How Electronic Journals Are Changing Patterns of Use

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Summary

Surveys of faculty, students, and scientists in non-university settings over time show that journals and journal articles continue to be a valued resource. Scientists today read from a variety of sources, including print journals, electronic journals, eprint servers, and full text databases, although the amounts for each vary with subject discipline and library collection decisions. Scientists value library provided resources and electronic journals that are designed to meet the needs of their specific discipline.

Introduction

Within the last decade electronic journals have become commonplace. According to the Ulrich’s Periodicals Directory, over 80% of today’s active, peer reviewed journals are now available in some digital form. A few of these are electronic only with no print equivalent, but more are electronic journals that replicate print versions or add additional information and features to what is available in a print version. Selected articles from journals are also available in full text databases from aggregators such as ProQuest, Ovid, Factiva, InfoTrac, and from individual journals on a pay per view basis. Readers in some disciplines also obtain scholarly articles from e-print servers such as arXiv.org, from institutional repositories based on the Open Archives Initiative, or directly from authors’
web sites. These article separates alternatives are commonly called electronic journals, but in reality are selected electronic articles rather than complete journals.

Libraries vary in their adoption rates of electronic journals or alternatives, although most, such as the electronic journal collections of the member libraries of the Association of Research Libraries (www.arl.org), show steady growth. Some libraries or consortia, such as Drexel University in Philadelphia and the Coalition of Australian University Libraries, have formulated collection development policies that favor the licensing of electronic journals or full text databases over the continued purchase of print journals.

It can be expected that this widespread availability of electronic journals and electronic separate articles will have some effect on the reading patterns of scholars. This paper reports on surveys of reading patterns over time to show how electronic journal collections are changing reading patterns and what patterns are more a function of a specific work field or work place and do not change with the availability of electronic journals or electronic articles.

**Selected Literature Reviews**

Reading patterns of scientists and social scientists through the 1990s are summarized in Tenopir & King (13) and King & Tenopir (5). These two sources provide extensive literature reviews of reading and authoring studies and serve as background to the data presented here. The ongoing massive bibliography by Bailey (1) and a review article by Kling & Callahan (6) also point to many articles that discuss the development of electronic journals and their use. A forthcoming Council on Library and Information
Resources (CLIR) report discusses lessons learned from many usage studies of digital library resources (11).

Although the studies differ in methods and some conclusions, many common findings emerge. Faculty, students, and scientists in non-university work settings prefer journal versions that allow them to do their work most efficiently and that are convenient. For many that means desktop access of electronic versions with PDF for printing. Medical practitioners seem to be an exception, still preferring personal print subscriptions (16). Specific reading patterns and how these patterns have changed with the widespread adoption of electronic journals and articles are discussed in this paper.

**Reading Patterns Over Time**

In a recent article in *D-Lib* magazine (14) we examined three evolutionary phases in journal use. We compared results of surveys of scientists and social scientists in a variety of work settings conducted by the authors over the last 14 years to see how (or if) reading changed over time as more electronic journals and journal alternatives became available and as the electronic journal delivery systems become more sophisticated in design.

The first evolutionary phase (“early phase”, 1990-1993) was a pre-web world, where full text databases of journal articles existed online or on CD-ROM, but only a very small percent of the total article readings by scientists and social scientists came from anything other than print journals. The second phase (the “evolving phase”) began in the late 1990s and continues today. It is marked by the availability of both print and electronic journals, with readings from print journals, electronic journals, and journal alternatives. We call the third, “advanced phase”, an era existing today in some subject
disciplines where electronic information systems are designed specifically to enhance the way scientists or social scientists do their work. In our comparison, these mature electronic journal systems are represented by the system developed by the American Astronomical Society (AAS) together with NASA’s Astrophysics Data System for astronomers.

Results in the early phase are from surveys of scientists and social scientists in two universities and eight other organizations (over 860 respondents). The evolving phase included surveys of the University of Tennessee, Drexel University, and Oak Ridge National Laboratory (235 respondents.) The advanced phase provides results from over 1000 members of the AAS. (The AAS survey is described in detail in 15). In all of the surveys, scholarly articles were defined to include "those found in journal issues, author web sites, or separate copies such as preprints, reprints and other electronic or paper copies." Reading was defined as "going beyond the table of contents, title, and abstract to the body of the article."

The total number of articles read per year has been found to vary considerably by work field, but overall, the number of articles read is increasing (13). The number of articles read and total time spent increases in each of our three evolutionary phases, from an average of 100 articles per year in just under 90 total hours in the early phase, to nearly 160 article per year in about 130 hours in the evolving phase, to nearly 230 articles per year by astronomers in 144 total hours in the advanced phase.

How articles are identified and the source used to obtain them, varies throughout these three phases as well. Reading from various electronic sources grew from under 1% of total readings (.3%) in the early phase, to 39% in the evolving phase, to nearly 80% in
the advanced phase. Library collection development policies influence where readers obtain articles, as nearly half of all readings in both the evolving and advanced phases come from library subscriptions (either print or electronic.) Table 1 shows that the use of separates (mostly electronic) rose considerably in the advanced phase. The growth in separates from full text databases, e-print servers, and author web sites means that readers now read articles from a wider variety of journal titles—at least one article per year from 13 titles in the late 1970s, to 18 in the mid-1990s, to approximately 23 titles by the year 2001.

Table 1. Source of Articles Read in Three Phases (14)

<table>
<thead>
<tr>
<th>Source of Article Read</th>
<th>Evolutionary Phase</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early %</td>
<td>Evolving %</td>
<td>Advanced %</td>
<td></td>
</tr>
<tr>
<td>Personal Subscription</td>
<td>46.3</td>
<td>36.0</td>
<td>15.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[100.0]</td>
<td>[67.8]</td>
<td>[54.5]</td>
<td></td>
</tr>
<tr>
<td>Print</td>
<td></td>
<td>[32.2]</td>
<td>[45.5]</td>
<td></td>
</tr>
<tr>
<td>Electronic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Library Subscription</td>
<td>40.6</td>
<td>49.1</td>
<td>49.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[99.1]</td>
<td>[80.0]</td>
<td>[12.7]</td>
<td></td>
</tr>
<tr>
<td>Print</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic</td>
<td>[0.9]</td>
<td>[20.0]</td>
<td>[87.3]</td>
<td></td>
</tr>
<tr>
<td>Separate Copy</td>
<td>13.1</td>
<td>14.9</td>
<td>35.8</td>
<td></td>
</tr>
<tr>
<td>Preprint</td>
<td>0.2</td>
<td>1.5</td>
<td>18.5</td>
<td></td>
</tr>
<tr>
<td>Archive (ADS)</td>
<td>0.0</td>
<td>0.0</td>
<td>10.2</td>
<td></td>
</tr>
<tr>
<td>Colleague Provided</td>
<td>9.2</td>
<td>9.2</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>ILL/Document Delivery</td>
<td>3.6</td>
<td>3.8</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Author Web Site</td>
<td>0.0</td>
<td>0.3</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.1</td>
<td>0.1</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Sample Size: Early (n=862), Evolving (n=235), Advanced (n=508)
Another change in reading patterns between the three phases occurs in how readers find out about the articles they choose to read. Table 2 shows that browsing in journal issues (print or electronic) has steadily gone down, while online searching by topic has increased and is likely to increase even more as linking services such as SFX become commonplace. Scientists and social scientists continue to rely on their colleagues and following links from citations to locate additional readings.

Table 2. How Scientists Learned About Articles in Three Phases (14)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early % 1990 – 1993</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Browsing</td>
<td>57.6</td>
<td>46.4</td>
<td>20.6</td>
</tr>
<tr>
<td>Print Journals</td>
<td>[100.0]</td>
<td>[65.3]</td>
<td>[45.2]</td>
</tr>
<tr>
<td>Electronic Journals</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>

Sample Size: Early (n=862), Evolving (n=235), Advanced (n=508)

This should not be interpreted to mean that browsing is no longer important. A relatively lower percentage of total readings come from browsing, but, the overall total number of readings has increased. In addition, browsing remains important in journal titles considered to be core to an individual’s work and is especially important for current
awareness reading of current issues. Searching is done more for new topics, older articles, and for primary research and writing.

One thing that does not appear to change over time or with the different evolutionary phases is the relative age of articles read. In all three phases, approximately one-third of readings come within one year of publication. The remaining third are distributed over time in about the same proportion. Older readings are often re-readings of something read in a cursory manner when it was new, and are reported to be highly valuable to the purpose of the reading. (Table 3.)

Table 3. Age of Articles Read In Three Phases. (14)

<table>
<thead>
<tr>
<th>Age of Articles Read</th>
<th>Early %</th>
<th>Evolving %</th>
<th>Advanced %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 yr.</td>
<td>61.5</td>
<td>68.8</td>
<td>63.8</td>
</tr>
<tr>
<td>2 yrs.</td>
<td>13.3</td>
<td>10.2</td>
<td>9.9</td>
</tr>
<tr>
<td>3 yrs.</td>
<td>2.6</td>
<td>5.2</td>
<td>5.5</td>
</tr>
<tr>
<td>4 - 5 yrs.</td>
<td>8.4</td>
<td>5.4</td>
<td>7.8</td>
</tr>
<tr>
<td>6 - 10 yrs.</td>
<td>10.2</td>
<td>5.2</td>
<td>5.7</td>
</tr>
<tr>
<td>11 - 15 yrs.</td>
<td>1.7</td>
<td>1.7</td>
<td>2.8</td>
</tr>
<tr>
<td>&gt; 15 yrs.</td>
<td>2.3</td>
<td>3.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Total 100.0 100.0 100.0 100.0

Source: Early (n=862), Evolving (n=235), Advanced (n=508)

Tables 1-3 show overall averages of all of the surveys within each phase. A closer examination of some recent surveys provides a more in depth look at reading patterns. Surveys done from 2000-2003 of AAS members, and faculty and students at Drexel University, the University of Tennessee, and the University of Pittsburgh reveal both
differences among disciplines and sub-disciplines, plus how publisher’s design decisions and libraries’ collection development decisions can effect reading patterns by users.

**How Collection Development Policies Influence Use**

Three of our readership surveys provide us with an opportunity to examine how the size of a library’s electronic collection might influence readers’ information seeking and reading patterns. In 1993 we conducted a survey of faculty at the University of Tennessee when the university library had a negligible electronic collection and another survey was conducted in 2000 for science faculty only (including engineers and social scientists). By 2000 the university library had installed a partial electronic journal collection and also had made cuts to the print serials collection. In 1998, Drexel University began migrating to an almost exclusive electronic collection and by 2002 the print collection had declined from about 1,700 titles to 370 titles and the electronic collection had increased to 8,600 unique titles (10). In 2002 a readership survey, using the same instrument as the two surveys above, was performed with Drexel faculty and doctoral students.

We felt that these three readership surveys could provide an indication of how three levels of university library electronic collections might influence information seeking and use patterns. Because the survey of faculty in 2002 involved only scientists, we extracted survey responses from scientists’ responses in the other two surveys, yielding sample responses from scientists of 71 in 1993, 96 in 2000 and 71 in 2002 (i.e., negligible, partial, and nearly all electronic collections respectively). We emphasize that the three surveys merely provide an indication of the effects of electronic collection sizes because there have been clear trends over the years in use patterns and there may also be
natural differences in faculty journal use patterns at Drexel University and the University of Tennessee. Nevertheless, we provide this evidence for others to contemplate. This analysis will follow the format as given above for the three evolutionary phases and definitions of reading remain the same.

As shown in Figure 1, the average number of article readings per scientist increased from 188 in 1993 to 201 in 2000 to about 214 in 2002, a trend that has generally held since 1977 (13).

Source: University of Tennessee 1993 (n=71), University of Tennessee 2000 (n=96), Drexel University 2003 (n=71)

Figure 1. The Annual Amount of Reading by Scientists in Universities with Libraries Having Different Levels of Electronic Collections

The amount of time spent per reading was estimated to be 49 minutes in the 1993 survey, 36 minutes in 2000 and 42 minutes in 2002. More is said about the observed differences later.
There was a substantial difference in the sources used by scientists when they had the three levels of electronic collections available to them. The sources are categorized by personal subscriptions (print or electronic), library collections, including through interlibrary loan (print or electronic), and separate copies obtained from other persons such as colleagues, authors, etc. (print or electronic). The amount of reading from print journals decreases substantially with the availability of electronic collection from 188 articles in 1993 to 159 in 2000 and 115 in 2000 at Drexel. Also shown in that figure is the corresponding increase in reading from electronic articles from zero in 1993 to 42 in 2000 to nearly 100 in 2002 at Drexel where the collection is nearly all electronic.

Figure 2    Amount of Reading from Print and Electronic Articles by Scientists in Universities With Libraries Having Different Levels of Electronic Collections
Figure 3  

Amount of Reading from Personal Print Subscriptions by Scientists and Universities With Libraries Having Different Levels of Electronic Collections.

Reading from the print format seems to vary somewhat. For example, reading from personal print subscriptions varied as shown in Figure 3 from 72 in 1993 to 86 in 2000 and back to 72 in 2002. This shows that scientists continue to rely on print rather than electronic personal subscriptions. Also, the amount of reading from the print personal subscriptions increased some from 1993 to 2000 (with a partial electronic collection) even though the average number of personal subscriptions decreased from 3.86 in 1993 to 3.64 subscriptions per scientist in 2000.

The reading from print library collections was 103 in 1993 (negligible electronic collection), 52 in 2000 (partial electronic collection) and down to 18 readings from print articles in 2002 (nearly all electronic collection). Thus, this pattern appears to be related inversely to availability of the library electronic collections. The same is true of reading from separate copies of articles in print that rose from 13 in 1992 to 21 in 2000 and 24 in 2002.
Examination of reading from electronic sources is more complex since there is some evidence that the survey respondents in 2000 reported that they obtained electronic versions of articles from personal subscriptions (e.g., the pre-coded responses “free Web journals”) when, in fact, the journals were from the library electronic journal collection. There appears to have been a library “branding” problem at that time at the University of Tennessee (and observed elsewhere as well). At Drexel, the conversion to the electronic collection was particularly well publicized to the relatively small faculty and, therefore, this appears not to have been a problem.

After the University of Tennessee adapted a partial library electronic collection, the scientists began using it to the point that, in 2000, annually about 17 articles per scientist were reported to be read from this source. However, this amount could be as high as 25, if our sense of the branding issue is correct. The respondents reported an average of 15 readings from their personal electronic collections. This seems high although it may be that scientists subscribed to electronic collections because the library only had a partial electronic collection. Altogether the scientists in 2000 used electronic articles for 21% of their reading which shows a trend toward acceptance and adoption of electronic sources of articles at that time.

With a nearly all library electronic collection at Drexel, about 82% of reading from that collection is from electronic format with most of the reading from print journals being older titles that are not (yet) available in electronic format. Only 14% of the readings from personal subscriptions are in electronic format and about 20% of separate copy reading is from electronic format. That is, of 100 total readings from electronic articles, 82 are from the Drexel electronic collection. Collectively, about 46% of all
reading is from the library collection which is a typical proportion observed in other universities.

In Table 4 we show how scientists learned about the articles they read. The amount of reading found while browsing remained about the same with the three levels of library electronic collections (i.e., 114, 106 and 112 readings per scientist in 1993, 2000 and 2002 respectively), although the amount read from print personal subscriptions dropped from 114 to 77. The most dramatic change has been in the use of online searching as a method of identifying articles (from 27 to 57 articles identified and read). This increase reflects a general trend, observed elsewhere, and may simply be due to increased use of electronic resources.
Table 4  How Scientists Learned About Articles Read in Universities With Libraries Having Different Levels of Electronic Collections

<table>
<thead>
<tr>
<th>Method of Learning About Article</th>
<th>Level of Electronic Journal Collections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>%</td>
</tr>
<tr>
<td><strong>Browsing</strong></td>
<td></td>
</tr>
<tr>
<td>Print Journals</td>
<td>60.5</td>
</tr>
<tr>
<td>Electronic Journals</td>
<td>[100.0]</td>
</tr>
<tr>
<td><strong>Online Search</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.6</td>
</tr>
<tr>
<td><strong>Other Persons</strong></td>
<td></td>
</tr>
<tr>
<td>Citations</td>
<td>14.1</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>4.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: University of Tennessee 1993 (n=71), University of Tennessee 2000 (n=96), Drexel University 2003 (n=71)

The age of articles read is shown in Table 5. The pattern of age of articles is similar for 1993 when there was negligible availability and for 2002 when Drexel had a nearly all electronic collection. Thus, it appears that the latter availability with a relatively new electronic collection did not affect the use of older and more valuable articles. However, the pattern of use is different when the partial library collection is available. Here, a much higher proportion of readings is from recently published articles (i.e., 71% in the first year following publication). All of this evidence suggests that the new, partial library electronic collection in 2000 may have altered use patterns, at least for a time. The University of Tennessee library collection was used far less in 2000 (69 articles) than in 1993 (103 articles), including for older articles. Greater use of current materials in 2000 (71%) vs. 1993 (61%) and the reduced time spent reading articles (49 minutes in 1993 to 36 minutes in 2000) support this finding, since older articles that are
read tend to be more useful and readers spend more time reading them. A combination of adapting a new partial electronic collection and cuts to the library’s print journal collection may together result in the shift from the library use to personal collections and other sources of articles.

Table 5 Age of Articles Read by Scientists in Universities with Libraries Having Different Levels of Electronic Collections

<table>
<thead>
<tr>
<th>Level of Electronic Journal Collection</th>
<th>Negligible</th>
<th>Partial</th>
<th>Nearly All</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58.5</td>
<td>71.6</td>
<td>61.2</td>
</tr>
<tr>
<td>2</td>
<td>12.3</td>
<td>9.1</td>
<td>12.9</td>
</tr>
<tr>
<td>3</td>
<td>6.2</td>
<td>4.5</td>
<td>7.2</td>
</tr>
<tr>
<td>4-5</td>
<td>7.7</td>
<td>4.6</td>
<td>5.9</td>
</tr>
<tr>
<td>6-10</td>
<td>9.2</td>
<td>5.7</td>
<td>4.7</td>
</tr>
<tr>
<td>11-15</td>
<td>1.5</td>
<td>2.2</td>
<td>4.7</td>
</tr>
<tr>
<td>&gt; 15</td>
<td>4.6</td>
<td>2.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: University of Tennessee 1993 (n=71), University of Tennessee 2000 (n=96), Drexel University 2003 (n=71)

Differences In Astronomers’ Reading Patterns by Age and Productivity

The development of the advanced information system in use by astronomers was spearheaded by the American Astronomical Society (AAS) which prepared a plan in 1992 for publishing their journals in electronic form. By 1995 their first journal appeared on the Web. The full-featured electronic journals system was developed in conjunction with the University of Chicago Press, based on partial support of the National Science Foundation and NASA (2, 3). A sophisticated set of links and protocols was constructed in collaboration with the NASA-supported Astrophysics Data System (ADS) which simultaneously developed an effective, searchable abstract database and complete, full text backfiles of the core literature, back to the mid 1800s (8). The complete system
includes extensive interlinking features (backward and forward citations, a searchable abstract database, published and original numeric data sets, moving graphics, etc.). In addition, the system includes deep links to the numeric data sets maintained in international astronomical databases, which, in turn refer back to the literature.

All of these advanced features reside in a single system of standards and protocols which facilitates the interlinking and the delivery of the information directly to the reader's desktop. Since the system is well established, astronomers and astrophysicists are well aware of its capabilities and have had ample experience in its use. Even though astronomy and astrophysics are different from other scientific disciplines in some ways, examination of their journal use provides a glimpse of what might occur in reading patterns of other disciplines as they progress towards advanced e-journal systems designed specifically to meet their research needs.

Our surveys of the AAS members reveal that within a relatively short period of time nearly all users have adopted the electronic information system for some of their readings. Five years after launch, the critical elements of an electronic information system, i.e. the journals and the abstract database, are used by more than 90% of all astronomers and the system is the most frequent source of their readings. The widespread adoption of the ADS by astronomers indicates an important aspect of the scholarly information system. It has to be a unified total information system. Too often we tend to think in terms of the individual links in the information chain. As producers and servers of information, we separate the information (the journals) from the tools we use to locate the relevant articles (the ADS), and from the system used to store and make available the information (the library). But, the working scientists need the all the units in the
information system, and all the units must work together effectively.

The tasks a scholarly researcher must go through in order to use (and produce) information can be represented in five categories listed in Table 6. The corresponding components of the information system are listed in the right-hand column.

Table 6. Tasks and Components for an Electronic Information System

<table>
<thead>
<tr>
<th>Tasks</th>
<th>System Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find</td>
<td>Searchable Abstract Database</td>
</tr>
<tr>
<td>Access</td>
<td>Linked Accessible Collection</td>
</tr>
<tr>
<td>Read</td>
<td>Journal Article</td>
</tr>
<tr>
<td>Use</td>
<td>Tabular and Auxiliary Data</td>
</tr>
<tr>
<td>Publish</td>
<td>Journal</td>
</tr>
<tr>
<td>Store</td>
<td>Accessible (Archival Quality) Collection</td>
</tr>
</tbody>
</table>

An effective electronic information system has to encompass all the components, providing tools with which to accomplish all the tasks. In general, the development of these components has been done independently by different groups of people with little thought given to how each unit will interoperate with the other units. Consequently, the various tasks do not operate smoothly with one another. In contrast, the astronomical information system was built with all the tasks in mind. Each component is tightly linked to all the other components, and the level of interoperation is excellent. This makes for a system which is easy and efficient for the user.
The rapid adoption of ADS by the astronomical community illustrates the importance of having a comprehensive and effective mechanism for locating information. On the basis of our surveys, we believe that having a system such as the ADS, from which the full text can be accessed seamlessly, is just as important as the availability of the information itself. The sharp increase in online searching shown in Table 3 arises from the widespread use of the ADS as shown in Table 7.

One surprising result of our usage surveys of astronomers is the small effect that age plays in the adoption of electronic resources. Astronomers of all ages use the ADS electronic system for locating articles. Table 7 shows that nearly all (97%) of PhD astronomers under age 35 use the ADS, and this percentage drops off only slightly with age. Having an effective electronic search mechanism available on the users’ desktop must account in part for the sharp rise in the use of online searches to locate articles.

Table 7 Awareness and usage of the Searchable Abstract Database (ADS) and the e-print service (ArXiv) by astronomers

<table>
<thead>
<tr>
<th>Awareness and Usage</th>
<th>Young (Under 36)</th>
<th>Middle Aged (36 – 49)</th>
<th>Old (Over 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aware of ADS</td>
<td>98%</td>
<td>98%</td>
<td>94%</td>
</tr>
<tr>
<td>Use ADS</td>
<td>97</td>
<td>92</td>
<td>88</td>
</tr>
<tr>
<td>Aware of ArXiv</td>
<td>91%</td>
<td>87%</td>
<td>79%</td>
</tr>
<tr>
<td>Use ArXiv</td>
<td>80</td>
<td>77</td>
<td>69</td>
</tr>
</tbody>
</table>

The small dependence of the usage of electronic information with age is mirrored...
in nearly all the survey data we obtained. Astronomers of all ages, and presumably other academic researchers as well, will move to electronic information resources for much of their reading if they serve their needs. Age is no barrier.

Astronomy has a long tradition of using preprints, first in paper form and now in electronic form. The purpose of the preprints is to disseminate research results quickly. Astronomers have been active users of the Los Alamos e-print service (now moved to Cornell at http://arxiv.org/), which includes preprints of articles accepted for publication in journals, some reprints of published articles, and some e-prints that will never be printed in traditional journals. Table 7 shows that, while a smaller percentage of astronomers use the ArXiv e-print service than the ADS, a significant portion of astronomers are both aware of and use it. Again there is only a small drop in numbers with the age of the user.

Given this relatively high usage, some vocal supporters of the e-print servers have even questioned whether or not the traditional journals are still needed. One of the great attractions of the arXiv.org preprint server in physics was that it was available long before the traditional journals were available online. The popularity of the e-print servers in physics represents a vote for the online literature, and should not be construed as a statement about the worth of the unrefereed (some would say self published) literature. In our view, any online source is more convenient than the same information in paper form. A majority of articles posted to arXiv.org are also submitted to peer reviewed journals.

Electronic versions of astronomy journals became available beginning in 1995. At about the same time the e-print services were becoming well known in the astronomical community. Therefore, by 1997 there were competing electronic services available to
astronomers, and the choices which astronomers had available should represent accurately the importance of the e-prints as compared to the journals, and not simply a choice of online vs. paper. One of the goals of our surveys was to determine the impact of the freely available, but unrefereed e-prints upon the habits and preferences of users. To this end, we asked astronomers to rank their preferences and usage of journals and e-prints both for keeping up with recent developments in the field and for providing definitive information (defined as information more than 2 years old).

Our results showed that PhD astronomers slightly preferred the refereed journals for keeping up with the field, although the e-prints were also judged to be an important source of information. However, for definitive information, astronomers preferred the journals by a large margin. Among our respondents, 97% of PhD astronomers found the journals to be either important or absolutely essential to their work, versus 26% for the e-prints. Some astronomers like the e-prints for the rapid access to new developments, but virtually all astronomers preferred to go to the journals for their definitive information.

We further analyzed the survey data based on the productivity of the responder in terms of the number of journal articles they submitted per year. Table 8 shows the percentage of PhD astronomers who rate the information source as either “very useful” or “absolutely critical” to them.

Table 8. Usefulness of journals and e-prints

<table>
<thead>
<tr>
<th>Percent rating resource as very useful or Critical</th>
<th>Less Productive (&lt; 1 per yr)</th>
<th>Average Productive (1 – 2 per yr)</th>
<th>Productive Productive (&gt;2 per yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journals (for recent developments)</td>
<td>70%</td>
<td>72%</td>
<td>74%</td>
</tr>
</tbody>
</table>
We found that the more productive astronomers (those submitting 2 or more journal articles per year) were substantially more likely to rank both the journals and the e-print servers as critical to their needs in keeping up with recent developments in the field than were those who submitted less than one article per year. As a source of definitive information, which we defined as being older than two years, journals were the top choice. It is important to note that the more productive, and hence more active, astronomers were more likely to also value the e-prints highly. Those of us in the business of providing information are thus reminded that the productive users value our work more than do our less active colleagues. Perhaps in planning for the future by analyzing what the usage patterns tell us we should count more highly the responses from the more productive users.

**What Factors Affect Journal Use Patterns?**

Above we have shown that journal use patterns are influenced by the evolutionary stages of the journal systems, the level of library electronic journal collections, and some personal factors such as age and productivity. In other studies we have found that additional personal factors affect journal use patterns as well, such as a person’s profession or discipline, place of employment, gender, and so on (5, 12, 13). Here we will discuss some recent studies of the use patterns of engineers and scientists and the factors which emerge that have been shown to affect journal use patterns. Such factors affect
readers’ choices made concerning use of a particular journal, specific articles or their information content, the means used to identify articles, and the sources used to obtain them. The results in this section come from general faculty and all disciplines, and will be representative of the university environment as a whole. The results in some cases contrast with the advanced, discipline-specific, well-integrated information system which has been developed for astronomy. The results are more representative of the emerging phase referred to earlier.

A few of the factors that affect readers’ choices are:

- Ease of use, including physical and intellectual effort required
- Importance of attributes of journals and related services
- Awareness of journals and related services
- The usefulness and value of the information content

Below we give a few examples of how each of these factors have influenced journal use patterns.

The physical and intellectual effort required to use a journal or service is one of the most important factors in its use. Meadows clearly articulated this fact when he observed that “One of the firmest conclusions of information usage surveys seems to be, indeed, that the intrinsic value of an information channel has little, or no, bearing on the frequency with which it is used. The ultimate factor is always its accessibility” (9, p. 124).

While it is true that the ease of locating and accessing information is the primary factor, we see from the case of astronomy that when two sources are equally accessible,
the users overwhelmingly prefer the “trusted” source, the refereed journal, over the unrefereed source.

Some examples of the importance of ease of use are:

- Readers tend to choose to use a library electronic collection because they don’t have to go to the library. Our surveys show that this saves them about 15 minutes per reading on average.

- On the other hand, they tend to prefer a print format for their personal subscriptions. We believe that they find it easier to browse print.

- We find that readers tend to print out electronic articles when they read them in depth, because it is easier to do so.

- Scientists in non-university environments tend to use reference librarians to perform difficult online searches because they can do them faster and better.

Attributes of journals and services also have a strong bearing on use. For example:

- **Journal Attributes.** Their price, quality (due to review and editing), available format, added features, size, and so on.

- **Library Collection Attributes.** Comprehensiveness, available format, hours that the library is open or electronic access is available, age of the collection, existence of a periodicals room, collection-related services (e.g., reference support, workstation capabilities, photocopying and printer availability), and so on.

- **Search Services.** Price, search quality (recall and precision), special search features, display features, and so on.
All such attributes have a bearing on use patterns. Our studies have shown that each use is unique, even to a particular reader, however, the astronomy data show that when the information system in interlinked effectively and operates as one system, the adoption of the electronic resources is rapid and complete.

Availability and attributes of alternatives are also important in choosing a journal or service. For example,

- Information content is often available from alternative sources (e.g., large eprint services, reports, conference presentations and proceedings, the author, colleagues, etc.) or a combination of other research and articles.
- Readers often know about the information reported or discussed in an article before they first read the article, yet they read in anyway (often in great depth).
- There are many alternative search engines available to readers and readers search for themselves or use intermediaries. This is in contrast to the astronomy system where the ADS is overwhelmingly the search system of choice.
- Readers can obtain articles from a range of sources (in alternative formats), such as personal subscriptions, library collections, author web sites, e-print archives, colleagues, and so on.

Readers have many options and choose from among them based on ease of use and how the attributes meet their needs. But when a system designed to meet the needs of a specific set of readers, such as the astronomy system, it becomes the overwhelming choice.

Another important factor, however, is awareness of the existence of a journal or alternative services. Examples of awareness issues are:
• Due to emergence of electronic journals, greater use of online searching, and increased use of libraries, the range of journals read by scientists has increased significantly, suggesting that previously they may not have been aware of some of the journals.

• Author web sites are now being used as a source by readers, but lack of awareness and their long-term availability can be a barrier to use. The data from astronomy indicates that when a large eprint server is available, the use of author web sites becomes negligible.

• Our studies show that users are often unaware of many important library services, but many would use the service if aware of them.

We recently asked university faculty at the University of Pittsburgh about their awareness of special electronic journal features, with the following results:

• All science respondents indicated they were aware of electronic journals, but 15% had not used them in the past 30 days.

• For journals published exclusively in electronic format, 89% were aware, but only 4% have published in them.

• 70% were aware of backward and forward citation linking, 41% have used either.

• Over half (52%) were aware of links to numeric databases and images, only 15% have used such features.

• 63% were aware of “large preprint archives”, 26% have used them.

• 44% are aware of author web sites and have used them, 19% reported they have their own author web site. However, as in astronomy, only a small percentage of the readings come from author web sites.
Scientists appear to be aware of advanced features of electronic journals, but less than half of the respondents in our recent survey used any one advanced feature.

**Conclusion**

All of the readership surveys discussed earlier show that scientists spend a great deal of time reading scholarly journals. They would not spend this time, their most important resource, on reading if the information was not worthwhile. Our studies since 1977 have repeatedly shown the usefulness and value of scientific journals as follows:

- The amount and time spent reading are both indicators of the value of article information.
- Primary Research is by far the principal purpose for reading.
- The information content is rated high in importance to achieving the primary research, as well as other purposes for reading such as teaching, writing, continuing education, etc.
- There are essential ways in which primary research (and other purposes) are affected by reading, such as inspiring new thinking, improving the result, and so on.
- Amount of reading is correlated with reader productivity.
- Many articles are shown to save readers’ time and other valuable resources.
- Reading is shown to help achieve the readers’ organization’s goals.
- Award recipients tend to read more than non-award recipients.

Since the emergence of electronic journals we have found these indicators to continue to hold. However, there appears to be little difference in them whether reading from electronic or print articles. Perhaps this is because the information content is essentially
the same in both formats of peer reviewed journals or articles from peer reviewed journals. We do believe as new features are used more, as with the case of astronomers, electronic journals will become even more useful and valuable.

A finding that has held through studies done since 1977, is that indicators of usefulness and value tend to be higher for articles obtained from library collections than from elsewhere. One possible reason is because nearly all older articles are obtained from library print or electronic collections and older articles are rated by our respondents as more useful and valuable on average than newly published articles. Also, librarians contribute to the intellectual aspect of identifying, locating, and acquiring relevant information.

Notes


15. Tenopir, Carol, Donald W. King, Peter Boyce, Matt Grayson, and Kerry-Lynn Paulson. (forthcoming.) Relying on Electronic Journals: Reading Patterns of Astronomers. Accepted by the *Journal of the American Society for Information Science and Technology* (JASIST), 2003.