-11 year olds and noted that children tend to disregard written text, preferring audio and visual material because many sites are inappropriate for the age group concerned. In a study of Yahooligans, a search engine designed for 7-12 year olds, Bilal (2002) notes that children search according to their cognitive developmental ability and without understanding how the search engine works. Bilal acknowledges the inadequacies of Yahooligans’ search mechanisms, but concludes that children need to be exposed to effective web training. Prior knowledge and internet experience are significant factors in successful searching and evidence suggests that children do not possess the necessary domain knowledge or experience and understanding of search engine functionality to use them effectively (Bilal 2002, Madden et al 2006, Slone 2003).

Many reports on internet use, particularly those published by bodies such as EduCAUSE, identify trends which cannot be ignored by the academic community, such as the imminent influx of internet savvy students, to whom resources like Google and Wikipedia, and instant messaging and social networking environments such as FaceBook and MySpace are second nature, into an environment populated by aging faculty (Oblinger, 2003). Members of the born-digital Google Generation apparently bring with them a confidence in using the internet for information retrieval purposes which belies their skills in critical evaluation and devising search strategies (Lorenzo and Dziuban, 2006, Rogers and Swan, 2004).

The ubiquitous use of search engines defines a conceptual model for information retrieval an early age. The translation of this model into those of traditional IR systems, such as library catalogues and bibliographic databases, and federated search tools such as MetaLib, which provide controlled access to organised information, may be problematic and has implications for future user awareness and training programmes (Brophy and Bawden 2005, Chen 2006). Murumatsu (2001) reports that users have difficulty in understanding how search engines transform queries by using a variety of default search mechanisms, such as automatic Boolean operators, stop words, truncation and term order sensitivity. Thus cognitive models of the internet, domain knowledge and understanding of the terminology, spelling, grammar and sentence structure contribute to the inability, particularly amongst younger (children under 13 years) and older (46-64) users to construct effective searches and evaluate the results (Slone 2003).

Access to, and familiarity with, the internet may also impact on the Google Generation’s information seeking skills and their educational aspirations. Factors such as policies and rules, technological and filtering controls and time constraints on teachers’ ability to support the development of information literacy within the curriculum restrict access to the internet in schools and prevent students from maximising the potential of the internet in educational activities (Selwyn 2006 Madden et al, 2006, PEW 2002, Williams and Wavell 2006).

The findings of these studies raise questions about the ability of schools and colleges to develop the search capabilities of the Google Generation to a level appropriate to the demands of higher education and research. Barriers to the use of electronic information resources have always existed and the TAPin project (Reid, 1998), an e-Lib initiative, demonstrated that one-to-one in-office support by librarians effectively increased the use of networked information by academic staff and boosted the departmental profile library staff.
Other perceived barriers to use of library resources include authenticated access to databases, searching and navigating library websites and lack of customer focus (OCLC 2002).

Recent reports identify generational differences as obstacles to information-seeking behaviour (Lorenzo, Oblinger and Dziuban 2006; Lorenzo and Dziuban, 2006; Jones, 2002; Levin and Arafeh, 2002) and forecast challenges for information provision in higher education. The need for targeted instructional activities, which recognise disciplinary differences in information-seeking behaviour, and the specific needs of remote, off-campus users has been identified by Whitmire (2001). Gardner and Eng (2005) consider the implications for academic libraries of differences in the learning styles of Net Generation students, who have high expectations of IT infrastructures and round-the-clock access. Group work, peer learning, electronic learning environments such as WebCT, BlackBoard and Moodle, and remote access to information resources for distance learning contribute to a need to support:

1. Demand for quality academic facilities and high academic achievement
2. The need for customisation of technology and research
3. The need for integration of technology into learning
4. The usage of new communication modes

Initiatives designed to support users outside the physical library, for example the ‘Roving Librarian’ project at Harvard which, in spring 2003, placed librarians equipped with wireless-enabled laptops in spaces such as the students union, are quoted in Gardner and Eng (2005). Other innovative tactics such as relentless promotion, instruction and customer service are recommended to overcome barriers and market the support that users seem to consider unnecessary.

Summary of key findings

Despite the many difficulties of trying to extract general meaning from particular studies, the summary conclusions which follow attempt to capture a range of key issues as reflected in the current literature. The fact that we are at such an interim stage in the full evolution of the digital library means that these will have to remain highly provisional findings but they suggest a number of fruitful lines for further research.

• Researchers appear to be reading more primary journal materials than ever before, from a wider range of sources. The availability of end-user search tools and changing working practices as researchers engage more in Mode II knowledge production appear to be the key drivers.

• Specialist secondary services remain strong only in a few areas with strong Mode I characteristics: generic services like the Web of Knowledge are very much in the ascendant.

• Less time is being spent on reading, per article, and researchers ‘see’ an increasingly narrow view of their own discipline as a result of the growth in the literature

• Despite many problems with the current publishing system, there is little consensus on the best way forward: positions are entrenched both in terms of stakeholder tribe and adherence to economic, technological or behavioural determinist positions.
Where implemented, electronic versions of journals have displaced print use dramatically and at much faster than some have anticipated.

The introduction of electronic journal services impacts very negatively on print-only titles, such is the convenience and consumer acceptance of the new medium, raising big issues for the continuing value of the print legacy.

An isolated study suggests, in bald contradiction, that the introduction of e-platforms actually increases print use by raising the profile of journals as an information source, and this is worthy of further investigation.

There has been a major shift from a focus on the journal to a focus on separates.

Convenience and digital visibility are crucial in the new information landscape.

There is a strong correlation between print and electronic journals in that the more popular titles tend to be used (relatively) more heavily in both formats.

Mediated library services are declining rapidly in favour of user self-service, to the point of near extinction in many cases.

Much of the current thinking about the digital transition lacks sensitivity to some really deep-rooted domain differences: the idea that all disciplines are moving towards a common end point, symbolised by the physics community, is not tenable.

Specialties, or disciplines, are a more useful, more natural unit of analysis for studies of scholarly communication than studies at the institution or journal level.

Greater sensitivity to disciplinary variation is needed in the design of user behaviour studies.

A theoretical perspective which begins to explain some of the scholarly communication preferences of different user groups is beginning to emerge but it remains a high level concept and one which is difficult to operationalise effectively in practice, either in terms of designing research studies or digital libraries.

The findings of Torma and Vakkari (2004) point to the value of including data on perceived availability and satisfaction in user studies.

The introduction of databases of electronic journals signals a major shift from browsing to search behaviours.

Researchers are not technically proficient at searching and employ a range of coping strategies to navigate digital libraries.

Despite the huge increase in the use of electronic reserves, print still features as an important aspect of the day-to-day life of the typical academic.

Print-based and electronic systems are used for different purposes and at different times in the information seeking cycle.

Digital libraries offer major cost savings in terms of time savings and productivity enhancements.
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