Information Seeking Behavior of Scientists in the Electronic Information Age: Astronomers, Chemists, Mathematicians, and Physicists

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The information seeking behavior of astronomers, chemists, mathematicians, and physicists at the University of Oklahoma was assessed using an electronically distributed questionnaire. All of the scientists surveyed relied greatly on the journal literature to support their research and creative activities. The mathematicians surveyed indicated an additional reliance on monographs, preprints, and attendance at conferences and personal communication to support their research activities. Similarly, all scientists responding scanned the latest issues of journals to keep abreast of current developments in their fields, with the mathematicians again reporting attendance at conferences and personal communication. Despite an expression by the scientists for more electronic services, the majority preferred access to journal articles in a print, rather than an electronic, form. The primary deficit in library services appeared to be in access to electronic bibliographic databases. The data suggest that a primary goal of science libraries is to obtain access to as many appropriate electronic bibliographic finding aids and databases possible. Although the results imply the ultimate demise of the printed bibliographic reference tool, they underscore the continued importance to scientists of the printed peer-reviewed journal article.

Introduction

As the twenty-first century approaches, successful storage and retrieval of the exponentially growing body of scientific information is quickly becoming dependent upon the Internet and the World Wide Web (WWW). The way in which scientists seek information to support teaching, research, and creative activities is changing as new technologies and information delivery systems emerge. Consequently, the traditional model of scientific communication proposed by Garvey and Griffith (1972) wherein information is primarily disseminated through, and subsequently becomes most highly valued when printed in, referred journals, is being challenged. An early model of electronic communication proposed by Lancaster (1978) and modernized by Hurd (1996), bypasses printed journals, indexes, and abstracting tools and suggests that scientific information dissemination will eventually be purely electronic. In light of the escalating cost to libraries for purchasing and archiving printed scholarly journals, electronic journals may prove to become the only alternative for maintaining an active platform for scientific scholarly communication (Tenopir & King, 1997; Odlyzko, 1998; Walker, 1998). Nonetheless, as the electronic mode of communication in science is in its infancy, it is not clear whether it meets the needs of the scientists creating and using the information.

In an effort to understand how scientists are responding to the changing methods of information dissemination, this study was designed to survey the information seeking behavior of scientists at the University of Oklahoma in Norman, Oklahoma (OU). Scientists from four disciplines; Astronomy, Chemistry-Biochemistry, Mathematics, and Physics were surveyed. Previous studies assessing the information seeking behavior of astronomers, chemists, mathematicians, and physicists have shown differences in the way these different types of scientists seek information. Chemists' information needs are continuous and on-demand, and rely heavily on current journals (Hurd, Weeler, & Curtis, 1992). Although mathematicians also make use of current journal literature, older material appears to be more important to mathematics research as it is cited more frequently than in other scientific disciplines (Garfield, 1983). Additionally, more mathematics research is published in monographs, specifically in monographic series, than in other sciences (Garfield, 1977). Physicists and astronomers also place a high value on current journal literature, but additionally depend on preprints of articles that may eventually appear in a research journal (King & Roderer, 1982). In fact, physicists studying high-energy particle theory were among the first scientists to make use of electronic infor-

Received August 24, 1998; revised April 6, 1999; accepted April 6, 1999

mation delivery when the Los Alamos National Laboratory (LANL) electronic preprint archive was established in 1991 (Taubes, 1993; Ginsparg, 1994). None of the studies, however, has detailed how these different scientists are seeking information in the changing electronic environment. Obtaining insights into how scientists use the OU library system as information becomes progressively more electronic, will enable the design and implementation of library programs and services that best meet their specific requirements.

Methodology

The Questionnaire

The questionnaire was composed of 20 questions plus an option to express any additional comments regarding library resources and services (Appendix I). The respondents were asked about approaches and preferences for finding information; use of the OU library system; and use of the indexing/abstracting tools available at OU. Similar questionnaires have been employed to survey the information seeking behavior of veterinary medicine students (Pelzer & Leysen, 1988a, 1998b) and health science faculty (Curtis, Weller, & Hurd, 1993, 1997). To reduce paper use and to take advantage of electronic communication, the survey was distributed electronically (i.e., e-mail). The questionnaire was first distributed to 10 Chemistry-Biochemistry and Mathematics graduate students to assess any strengths and weaknesses, to estimate the time required to complete the survey, and to ensure that all pertinent variables were included. After making minimal modifications, the questionnaire was e-mailed in May of 1998 to all the Chemistry–Biochemistry (26), Mathematics (27), and Physics–Astronomy (27) faculty members at OU. Two respondents requested a printed questionnaire due to problems with their e-mail accounts. Another faculty member who did not use e-mail also requested a printed questionnaire. The respondents were asked to return their questionnaire as soon as possible. After a two week time period, another e-mail was sent to encourage the non-respondents to return a completed questionnaire. A final query was sent in June of 1998 to the remaining faculty. To maintain confidentiality, all data were cataloged by an assigned identification number and the returned e-mail questionnaires were deleted. Approval for the use of human subjects in this investigation was granted by the Institutional Review Board of OU.

The Survey Population

Forty-nine of the 80 persons queried responded to the questionnaire, for a response rate of 61%. Faculty representation was 41% Chemistry-Biochemistry (74% of faculty responding), 29% Mathematics (48% of faculty responding), and 31% Physics-Astronomy (60% of faculty responding). Sixty-one per cent of the subjects held the rank of Professor, 22% Associate Professor, 10% Assistant Professor, and 2% Visiting Professor. None of the respondents were adjunct faculty, while 4% listed their status as "other." Ninety-two percent of the respondents were male, 8% were female. Twenty-two percent of the respondents had been faculty at OU for five years or less, 22% six to ten years, 14% ten to fifteen years, and 43% sixteen or more years. When the subjects were asked the number of articles published in the last five years, 15% responded to publishing less than five, 29% six to ten, 15% eleven to fifteen, 19% sixteen to twenty, and 23% greater than twenty. On average the subjects spent six hours per week reading journal articles with a range from one-half to twenty-four hours weekly.

Library Resources at the University of Oklahoma

The OU Library system is comprised of a main library and six branch libraries, including the Chemistry-Mathematics and Physics-Astronomy branch libraries. The Chemistry-Mathematics Library, located within the same complex as the Chemistry-Biochemistry and Mathematics departments, holds over 70,000 volumes and receives approximately 500 journal titles. The Physics-Astronomy Library is located in the same building as the Physics-Astronomy department and contains more than 35,000 volumes and subscribes to 185 journals. Campus wide electronic access via the WWW is available to five American Physical Society journals and 23 Institute of Physics journals (Appendix II).

Both libraries are reaching their maximum storage capacity, therefore all of the journals in the Physics-Astronomy collection and 6% of the those in the Chemistry-Mathematics collection are on a one-in-one-out schedule. Using this schedule the oldest bound volume is transferred to the main library when the newest one returns from the bindery. Consequently, the scientists are required to walk a short distance to the main library for older issues of journals. Also, because of the interdisciplinary nature of the biochemistry material, many of the monographs and journals in this area are housed in the main library. In fact, 58%, 31%, and 38% of the Chemistry-Biochemistry, Mathematics, and Physics-Astronomy faculty, respectively, indicated using the main library three to five times per month.

The importance, however, of the local branch libraries became evident when the scientists were asked how often they or their research assistants used the collections in their branch libraries. Eleven percent of the chemists visited the Chemistry-Mathematics library on a daily basis, while 58% visited three to five times per week. The mathematicians did not claim to use the Chemistry-Mathematics library daily but rather 31% used the collection three to five times per week, and 54% used it three to five times per month. Of the remaining mathematics faculty, eight percent claimed using the Chemistry-Mathematics library only three to five times per year and another eight per cent claimed never using the library. Thirty-one percent of the physicists and astronomers responding reported using the Physics-Astronomy li-

TABLE 1. Indexing and abstracting tools available at the University of Oklahoma for use by patrons free of charge.

Discipline	Title and access modes
General	
	Article First
	Via OCLC First Search WWW version
	Carl UnCover
	Via WWW
	Via Telnet
	Science Citation Index
	Print
Chemistry–Biochemistry	
	Chemical Abstracts
	Print
	As *CA Student Edition* via OCLC First Search WWW version
	MEDLINE
	Via OCLC First Search WWW version
	As *PubMed* via the WWW
Mathematics	
	Current Mathematical Publications
	Print
	As *MathSciNet* via the WWW
	ERIC (Educational Resource Information Center)
	CD-ROM
	Via OCLC First Search WWW version
	Mathematical Reviews
	Print
	As *MathSciNet* via the WWW
	Zentralblatt fur Mathematik/Mathematics Abstracts
	Print
Physics–Astronomy	
	Physics Abstracts
	Print

brary every day; 56%, three to five times per week; and 13%, three to five times per month.

The panoply of indexes and abstracts available for use at no charge to patrons at OU and their modes of access are listed in Table 1.

Use of the Collections

To obtain an estimate of the in-house use of printed journals and indexing/abstracting tools, reshelving statistics were collected for these materials. The data were collected in the Chemistry-Mathematics library from March to July 1998 and in the Physics-Astronomy library from April to July 1998.

Findings

Resources Used for Teaching and Research

Faculty were asked to indicate on a list which tools they used to support their teaching and research activities (Table 2). For teaching support, textbooks were the tool of choice for all three types of scientists responding to the questionnaire. Chemistry-Biochemistry and Physics-Astronomy faculty also made use of monographs and journals for teaching. The chemists, physicists, and astronomers indicated journals to be the primary source for support of their research activities (Table 3). Although mathematicians also indicated a high dependence on journals for research information (92%), they also indicated the importance of preprints (92%), conference attendance (92%), and personal communication (97%). It is also interesting to note that fewer mathematicians use monographs to gather information for teaching, than the scientists in the other two disciplines, but in contrast, they indicate a higher use of monographs (85%) in their research programs than did the other scientists. High use of journals is reflected in the reshelving statistics collected at the Chemistry-Mathematics and Physics-Astronomy branch libraries (Table 4).

Approaches and Preferences for Seeking Information

1. Current scientific awareness

In order to discover how the scientists locate the information they require for teaching and research, the subjects were asked how they keep abreast with current developments in their field (Table 5). Eight-five percent of the chemists indicated that they scan current issues of journals to stay current in their field. Also important to 60% of the chemists for keeping currently aware was attendance at conferences and use of a current awareness service. Thirty-three percent of the chemists using a current awareness service indicated using *Carl UnCover Reveal*, a weekly table contents alerting service that is available at no cost to

TABLE 2. Tools used to support teaching activities.

	% Faculty members		
Tool	Chemistry–biochemistry	Mathematics	Physics–astronomy
Monographs	65	23	60
Textbooks	94	92	93
Journals	53	15	40
Preprints	12	0	6
Conference attendance	12	7	6
Conference proceedings	12	7	0
Personal communication	12	15	13

TABLE 3. Tools used to support research activities.

Tool	% Faculty members		
	Chemistry–biochemistry	Mathematics	Physics–astronomy
Monographs	76	85	53
Textbooks	19	23	33
Journals	90	92	87
Preprints	43	92	67
Conference attendance	71	92	60
Conference proceedings	43	54	47
Personal communication	48	97	33

the faculty and graduate students in the science disciplines at OU. One chemist indicated for current awareness using Chemical Abstracts Service's *CA SELECTS*, a publication of abstracts and bibliographic information on subjects in an area of interest specified by the user. Two other chemists pointed to the Institute for Scientific Information's *Current Contents* on disk for their current awareness. Neither of these databases are available through the OU library system and therefore must be accessed at a cost to the scientist.

Mathematicians also scan current journals to stay up-to-date in their field (91%), but in contrast to the chemists, mathematicians make greater use of personal communication (85%) and attendance at conferences (92%) for current awareness. Two of the mathematicians reported using *MathSciNet* for current awareness. The *MathSciNet* database, produced by the American Mathematical Association, is available to the OU community through the Mathematics Department at no cost to the user. One mathematician reported use of *Current Contents* for locating current information. Although no specific URL or database was specified, one mathematics faculty noted the WWW and the Internet as their primary source of current information.

Similar to chemists and mathematicians, but to a lesser extent (69%), Physics-Astronomy faculty rely on current journals to learn of new developments in their fields. These scientists also make use of attendance at conferences (75%) and personal communication (62%) to keep abreast of research advances. Also indicated by three physicists in the field of high-energy particle theory was the LANL electronic preprint archive (http://xxx.lanl.gov/), while one other noted the current awareness service provided by Stanford Public Information REtrieval System (SPIRES) (http://www-spires.slac.stanford.edu/find/spires.html). Both these services are freely available on the WWW. In contrast to the chemistry respondents, none of the faculty in the Mathematics or Physics-Astronomy departments indicated use of *Carl UnCover Reveal* for current awareness, despite its free availability at OU.

TABLE 4. Reshelving of journals in the chemistry–mathematics and physics–astronomy branch libraries.

Discipline	Frequency of reshelving (pieces/week)	
	Current issues[a]	Bound volumes[b]
Astronomy[c]	4	15
Chemistry–Biochemistry[d]	41	146
Mathematics[d]	20	12
Physics[c]	23	41

[a] Most recent issues; in general, published since 1996.
[b] Yearly compilations of issues; in general, published before 1996.
[c] Data collected 4/98–7/98.
[d] Data collected 3/98–7/98.

2. Top five journals for staying current in science

To learn more about how the scientists keep abreast of developments in their fields they were asked to list the top five journals they read on a regular basis and whether they have a personal subscription to them. They were also asked whether they read the latest issues of *Science* and/or *Nature* regularly. Of the 20 Chemistry-Biochemistry faculty responding, 60% indicated the *Journal of the American Chemical Society* to be one of most important journals to read to for current chemistry information, regardless of their specific field of interest. Forty-one percent of those reading the *Journal of the American Chemical Society*, had a personal subscription. Also, 60% of the chemists noted that they regularly read their personal subscription to *Science*. Other important journals for chemists were discipline specific and included the *Journal of Organic Chemistry* (25%–20% personal subscriptions), *Organometallics* (25%–60% personal subscriptions), the *Journal of Physical Chemistry* (25%–no personal subscriptions). Twenty-five percent of the chemists responding to the survey indicated reading the recent issue of *Nature* (25% personal subscriptions).

Two mathematics faculty reported that the identification of only five important journals was not possible. They indicated a requirement to read broadly across many journals in order to stay current in their fields. Nonetheless, 31% of the Mathematics faculty indicated *Transactions of the American Mathematical Society*, *Inventiones Mathematicae*, and *Topology and Its Applications* to be important for their current awareness. None of the respondents indicated having a personal subscription to these journals. Personal

TABLE 5. Methods used for keeping abreast of current developments.

Method	% Faculty members		
	Chemistry–biochemistry	Mathematics	Physics–astronomy
Scanning of current issues of journals	85	91	69
Scanning recent issues of indexing/abstracting tools	30	46	44
Personal communication	35	85	62
Attendance at conferences	60	92	75
Current awareness service	60[a]	31[b]	13[c]

[a] 33% indicated *Carl UnCover Reveal,* 5% indicated *CA Selects,* 10% indicated *Current Contents.*
[b] 8% indicated *MathSciNet,* 4% indicated *Current Contents,* 4% World Wide Web and the Internet.
[c] 19% indicated Los Alamos National Laboratories (LANL) electronic preprint archive, 6% Stanford Public Information Retrieval System (SPRIES).

subscriptions to mathematics journals were denoted primarily by the faculty specializing in the area of mathematics education (17% of respondents). These journals included; *Cognition and Instruction, Journal for Research in Mathematics Education, Journal of College Science Teaching, Review of Educational Research, Science Education*, and *Journal of Women and Minorities in Science and Engineering*. Only one mathematics faculty member (7%) noted regular scanning of the table of contents of their personal subscription to *Science* for relevant articles in mathematics education.

Physical Review Letters was considered to be important for keeping abreast with current developments for 62% of the Physics-Astronomy faculty responding (10% personal subscriptions). Twenty-five percent of the physicists and astronomers indicated the following journals to be important to their research; *Physics Letters B* (no personal subscriptions), *Physical Reviews B* (no personal subscriptions), *Physical Review D* (25% personal subscriptions), *Journal of Applied Physics* (no personal subscriptions), the *Astrophysical Journal* (50% personal subscriptions), and *Astronomy and Astrophysics* (no personal subscriptions). The *Astronomical Journal, Monthly Notices of the Royal Astronomical Society*, and *Nuclear Instruments and Methods in Physics Research* were each listed as important by 19% of the scientists responding, although none indicated taking a personal subscription. Forty-four percent and 38% of the Physics-Astronomy faculty reported regular reading of the current issue of *Science* and *Nature*, respectively. None however, indicated having a personal subscription to either journal.

3. Less recent scientific information

In order to discover how scientists find older information for teaching and research, the subjects were asked how they become aware of less recent knowledge (Table 6). The scientists overwhelmingly indicated the use of citations at the end of journal articles to find less recent information (92–95%). Citations at the end of book chapters and retrospective searching of indexing/abstracting tools both played a greater role in locating less recent information for chemists and mathematicians than for physicists and astronomers. Personal communication was noted to be more important for finding less recent information for mathematicians (69%) than for the other scientists responding, especially the chemists (35%). One chemist suggested the importance of review articles in locating older chemistry information, while one mathematician noted that *Science Citation Index* would be of greater use for finding older information if it were available electronically. Currently at OU, *Science Citation Index* is only available in print, however, mediated searches through DIALOG may be performed by the library faculty on a pay per search basis. Two physicists indicated the use of SPIRES for finding older information about high-energy physics.

TABLE 6. Methods used for finding less recent information.

Method	% Faculty members		
	Chemistry–biochemistry	Mathematics	Physics–astronomy
Citations at end of journal articles	95	92	94
Citations at end of book chapters	65	62	25
Retrospective searching of indexing/abstracting tools	70	69	56
Personal communication	35	69	50
Browsing older volumes	20	23	19
Other	5[a]	7[b]	12[c]

[a] 5% indicated review articles.
[b] 8% indicated *Science Citation Index.*
[c] 13% indicated Stanford Public Information Retrieval System (SPRIES).

TABLE 7. Use of general indexing and abstracting tools in the past six months.

Index/abstracting tool	Frequency of response (%)				
	More than five times	3–5 times	Once	Never	Never heard of it
Chemistry–Biochemistry					
Article First	20	13	0	13	53
Carl UnCover	67	20	7	0	7
Science Citation Index	38	13	13	38	0
Mathematics					
Article First	0	0	0	42	58
Carl UnCover	0	8	0	92	0
Science Citation Index	0	18	45	36	0
Physics–Astronomy					
Article First	6	12	0	47	35
Carl UnCover	0	19	6	69	6
Science Citation Index	29	18	41	12	0

Index and Abstract Tool Usage

The faculty were asked to indicate on a check list how often in the last six months they had used the various indexing and abstracting tools available at OU listed in Table 1. An option was also given to indicate if they had "never heard of it [the tool]" and to list any other bibliographic finding aids they had used in the last six months. Of the general science indexes, *Science Citation Index* was the only indexing tool familiar to all the scientists responding to the survey (Table 7). In fact, 13%, 45%, and 41% of the faculty in the Chemistry-Biochemistry, Mathematics, and Physics-Astronomy Departments, respectively, reported using *Science Citation Index* at least once. In contrast, the other two general indexes, *Carl UnCover* and *Article First*, were virtually unused or unheard of by the mathematicians, physicists, and astronomers. The chemists, however, were aware of *Carl UnCover* (67% indicated using it more than five times) and *Article First* (20% indicated using it more than five times).

The scientists utilized the indexing and abstracting tools specific to their disciplines and were essentially unaware of those specific to other fields. The data are therefore presented by discipline (Tables 8–10). Fifty-six percent of the chemists had used the printed *Chemical Abstracts* more than five times in the six months prior to answering the survey (Table 8). This usage is reflected by the reshelving statistics collected at the Chemistry-Mathematics library from March to July of 1998. On average 26 volumes of the printed *Chemical Abstracts* were reshelved per week. Fewer (20%) reported using the electronic *CA Student Edition*, in fact, 27% had never heard of *CA Student Edition*. Access to *MEDLINE* was greater via *PubMed* on the WWW, rather than through OCLC First Search. In addition, three chemistry faculty reported use of other bibliographic tools which they accessed at their own expense. One listed regular use (more than five times in the past six months) of *Chemical Abstracts* via STN and of *Marinlit*, a database, purchased on CD-ROM, of the literature on Marine Natural Products produced by the Marine Chemistry Group at the University of Canterbury, Christchurch, New Zealand. The other noted using *Chemical Abstracts Services Patents Plus* database via the Internet, more than five times in the past six months, while one other reported using *Current Contents* with similar regularity.

Mathematics education was listed as the area of expertise of 17% (n=2) of the mathematics faculty who responded to the survey. Both of these faculty reported using the Educational Resource Information Center (*ERIC*) CD-ROM more than five times in the previous six months and one reported accessing *ERIC* via OCLC First Search with the same frequency (Table 9). One of these faculty also indicated use of *PsycINFO* and *Sociofile*, two CD-ROM products available on the OU local area network, at least three to five

TABLE 8. Use of chemistry indexing and abstracting tools by chemistry–biochemistry faculty in the past six months.

Index/abstracting tool	Frequency of response (%)				
	More than five times	3–5 times	Once	Never	Never heard of it
Chemical Abstracts					
Print	56	13	6	19	6
CA Student Edition	20	0	7	47	27
MEDLINE					
OCLC First Search	0	0	0	92	8
PubMed	20	7	0	73	0

TABLE 9. Use of mathematics indexing and abstracting tools by mathematics faculty in the past six months.

Index/abstracting tool	Frequency of response (%)				
	More than five times	3–5 times	Once	Never	Never heard of it
ERIC					
CD-ROM	17	0	0	50	33
OCLC First Search	8	0	0	58	33
Current Mathematical Publications					
Print	33	17	8	42	0
Mathematical Reviews					
Print	58	25	0	17	0
MathSciNet					
WWW	67	8	0	25	0
Zentralblatt fur Mathematik					
Print	36	18	0	45	0

times in the previous six months. *Current Mathematical Publications* and *Mathematical Reviews* were reported to have been used more than five times in the past six months by 33% and 58% of the mathematics faculty, respectively. These indexes however, were reshelved less than one time per week during March to July 1998. *MathSciNet*, the electronic equivalent to *Mathematical Reviews* and *Current Mathematical Publications*, was used more than five times in the previous six months by 67% of the mathematics faculty. All the faculty responding were aware of the availability of *MathSciNet*. Thirty-six percent of the mathematics faculty had used *Zentralblatt fur Mathematik* more than five times in the six months previous to answering the questionnaire. Similar to the reshelving data collected for *Mathematical Reviews* and *Current Mathematical Publications*, *Zentralblatt fur Mathematik* was reshelved less than one time per week during March to July 1998. One faculty member indicated regular use of the Kluwer's *Encyclopedia of Mathematics* for finding mathematics information.

The scientists responding from the Physics-Astronomy department do not appear to rely greatly on the tools available through the OU library system (Table 10). In fact, *Physics Abstracts* was only reshelved five times per week during April to July 1998. Nineteen percent of the Physics-Astronomy faculty however, indicated accessing the *INSPEC* database more than five times in the previous six months using their own personal academic user accounts available through STN. Eighteen percent of the faculty in the Physics-Astronomy department indicated using both the LANL preprint archive and SPRIES more than five times in the last six months. One astronomer listed frequent use (more than five times) of *NASA Astrophysics Data System* which is available freely on the WWW (http://cdsads.u-strasbg.fr/ads_services.html).

Methods of Obtaining Science Journal Articles

First the faculty were asked if they delegated their research to an assistant. Then they were asked to check the method(s) they used to obtain journal articles (Table 11) and how they subsequently organized them. Also, the scientists were asked whether they preferred a printed or an electronic version of a journal article.

Overall, the scientists personally obtained the journal articles they needed rather than delegating this task to a research assistant. This was especially true for the mathematicians, 92% of whom reported never delegating their research to an assistant. The high reliance on the library's printed copy was evident from the responses of all the faculty. One hundred percent of the Mathematics faculty reported photocopying the library's copy, while 90% and 81% of the Chemistry-Biochemistry and Physics-Astronomy faculty, respectively, also reported photocopying the library's printed copy.

Since the fall of 1997, the science faculty at OU have had the ability to order articles from journals that OU does not subscribe to, at no charge, using the document delivery service, *Carl UnCover*. Of the 45% of chemists who reported using a document delivery service, all but one had used *Carl UnCover* to obtain journal articles. The remaining

TABLE 10. Use of physics–astronomy indexing and abstracting tools by physics–astronomy faculty in the past six months.

Index/abstracting tool	Frequency of response (%)				
	More than five times	3–5 times	Once	Never	Never heard of it
Physics Abstracts					
Print	13	50	19	13	6
INSPEC					
Electronic via STN	19	13	0	50	19

TABLE 11. Methods of obtaining journal articles.

Method	% Faculty members		
	Chemistry–biochemistry	mathematics	Physics–astronomy
Personal subscription	55	23	38
Read library's copy	75	62	75
Photocopy library's copy	90	100	81
Personal subscription to electronic	5	8	6
Library's electronic	5	8	19
Free electronic version	20	31	44
ILL	60	46	44
Document delivery	45[a]	15[b]	25[c]

[a] 89% indicated *Carl UnCover*, 11% indicated requesting reprint from author.
[b] 100% indicated requesting reprint from author.
[c] 25% indicated *Carl UnCover*, 25% indicated Los Alamos National Laboratory Preprint Archive (LANL), 25% indicated LANL and Stanford Public Information Retrieval System (SPRIES), 25% indicated requesting reprint from author.

chemist reported requesting reprints from the article's author. Only one other scientist, a Physics-Astronomy professor, noted use of *Carl UnCover* to retrieve articles. Mathematicians, physicists, and astronomers reported requesting reprints from authors while the Los Alamos National Laboratory preprint archive and *SPRIES* were also mentioned by Physics-Astronomy professors as sources of articles. Forty-four to 60% of the scientists also made use of the Interlibrary Loan services at OU to obtain journal articles.

Eighty-five to 95% of the scientists reported maintaining a collection of reprints and copies of journal articles. These collections were of considerable size, especially for those maintained by chemists (63% reported collections of over 500 reprints). To organize their collections, eight of the nine chemists, listed the use of the electronic database EndNote. BibTeX was the electronic database of choice reported for one Mathematics and four Physics-Astronomy faculty members. Microsoft Access and AMSTex were listed by one faculty each for the organization of reprints. Although one Physics-Astronomy faculty member reported organizing reprints with "just a list," the remaining scientists who reported maintaining a reprint collection did not specify a method of organization.

Less than 50% of the respondents reported utilizing some form of electronic subscription to obtain journal articles. Sixty-two percent to 65% of the scientists reported a preference for a print journal while 23% to 31% preferred an electronic version. A small fraction of the scientists (5–16%) expressed a preference for access to both print and electronic forms and two of these scientists stipulated that the electronic would be preferred only if it were "printable."

Additional Comments

The survey provided an opportunity for the scientists to add any other comments regarding library resources and services. They were also asked whether there were any services they required that the OU libraries did not provide. The comments were generally favorable, expressing satisfaction with the service provided by the Chemistry-Mathematics and Physics-Astronomy branch libraries. The scientists appreciated services such as a Table of Contents service provided to the Physics-Astronomy faculty, and monthly e-mail posting of new acquisitions. Concern was expressed however, over the quality of the articles sent via FAX machine from *Carl UnCover*. One Physics-Astronomy professor expressed that for their work "where greyscale figures are very important" the copies generated by a FAX machine were not acceptable. Similarly, a Chemistry-Biochemistry faculty member found the figures from *UnCover* to be "unreadable." The other major concern across all departments was gaining timely access to all available electronic journals and appropriate electronic bibliographic databases. Specific bibliographic databases listed were ISI's *Current Contents*, and Chemical Abstracts Service's *SciFinder Scholar*. One mathematician expressed a desire for a service similar to *MathSciNet* for physics and engineering literature. Finally, a chemist proposed their "ideal" service wherein the titles, abstracts, and full text of journal articles could be electronically searched on a personal computer, followed by downloading and printing of targeted articles, for an "affordable" charge.

Discussion

This study illustrates the information seeking behavior of astronomers, chemists, mathematicians, and physicists at the University of Oklahoma. The scientists surveyed were a productive, dynamic, and mature group of scientists who relied greatly on the journal literature to support their research and creative activities. The mathematicians surveyed indicated an additional reliance on monographs, preprints, and "the invisible college," i.e., attendance at conferences and personal communication to support their research activities. Similarly, all scientists responding scanned the latest issues of journals to keep abreast of current developments in their fields, with the mathematicians again reporting conference attendance and personal communication for

current awareness. These differences are reflected in the frequency of use of the branch libraries reported by the scientists. The Chemistry-Biochemistry and Physics-Astronomy faculty reported both regular daily and weekly use of the branch libraries in their buildings. In contrast, the majority of the Mathematics faculty reported using the Chemistry-Mathematics library only on a monthly basis. It appears that the mathematicians questioned did not rely as greatly on the library as did the astronomers, chemists, and physicists surveyed. When asked to cite the top five journals read on a regular basis, very few of the scientists, regardless of field, reported holding a personal subscription. All the scientists responding indicated a high reliance on the library's printed copy for current and archival information.

Despite an expression by the scientists for augmentation of the currently available electronic services at OU, the majority preferred access to journal articles in a print, rather than an electronic, version. Those listing a preference for access to both versions, still desired the ability to print the electronic version. The primary deficit in library services appeared to be in access to electronic bibliographic databases. Of the scientists surveyed, however, only the chemists were making extensive use of the document delivery service and table of contents altering service available at OU through *Carl UnCover*. This suggests that the information available through *Carl UnCover* does not satisfy the needs of the other scientists surveyed or that they are using other methods to gain access to journal articles. The mathematicians did express a reliance on *MathSciNet* and the Physics-Astronomy faculty listed the LANL preprint archive and SPRIES as important bibliographic databases for their current awareness and research activities. Scientists from all three disciplines pointed to ISI's *Current Contents* for current awareness. This service is not provided by the library.

Conclusion

As the twenty-first century approaches and information delivery systems are becoming more electronically oriented, science librarians must be aware of how the scientists they serve prefer to access information. The information presented in this paper provides a sketch of the information seeking behavior of scientists at the University of Oklahoma. Consequently, the information seeking behavior observed may be influenced to some degree by what is available for their use through the University of Oklahoma library system. Yet, several of the scientists responding looked beyond the collection at OU and found their needs were well served by electronic databases provided by organizations such as the Institute for Scientific Information and the Los Alamos National Laboratory. Therefore, the results may be extrapolated to scientists in other academic institutions.

The scientists are embracing electronic bibliographic databases and would like to see the access to and the capabilities of these expanded. The ultimate preferred source for information was shown to be the printed journal article. This perhaps will remain the case, as Walker suggests, "until researchers, librarians, and publishers agree that there is a better way—and what that is" (Walker, 1998). The data presented suggest that a primary goal of science libraries should be to obtain access to as many appropriate electronic bibliographic finding aids and databases possible. To ensure an information literate patron population however, the availability of the tools should be publicized and subsequent instruction in their use should be given.

The information presented in this paper implies the ultimate demise of the printed bibliographic reference tool however, it underscores the continued importance to scientists of the printed peer-reviewed journal article.

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Appendix I Questionnaire

Dear Faculty Member-

Two weeks ago I wrote to you concerning a survey to improve your access to information from the Chemistry–Mathematics and Physics–Astronomy Branch Libraries. The survey is attached below this message. Completion of the questionnaire should take less than 15 minutes. Please send it back to me via reply e-mail as soon as possible. If you would rather complete the questionnaire on paper, please contact me and I will deliver a printed copy to your office.

Thank you very much for your participation.

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Information Seeking Behavior of Science Faculty at the University of Oklahoma

1. What department are you in?
____ Chemistry–Biochemistry
____ Mathematics
____ Physics–Astronomy

2. What is your major field of research?

3. Approximately how many hours do you spend reading journal articles?
___ hours weekly OR ___ hours monthly

4. What are the five (or fewer) most important journals that you read to stay current in your field? (please indicate with a "p" if you have a personal subscription to any of the titles listed, i.e., *Journal of Biological Chemistry*–p)
1.
2.
3.
4.
5.

5. Which of the following do you use as your primary source of information for your
(a) teaching, and
(b) research (please put an "a" and/or "b" next to those that apply)
___ monographs
___ textbooks
___ journals
___ preprints
___ attendance at conferences
___ conference proceedings
___ personal communications
___ other (please describe):
_____

6. How do you keep abreast of current developments in your field(s)?
___ scanning of current issues of journals
___ scanning recent issues of abstracting/indexing tools
___ personal communication
___ attendance at conferences
___ current awareness service (please describe, i.e., *CarlUnCover Reveal, Current Contents*):
_____
___ other (please describe):
_____

7. Do you read the current issue of (please check if yes):
___ *Science*
___ *Nature*

8. How do you become aware of other less recent journal articles?
___ citations at end of journal articles
___ citations at end of book chapters
___ retrospective searching of indexing/abstracting tools (e.g., *Chemical Abstracts*, *MathSciNet*, *Physics Abstracts*)
___ personal communication
___ browsing through older volumes
___ other (please describe):
_____

9. How do you obtain journal articles? (please check all the methods you use)
___ personal subscription to print
___ read library's copy
___ photocopy library's copy
___ personal subscription to electronic version
___ library's electronic version
___ free electronic version
___ interlibrary loan
___ document delivery (please specify) :
___ other (please describe) :
_____

10. Do you maintain a personal reprint collection?
___ no
___ yes, approximate size:
___ less than 100 ___ 101–500 ___ greater than 500

11. Do you maintain a personal bibliographic database?
___ no
___ yes, please specify the software you use (e.g., EndNote):
_____

12. If given the option, how would you prefer to obtain journal articles?
___ print copy ___ electronic version

13. Do you delegate your library research to a research assistant?
___ always ___ sometimes ___ never

QUESTIONS 14 AND 15 PERTAIN TO THE LIBRARY RESEARCH YOU
AND/OR YOUR PRIMARY RESEARCH ASSISTANT CARRY OUT

14. How often do you and/or your research assistant use the following library's collections?

(a) Bizzell Memorial Library
___ daily ___ 3–5 times per year
___ 3–5 times per week ___ never
___ 3–5 times per month

(b) Chemistry–Mathematics Library
___ daily ___ 3–5 times per year
___ 3–5 times per week ___ never
___ 3–5 times per month

(c) Engineering Library
___ daily ___ 3–5 times per year
___ 3–5 times per week ___ never
___ 3–5 times per month

(d) Geology Library
___ daily ___ 3–5 times per year
___ 3–5 times per week ___ never
___ 3–5 times per month

(e) Physics–Astronomy library
___ daily ___ 3–5 times per year
___ 3–5 times per week ___ never
___ 3–5 times per month

15. How often have you used each of the following indexes or databases in the last six months?

(a) *ArticleFirst* via FirstSearch
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(b) Basic *BIOSIS* via FirstSearch
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(c) *Biological Abstracts* (print)
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(d) *BIOSIS* via CD-ROM
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(e) *Carl UnCover*
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(f) *Chemical Abstracts* (print)
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(g) *Chemical Abstracts Student Edition* via First Search
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(h) *Current Mathematical Publications* (print)
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(i) *ERIC* via FirstSearch
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(j) *ERIC* via CD-ROM
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(k) *INSPEC* via STN
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(l) *Mathematical Reviews*
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(m) *MathSciNet*
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(n) *MEDLINE* via FirstSearch
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(o) *MEDLINE* via PubMed
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(p) *Physics Abstracts*
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(q) *Science Citation Index*
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(r) *Zentralblatt fur Mathematik/Mathematics Abstracts*
___ once ___ 3–5 times ___ more than 5 times
___ never ___ never heard of it

(s) Please specify any other indexes or databases that you use which are not listed and your frequency of use in the last six months:

_____
___ once ___ 3–5 times ___ more than 5 times

_____
___ once ___ 3–5 times ___ more than 5 times

_____
___ once ___ 3–5 times ___ more than 5 times

_____
___ once ___ 3–5 times ___ more than 5 times

_____
___ once ___ 3–5 times ___ more than 5 times

16. What determines your choice of journals for the publication of your own work? (please check all that apply):

___ standing of journal in your field
___ audience
___ distribution
___ editorial board
___ speed of publication
___ page charges

17. How many articles have you published in referred journals in the last 5 years?

___ 0–5 ___ 6–10 ___ 11–15 ___ 16–20 ___ over 20

18. What is your faculty rank?

___ Professor ___ Visiting Professor
___ Associate Professor ___ Adjunct Professor
___ Assistant Professor ___ other (please specify): _____

19. How many years have you been a faculty member at the University of Oklahoma?

___ 0–5 ___ 6–10 ___ 10–15 ___ more than 16

20. What is your sex?

___ female ___ male

21. Please add any other comments regarding library resources and services. Are there services that you require that University of Oklahoma Libraries does not provide?

Appendix II Electronic Journal Subscriptions at the University of Oklahoma

American Physical Society

- *Physical Review A*
- *Physical Review B*
- *Physical Review C*
- *Physical Review E*
- *Physical Review Letters*

Institute of Physics

- *Journal of Physics A: Mathematical and General*
- *Journal of Physics B: Atomic, Molecular and Optical Physics*
- *Journal of Physics: Condensed Matter*
- *Journal of Physics D: Applied Physics*
- *Journal of Physics G: Nuclear and Particle Physics*
- *Classical and Quantum Gravity*
- *Distributed Systems Engineering*
- *European Journal of Physics*
- *High Performance Polymers*
- *Inverse Problems*
- *Journal of Micromechanics and Microengineering*
- *Measurement Science and Technology*
- *Modelling and Simulation in Materials Science and Engineering*
- *Nanotechnology*
- *Nonlinearity*
- *Physics Education*
- *Plasma Physics and Controlled Fusion*
- *Plasma Sources Science and Technology*
- *Reports on Progress in Physics*
- *Semiconductor Science and Technology*
- *Smart Materials and Structures*
- *Superconductor Science and Technology*
- *Waves in Random Media*