



Electronic journals: how user behaviour is changing

Carol Tenopir

University of Tennessee, USA

Donald W. King

University of Pittsburgh, USA

Abstract: From 1977 through 2001 the authors have conducted a series of studies that examine reading and publishing habits of scientists in both university and non-university settings (including private companies and national laboratories). For the last decade the studies have measured the influence of ejournals on scholarly reading and publishing behaviours. These studies demonstrate that scientists continue to read widely from scholarly journals primarily for research and current awareness. Reading of scholarly articles has increased to approximately 120-130 articles per person per year, with engineers reading fewer journal articles on the average and medical faculty reading more. A growing amount of these readings come from eprints and other separate copies. A greater percentage of readings are now of new articles and readings from electronic journals are more likely to be of current articles. Approximately half to all of scientists in a discipline now use electronic journals at least part of the time, with considerable variations among disciplines. On the average, nearly one-third of journal articles read now come from electronic journals or digital databases. Evidence suggests that scientists are reading from a broader range of journals than in the past, influenced by timely electronic publishing and by growth in bibliographic searching and interpersonal communication as means of identifying and locating articles. Although the scholarly journals system has changed dramatically in the past few decades, it is evident that the value scientists place on the information found in scholarly journal articles, whether electronic or print, remains high.

Keywords: electronic journals, reading habits, user behaviour, eprints, scholarly publishing

1. Introduction

Studies conducted over the last four decades show that scientists on the average value journals and journal articles more than any other single information resource (Ref 1). (In our studies 'scientists' include life and physical scientists, social scientists, and engineers.) Journals are valued because the peer-review and editorial processes provide quality filters, they come from trusted sources, they bundle together articles on related topics, and they provide an archive of important research (Ref 1). They are probably valued also because they are familiar – some of which may be due to the traditional form and format of print-on-paper journals. As more journal articles are available in electronic forms, both as part of complete electronic journals and within databases of separate articles, several questions arise. Do scientists value electronic journals as much and for the same reasons as print journals? Do scientists in all academic disciplines use electronic and print journals in the same way? Will electronic journals or collections of electronic articles make print journals obsolete? Will eprint server collections replace traditional journals? A series of studies we conducted in 2000 and 2001 shed some light on these questions.

2. Background and literature review

2.1. Reading surveys

From 1977 through 2001 we surveyed nearly 15,000 scientists in all disciplines mostly in North America to track their communication and reading habits. These individual and collective results have been well documented (Ref 1). Some key findings include:

- the amount of reading is going up in all workfields;
- the number of personal subscriptions is going down, so scientists rely more on library-provided copies;

- the amount of reading varies with workfield;
- scientists, on the average, read more journal articles than do engineers;
- journals articles are reported to be of high value by both scientists and engineers;
- a majority of readings are articles that are less than two years old, but readings of older articles are reported to be very valuable.

Time spent reading an article varies from several minutes to hours. Quick reading generally involves newer articles and is done for the purpose of current awareness or professional development. Older articles get the most in-depth reading and are also often reread (37 per cent of university scientists reading articles older than two years old were not reading them for the first time).

There is a correlation between reading journal articles and professional achievement – award winners read 53 per cent more articles than non-winners. Scientists who serve on high-level projects or special committees read around 21 per cent more journal articles than those scientists who do not. Scientists who are considered high achievers by their peers read 59 per cent more articles than their colleagues even when other variables are held constant. University scientists who have won awards for their teaching and those who have won awards for their research read roughly 26 per cent and 33 per cent more articles, respectively, than their cohorts.

Through the 1990s, university scientists relied on libraries for over half of their readings (54 per cent), while personal subscriptions account for 36 per cent of their readings, and 11 per cent of their readings come from other sources. For non-university scientists, there is less reliance on personal subscriptions (24 per cent of their readings), but greater reliance on libraries: 19 per cent of their readings come from their organisation's library; 23 per cent from routed journals; 11 per cent from interlibrary loan services; 3 per cent from academic, government or public libraries.

2.2. Electronic journal adoption

All of the readings in our earliest surveys and many in the later surveys came from printed journals or from copies of print articles. The percentage of reading in electronic journals was clearly going up throughout the 1990s. However, our early surveys did not specifically measure the format. Others have reported widespread adoption of electronic scholarly journals, with the amounts varying substantially by workfield. With the growth of electronic distribution of journals and alternatives to traditional journals, use levels and patterns of such media may be expected to change. Several recent chapters of the *Annual Review of Information Science and Technology* (ARIST) provide literature reviews of developments in and use of electronic journals (Refs 2-4).

Studies have found that the perception of quality of sources is an important aspect in whether or not they are used and this may be particularly important in electronic journals. Speier et al. (Ref 5) asked business school faculty to rate the quality of peer-reviewed electronic journals versus paper, from those of substantially lesser quality (1) to those of substantially greater quality (7). About 61 per cent of respondents rated electronic journal quality in the three lowest ratings (average rating of 2.9, excluding non-responses)(Ref 3). Budd and Connaway (Ref 6) also asked about the quality of electronic and print journals. Although most respondents (77.1 per cent) said they could not judge, the majority of remaining respondents rated electronic journals inferior to most print journals. Some felt that electronic journals were improving, but 85 per cent said they could not judge (Ref 2).

Ease of use also affects whether or not sources will be used. Reading on a screen is a common problem for users. Richardson (Ref 7) found that none of his survey respondents appeared to have read articles on the screen. Schauder (Ref 8) found that 75 per cent of respondents preferred to read printouts. Simpson (Ref 9) observed similar results.

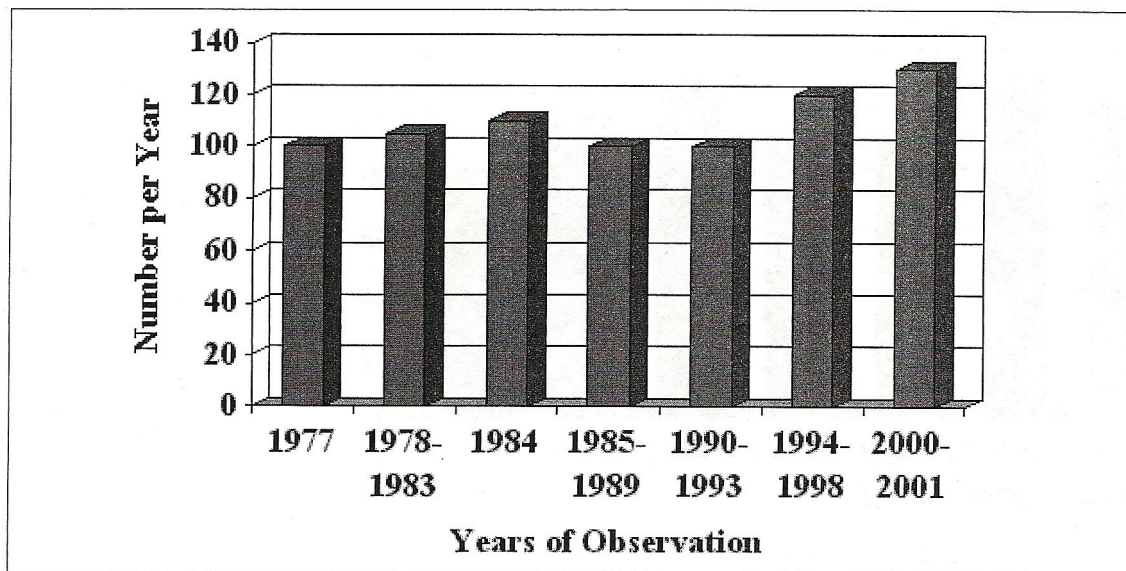
The SuperJournal Project in the UK (Ref 10) surveyed contributors to electronic journals about their perceptions of advantages and disadvantages of publishing in electronic journals. The greatest advantages of electronic journals were found to be easy access, convenience, search capabilities, direct access, and better-than-photocopy printouts; the greatest disadvantages were slow access, breadth or depth of journal coverage, reading on screen, poor graphics or presentation, and access problems.

When Speier et al. (Ref 5) asked respondents in Association of Research Libraries (ARL) institution business schools to rate their awareness of electronic journals, most respondents placed themselves on the middle to lower end of the awareness scale. These results are partially reflected in use of electronic journals by these respondents: over 40 per cent claim they rarely use electronic journals while another third of them say they never do. Lenares (Ref 11) also reports that 54 per cent of academics in her 1999 survey 'did not know of respected e-journals in my field', down from 61 per cent in the previous year. Still, over all, awareness of electronic journals grew throughout the last decade. In 2001, Rogers found that over half of the faculty and graduate student respondents to her survey use electronic journals and that acceptance of these alternative media is growing (Ref 12). Also in 2001, Brown surveyed physicists and astronomers who use the Los Alamos National Laboratory (LANL) arXiv.org service and observed that the majority (67 per cent) of respondents use preprints or eprints for the same reason many scientists use print journal articles (i.e. research support, current awareness and fact-finding) (Ref 13).

3. Current surveys

In 2000 and 2001 we conducted a series of surveys to allow us to compare findings with the earlier surveys, but also to measure specifically how much scientists are using electronic journals and other electronic sources of articles. In 2000/2001 we surveyed a sample of:

Figure 1:
Average number of scholarly article readings per year (all workfields).



- scientists and engineers at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee (to compare with a 1984 survey of this same government laboratory);
- faculty and research staff at the University of Tennessee, Knoxville (all departments except humanities to compare with a survey of this same faculty in 1994);
- the medical faculty at the University of Tennessee, Knoxville and Memphis campuses.

The first two of the above surveys are directly comparable to the results of earlier surveys of these same organisations, and will be reported here. Analysis of all surveys is ongoing. All of the 2000/2001 surveys asked questions about the scientists' relative use of print and electronic sources of journal articles.

3.1. Time spent reading and amount of reading

Scientists continue to read many journal articles on the average and spend many hours per year doing so. This has remained true over four decades and the number of readings on the average appears to be increasing (Figure 1).

The number of readings per scientist across all workfields averaged approximately 100 articles per year until the mid-1990s. In the last half of the 1990s, this average increased to approximately 120 articles per year and, in our surveys conducted in the early 2000s, it has gone up to an average of 130 per year across all workfields.

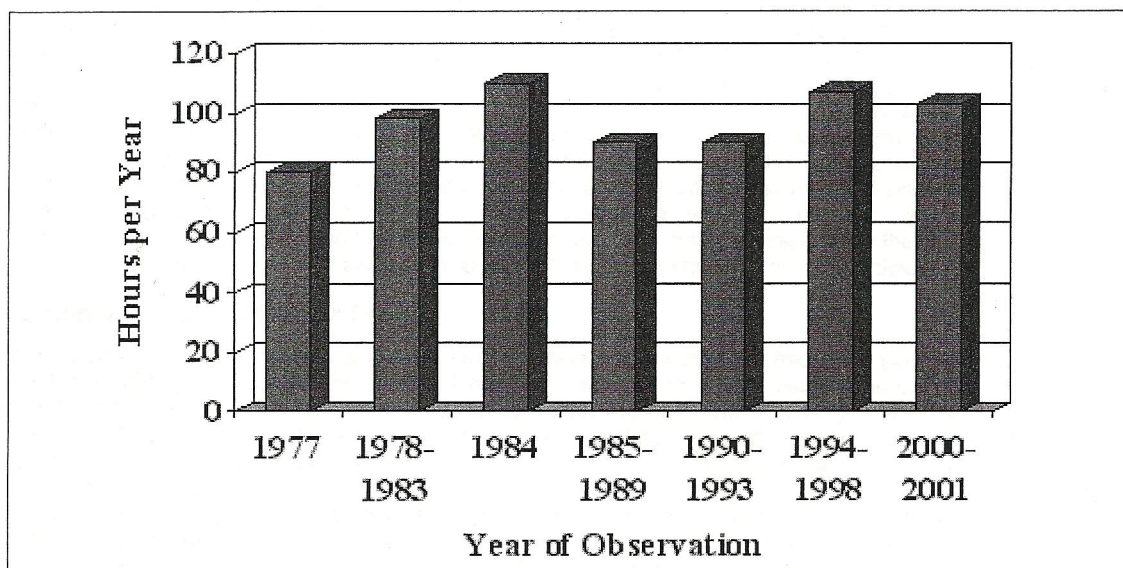
The average time spent reading has fluctuated and does not appear to be increasing as much as the number of readings. That means that scientists on the average are doing quite a bit more reading without spending a lot more time (Figure 2). (Some of the variation may be due to differences in population surveyed.)

The average number of article readings and the time spent reading per article vary among disciplines and workplace. Chemists read many more journal articles than do engineers, for example. In our recent studies we found that chemists at ORNL read an average of 276 articles per year, physicists an average of 204 articles per year, and engineers an average of 72. Academic scientists tend to read more than do scientists in other organisations such as government laboratories and companies, and university medical faculty tend to read the most – 322 article readings per year for UT medical faculty in 2001. The medical faculty spend an average of only about twenty minutes per article, however, so their total time reading is less than chemists (118 hours per year for medical faculty versus 198 hours per year for chemists) (Table 1).

Table 1:
Average article readings and the time spent reading by workfield per year per scientist

Article readings	Time spent reading
University medical faculty	~118 hours per year
Engineers	~92 hours per year
Physicists	~153 hours per year
Chemists	~198 hours per year

Figure 2:
Average time spent reading per scientist per year (all workfields).



3.2. Differences in reading from electronic and print journals – ORNL

Not surprisingly, scientists and engineers at the Oak Ridge National Laboratory (ORNL) rely much more on electronic sources to locate and read articles now than they did in 1984. Still, print sources are used more than electronic in most cases. ORNL respondents find articles to read both by searching indexes or citations (25 per cent), browsing (45 per cent) and other means. In 1984 about 13 per cent of readings were identified in printed indexes, but use of printed indexes dropped to zero in the 2000 survey, so all of the index searching in 2000 is in online indexes. Readings identified by citations in other publications dropped from 24 per cent in 1984 to about 12 per cent in 2000.

According to our 2000 survey of ORNL scientists, 20 per cent of the scientists found their articles by browsing personal subscriptions; 20 per cent also found articles through browsing electronic and digital copies of journals. Only 4 per cent of the scientists found articles by browsing the print collections at libraries, while a mere 1 per cent found articles by browsing their department collections.

The amount of reading of articles over one year old remained similar for the two time periods; however, in 2000 there appeared to be substantially more new articles read (80.2 readings per person in 2000 versus 59.4 in 1984). Nearly all the shift to recently published articles was attributable to reading of electronic or digital articles. Of all articles read from electronic or digital media, 85 per cent were published in the year 2000 (8 months into the year), while only 56 per cent of articles read from print subscriptions or copies were published in 2000. The oldest article read in the 2000 survey was 25 years old (Table 2).

The fact that the electronic/digital reading tended to be of more recent articles means that fewer of the articles had been read prior to the most recent reading (4 per cent in 2000 versus 22 per cent in 1984). In reading from both digital and print journals, a high proportion of the readings involved information that was known by the scientist prior to the first reading of the article (44 per cent electronic reading versus 58 per cent print). In both instances such articles were often found from citations in other publications or after mention of the article by another person.

Table 2:
Average Number of Readings of Articles Per Person by Age of Article Read: ORNL 1984 and 2000

Age of article	Readings per person	
	1984	2000*
1 year	59.4	80.2
2 years	12.9	10.2
3 years	5.9	4.5
4-5 years	11.9	6.8
6-10 years	4.0	4.5
11-15 years	3.0	2.3
Over 15 years	4.0	4.5

* Readings adjusted from 8 months to a year.

The time spent browsing or searching for each article and determining where the article was located approximately doubled from 1984 to 2000. In 2000, the reported time spent browsing electronic/digital articles was estimated to be 13.3 minutes per reading, but the time spent browsing print copies was half of that time (6.5 minutes). The time spent obtaining or accessing the article was about the same in the two surveys (7 and 6 minutes, respectively). When time involving other activities such as locating, displaying, and downloading or printing was added, the time spent totalled 17.7 minutes per electronic/digital reading, in 2000, compared with 8.2 minutes for browsing print copies (including locating and photocopying the articles). About 38 per cent of the electronic/digital readings were read from the screen. These readings tended to be of shorter duration than the downloaded/printed readings (20 versus 62 minutes, respectively). Interestingly, the proportion of print articles photocopied was about 50 per cent compared with 62 per cent of electronic/digital articles downloaded/printed out. The time spent photocopying was about three minutes compared with 4.5 minutes spent downloading/printing. When articles were identified by means other than browsing, the time spent using the two media was about the same (22 minutes per reading electronic/digital articles and 19 minutes for print articles).

3.3. Usefulness and value of journals at ORNL

In 2000, the principal purposes of the information obtained from the articles read were most frequently primary research (34 per cent of readings), background research (24 per cent), and current awareness or continuing education (22 per cent). These proportions of readings tended to be slightly higher for electronic/digital articles than for print articles. About 16 per cent of the readings were for communications-related purposes such as writing, making presentations, or consulting/advising others. Other purposes, such as administration, accounted for the remaining purposes of reading.

The respondents surveyed in 2000 indicated that they averaged 98 hours per year reading journals (96 hours in 1984). This estimate was based on estimated amounts of reading (99 readings in 1984 and 113 in 2000) and average time spent per reading (58 minutes and 52 minutes, respectively). Because their time is a scarce resource, this amount of time spent was an indicator of the value of information gained from reading journal articles. The amount of time spent reading electronic/digital articles was nearly identical to that of paper-based articles (52.2 minutes per article versus 51.4 minutes). Thus, this indicator of value was also the same for the two media sources. Other indicators of value of information include the observation that respondents whose most recent reading was from an electronic/digital article tended to be older and publish more articles.

3.4. Reading of preprints at ORNL

In some scientific fields, preprints of journal articles are an important distribution means. Physics, particularly high-energy physics, is an example. In a 1977 national survey of scientists, it was estimated that scientists received and read 2.1 million preprints (Ref 14). In 1981, physicists read about 20,000 separate copies of articles from 19 American Institute of Physics journals; 4,500 of them were preprints. Physical science authors averaged distributing 110 preprints per article (Ref 15). Several digital preprint services have evolved in recent years, including the LANL arXiv.org e-print archive and the Department of Energy (DOE) PrePRINT Network. We did not specifically include preprint reading in the 1984 survey of ORNL scientists, but rather included it as part of a general category of separate copies of articles. In the 2000 survey we asked respondents about their awareness of these (and other) preprint services, how much reading they did from them, and whether they submitted articles to the services.

About 29 per cent of the ORNL respondents were aware of the arXiv.org service, and about three-quarters of those who are aware had read an average of 7.9 preprints per person from the service in the past 12 months. Roughly one-half of physicists were aware of arXiv.org, and nearly all of those aware had read preprints from it in the past year. Other fields particularly acquainted with the service included engineering (31 per cent aware) and chemistry (20 per cent aware). Of all the respondents aware of the service, only 14 per cent of them had ever submitted article preprints to arXiv.org, even though those respondents averaged authoring or co-authoring about eight articles per person in the last two years. About 10 per cent of the articles published by those aware of arXiv.org were submitted to the LANL service.

A similar proportion of respondents (25 per cent) were aware of the DOE PrePRINT Network, but fewer of them (53 per cent) actually read preprints mentioned by the service. Those who did so averaged reading six preprints per person in the last year. Most of these readers were physicists or engineers. Other services were mentioned and used by a few of the respondents, including Physics of Plasmas, IOP, and Nuclear Fusion; ACM; and High Tc Update.

Altogether, the total electronic preprint reading amounted to about 3.6 per cent of all reading. In addition, about 4.5 per cent of readings were from preprints sent to respondents for article review or refereeing. Since about one-half of reading from separate copies of articles involved preprints, the increase in amount of reading from those separate copies may be partially attributable to reading from preprints and corresponding preprint services.

3.5. Differences in reading from electronic and print journals: UT Faculty

In autumn 2000 a sample of faculty and researchers from all natural and social science departments at the University of Tennessee at Knoxville was surveyed. This replicated a survey from 1994, but, like the survey to ORNL, asked specific questions about the use of electronic versus print journals. Results showed that in 2000 faculty at the University of Tennessee read an average of about 20 articles per month per person, or approximately 240 articles per year (compared to 185 articles per year in 1994).

Table 3:
Sources of Articles Read – UT 2000–2001

Source (n = 99)	Percentage
Personal print subscription	41
Separate copy/colleague	5
Separate copy/ILL	1
Separate copy/author's web page	2
Other	3
Personal electronic subscription	3
Library print subscription	24
Library electronic subscription	8
Free web journal	4
Separate copy/preprint	2
Separate copy/reprint	6
Separate copy/personal copy	1

Respondents at the University of Tennessee have an average of 3.6 personal subscriptions each, about one of which is paid by a grant. This is slightly higher than overall averages. University faculty seem to be largely unaware of eprint and preprint resources available to them. Of 99 respondents, only eight were aware of the LANL arXiv.org service, six were aware of the DOE PrePRINT network, and only four reported that they were aware of other preprint services. Eight faculty members reported that they were aware of the DOE PubSCIENCE electronic journal service. Although few are aware of such services, those that use them tend to use them often. Respondents who use these eprint services reported that they read 39 articles total from the arXiv.org e-print service, 16 articles from DOE PrePRINT, and 59 articles from other preprint services. They had only ever used PubSCIENCE 11 times.

4. Conclusions

Much of the increase in the amount of readings in all workfields is likely attributable to the prevalence of electronic journals or electronic sources of articles. Scientists in all disciplines and different places of work are reading more articles and a higher percentage of current articles (mostly electronic). Scientists use many sources for electronic journals, including institutional electronic database subscriptions, author's web sites, and eprint services such as DOE PrePRINT, PubSCIENCE and arXiv.org.

Traditionally there are many objectives of the scholarly journal system. Journal systems serve as a means of communication of new, peer-reviewed and edited information. Thus, the information should be trustworthy and, to the degree possible, supported by other research findings. Journals and articles should be readily available to readers and accessible to an unlimited audience beyond the author's primary or immediate community. Since many articles are read years after they are published, the system provides permanent, locatable and retrievable archives for the information. The system continue to provide alternative distribution means and media so that authors and readers can choose from alternatives that satisfy their specific needs and requirements, particularly to minimise their time and effort. The system is designed to protect against plagiarism, copyright ownership violation, and unauthorised modification or altering of the record of ideas, discoveries, and hypotheses tested. Journals convey the concept of prestige and recognition for authors, their research and their institutions. Electronic journals must fulfil these objectives as well, if they are going to take their place as a legitimate part of the scholarly journal system.

Carol Tenopir
School of Information Sciences
University of Tennessee
USA

References

- [1] Tenopir, Carol and Donald W. King. 2000. *Towards Electronic Journals: Realities for Scientists, Librarians, and Publishers*. Washington, D.C.: Special Libraries Association.
- [2] Bishop, Ann Peterson and Susan Leigh Star. 1996. Social informatics of digital library use and infrastructure. In: Williams, Martha E. (ed.) *Annual Review of Information Science and Technology* 31: 301–401. Medford, NJ: Information Today, Inc. for the American Society for Information Science.

- [3] Peek, Robin and Jeffrey P. Pomerantz. 1998. Electronic scholarly journal publishing. In: Williams, Martha E. (ed.) *Annual Review of Information Science and Technology* **33**: 321–56. Medford, NJ: Information Today, Inc. for the American Society for Information Science.
- [4] King, Donald W. and Carol Tenopir. 1999. Using and reading scholarly literature. In: Williams, Martha E. (ed.) *Annual Review of Information Science and Technology* **34**: 423–77. Medford, NJ: Information Today, Inc. for the American Society of Information Science.
- [5] Speier, Cheri, Jonathan Palmer, Daniel Wren, and Susan Hahn. 1999. Faculty perceptions of electronic journals as scholarly communication: a question of prestige and legitimacy. *Journal of the American Society for Information Science* **50**(6): 537–43.
- [6] Budd, John M. and Lynn Silipigni Connaway. 1997. University faculty and networked information: results of a survey. *Journal of the American Society for Information Science* **48**(9): 843–52.
- [7] Richardson, Robert J. 1981. end-user online searching in a high-technology engineering environment. *Online* **5**(4): 44–57.
- [8] Schauder, Don. 1994. Electronic publishing of professional articles: attitudes of academics and implications for the scholarly communications industry. *Journal of the American Society for Information Science* **45**(2): 73–100.
- [9] Simpson, Annette. 1988. Academic journal usage. *British Journal of Academic Librarianship* **3**(1): 25–36.
- [10] The SuperJournal Project. 1999. SuperJournals baseline studies report. Available at www.superjournal.ac.uk/sj/baserept.htm.
- [11] Lenares, Deborah. 1999. Faculty use of electronic journals at research institutions. In: Thompson, Hugh A. (ed.) *Racing Toward Tomorrow: Proceedings of the 9th National Conference of the Association of College and Research Libraries*, 8–11 April 1999: 329–334. Chicago, IL: Association of College and Research Libraries.
- [12] Rogers, Sally A. 2001. Electronic journal usage at Ohio State University. *College and Research Libraries* **62**(1): 25–34.
- [13] Brown, Cecelia. 2001. The e-volution of preprints in the scholarly communication of physicists and astronomers. *Journal of the American Society for Information Science and Technology* **52**(3): 187–200.
- [14] King, Donald W., Dennis D. McDonald, and Nancy K. Roderer. 1981. *Scientific Journals in the United States: Their Production, Use, and Economics*. Stroudsburg, Penn.: Hutchinson Ross Publishing Company. Available at: dwking@mail.sis.pitt.edu
- [15] King, Donald W. and Nancy K. Roderer. 1978. *Systems Analysis of Scientific and Technical Communication in the United States: The Electronic Alternative to Communication through Paper-Based Journals*. Washington, D.C.: King Research. Available from NTIS PB 281–847.