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Received 3 October 2007
Revised 26 October 2007
Accepted 31 October 2007

OTHER ARTICLES

Subject change between citing and cited literature on digital libraries

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Abstract

Purpose – The purpose of this paper is to analyze and compare the subject change for both citing and cited literature on digital libraries based on bibliometric techniques.

Design/methodology/approach – Library and Information Science Abstracts (LISA) was used to retrieve data of journal articles in digital libraries from 1960 to 2002. By employing the thesaurus search function, three descriptors for subject search, namely electronic library concept, digital libraries and virtual library concept, as suggested by LISA, were used to retrieve all relevant literature on digital libraries.

Findings – Most of the citing core journals on digital libraries are devoted to the subject of the application of computer and information technology to library implication, while the cited literature on digital libraries distributes mainly into four types of journals, namely, digital library orientation, general library and information science, new development in librarianship, and library technology. Digital libraries, electronic media and world wide web (WWW) are the three subject terms in common most for both citing and cited core journal literature. They also constitute the core subject for digital library literature. The change of highly used subject terms, such as WWW, internet, library technology, network, university or academic library, from cited to citing literature suggests that these subjects are becoming the main stream of researches in digital libraries.

Research limitations/implications – Most subject terms of this study for both citing and cited literature in digital libraries could be categorized into the technical issues. However, other related issues dealing with copyright, charging and authenticity; social issues; quality of preservation and availability; use and user study; economic issues; education and promotion have not been popular research areas yet by 2002. Further studies are needed.

Originality/value – The present work is unique in its study of the subject and the results obtained provide significant insights into the evolution of digital libraries by identifying the core journals and examining their characteristics, as well as subject changes between citing and cited literature on digital libraries.

Keywords Digital libraries, Serials, Information searches

Paper type Research paper



Introduction

The term “virtual library”, “digital library” and “electronic library” have appeared in the professional literature of library and information science since 1990s. What explicit definitions and contents they have is still an open question for discussion. Borgman (1999, p. 233) proposed a definition of a National Electronic Library as:

- a service;
- an architecture;
- a set of information resources, databases of text, numbers, graphics, sound, video; and
- a set of tools and capabilities to locate, retrieve and utilize the information resources available.

Borgman’s definition suggests the scope of digital libraries consisting of several phases with the contributions of scholars from many disciplines.

Borgman (2000) stressed that the current state of digital library research and development, especially in the USA, is influenced by the research definition of digital libraries. Indeed, the research and development on digital libraries is challenging because it inevitably must deal with four dimensions of the design space: community, technology, services and content (Marchionini and Fox, 1999). For example, two special issues of the *Journal of the American Society for Information Science – JASIS* (2000a, b), contain articles reflecting the state-of-the-art of digital library research (especially in the USA) and emphasizing various methods, tools and techniques that facilitate improved access to information in digital libraries. Consequently, there may be a significant literature scattering and subject changes between citing and cited literature on digital libraries.

The present study employed bibliometric techniques, in particular Bradford’s law, to analyze the scattering and subject changes between citing and cited literature for the field of digital libraries. Bradford law has been commonly employed to investigate the literature scattering. For example, by analyzing the source documents and their references by classification systems researchers in the world, Chung (1994) investigated core journals of the field for the period 1981-1990. Chung’s study showed that journal literature in classification systems conforms to Bradford’s law. Moreover, he also identified the core journals in the subject. Ungern-Sternberg (2000) explored the empirical use of Bradford’s law for decisions concerning information systems in problem-based fields. She proposed that results of comparison of the cores journals in different fields can be used as a base for tailoring an information system. In her study, Bradford’s law was applied on five databases in the topic “information retrieval and seeking” in order to compare the size and titles of the core journals. Her results confirmed that the Bradford analyses can be useful tools in developing information systems. Herring (2000) employed search words “digital” or “virtual” or “electronic” adjacent to “library” or “libraries” to search electronic indexes of *Library Literature*, *Humanities Abstracts*, *Social Sciences Abstracts*, *Wilson Business Abstracts*, *General Science Abstracts*, *Applied Science and Technology Abstracts*, *Applied Science and Technology Abstracts*, *Reader’s Guide Abstracts*, and *PAIS International*, to analyze 232 citations on digital libraries from 1992 to 1998. He found that of 105 journals listed, only 45 (42.8 per cent) published more than one article on the topic during the six-year period studied.

As demonstrated in the literature review given above, there is no study investigating the subject changes between citing and cited literature. Therefore, the present work is unique in its study of subject changes between citing and cited literature on digital libraries. The subject changes between citing and cited literature can be used to examine the intellectual structure and shed light on the evolvement of a special discipline, such as digital libraries in the present study. The diffusion of major concepts on digital libraries may then be revealed. This is of significant interest of the study of digital libraries. Moreover, the present work carries practical implications in a number of areas. For example, in building a comprehensive collection on digital libraries or information researcher should perhaps be concerned with both core journals of citing and cited literature on digital libraries.

After applying a citation analysis to articles published in the *JASIS*, Persson (1994, p. 37) found the tradition of information science has two major branches, bibliometrics and information retrieval. White and McCain (1989, p. 120) also argued that bibliometrics comprises fully half of the entire field of information science. Digital libraries deal with not only traditional library practices, but also with information technology, especially greatest relevance to information retrieval, hypertext and hypermedia, network, etc. Therefore, the present study using bibliometric method as a means to explore the state of digital library research and practice is of significant interest for information science and technology.

Methodology

Library and Information Science Abstracts – LISA (2003) was used to retrieve data of journal articles in digital libraries from 1960 to 2002. It is selected not only because it is one of the most important databases in information and library science, but also because it provides abstract access. The abstract accessed helps to identify a relevant article; therefore, an insightful analysis is possible. LISA is of good structure and is a well-organized bibliographic database that provides powerful retrieval capabilities and comprehensive search interfaces. Importantly, an online database, such as LISA, offers authority controls strictly for subject terminology that can enhance either recall or precision in searching. LISA includes abstracting and indexing of over 550 periodicals (dating from 1969) from over 65 countries in more than 20 different languages. It also includes unpublished academic and institutional research from the Current Research in Library and Information Science database (since 1981).

By applying the thesaurus search function, three descriptors for subject search, namely electronic library concept, digital libraries and virtual library concept, were suggested by LISA to retrieve all relevant literature on digital libraries. These three search terms are limited to the descriptor field of the database. The descriptor field utilizes controlled vocabulary from a thesaurus or from subject headings list that were created by the database producer. Lancaster (1986) indicated that a controlled vocabulary would control the synonyms, nearly synonyms, homographs and related term. LISA tends to include broad descriptive terms in its indexing, and hence the strategy used in this study would be expected to retrieve most of the papers on digital libraries.

Several journal titles may refer to the same journal if the name of the journal changes, or if the compilers of the database are inconsistent regarding the form used to cite the journal. In such cases, it would seem appropriate to sum the citations under the more recent or better known name. For example, *Journal of the American Society for Information Science*

and Technology (JASIST) is used in the present study instead of its former title of JASIS. To determine which journals changed names, the complete list was compared with the list of name changes in *Ulrich's International Periodical Directory* (2002).

All entries in LISA for journal articles are edited in a uniform style. The bibliographic citation includes: author(s), title of item, title of source (journal name, volume, issue number, year, and inclusive pagination), and original language indication for non-English publication. Whenever information in the bibliographic data is not enough to determine the subject of journal, additional tools are consulted. Most journals have been checked with *Ulrich's International Periodicals Directory*, LISA, and *Magazines for Libraries* (Katz and Katz, 2000), and the web page for each journal. Each relevant record with a uniform structure that retrieved from LISA was then downloaded to a compact disk and analyzed and processed by Access database software, Microsoft Excel and Perl programming language.

Results and discussion

A total of 1,479 journal articles on digital libraries from 248 journals in LISA, published from 1960 to 2002, were retrieved – this forms the database for the citing literature study of this work. As for the cited literature, 395 journal articles from 11 most productive citing journals, each published more than 20 papers on digital libraries, were selected, and their bibliographic references were analyzed. After eliminating non-journal and ambiguous items, the remaining 1,352 journal bibliographic references in 353 journals were used for the cited literature study.

Bradford zones

Bradford (1948, p. 154) proposed the law of journal literature scattering which states that:

If scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several other groups of zones containing the same number of articles as the nucleus.

According to Bradford's law, Table I shows that both citing and cited literature can be grouped into three zones, each yielding roughly the same number of articles for citing or cited literature. For citing literature, the number of journals for these three zones increases from 18 to 54 and to 176, (18:54:176 ~ 1:3:3²) by a multiplier fairly close to 3.

Zone	Journals	Articles
<i>Citing literature</i>		
1	18	515
2	54	544
3	176	420
Total	248	1,479
<i>Cited literature</i>		
1	6	451
2	43	430
3	304	471
Total	353	1,352

Table I.
Bradford zones of scatter
on digital libraries

For cited literature, the number of journals from Zones 1 to 3 is 6.43 and 304 (6:43:304 ~ 1:7:7²), respectively, resulting in approximately a multiplier of 7.

The journals in the first zone may be treated as the core journals. Therefore, the 18 journals in the first Bradford zone of the citing literature considered as the core journals for citing literature on digital libraries in this study; on the other hand, the six journals in the first Bradford zone of the cited literature are treated as the core journals for cited literature on digital libraries. The following sections are detailed analysis of the nature and subjects of core journals in both citing and cited literature.

Nature of core journals for citing literature

The subject scope of the 18 citing core journals for citing literature on digital libraries identified from the Bradford zones is summarized in Table II. These 18 citing core journals published 515 (31 per cent) of 1,479 total articles on digital libraries in the studied period. Each journal published 16-90 articles on digital libraries. Descriptions of the subject scope of these core journals have been drawn from *Ulrich's International Periodicals Directory* (2002), which is an authoritative source for journal descriptions. Moreover, the web pages of the journals are examined to confirm the subject scope of the core journals.

D-Lib Magazine is a solely electronic publication that focuses on digital library research and development; therefore, it ranks number one as one might expect. The number two journal, *Library Hi Tech*, focuses upon computing and technology for the library community. *Advanced Technology Libraries*, ranking number three, offers a concise review of information technology relevant to libraries. *Library Hi Tech News* (No. 10) is a supplement to *Library Hi Tech*. *Computers in Libraries* (No. 11) provides coverage of the news and issues in the rapidly evolving field of library and information technology. The above-five publications deal with computer and/or information technology relevant to library systems and services. *International Association of Technological University Libraries (IATUL) Proceedings (New Series)* (No. 4) is published by the IATUL. The text of this publication is in Swedish. It provides information about library development, information technology, conferences and news from member libraries. *The Electronic Library* (No. 5) is another journal that is devoted entirely to the subject of digital library. It covers a broad range of topics including libraries and the web, and digital libraries worldwide. *JASIST* (No. 6) covers the areas of theory of information science, communication, management, economics, marketing and applied information science. Another core journal that deals mostly with issues on digital libraries is *Ariadne (Online)* (No. 7). It is a quarterly journal and its main geographic focus is the UK. The journal reports current digital library initiatives, progress and development within the UK, Electronic Libraries Programme, programmes and services of Joint Information Systems Committee. *Library Journal* combines news, features, and commentary with analyses of public policy, technology and management developments. *Journal of Academic Librarianship* focuses on problems and issues germane to college and university libraries. *Journal of Library Administration* provides important trends and new ideas in library management. The above-three journals are general librarianship orientation with concentration on academic libraries and library administrative operation. *Bulletin of the Medical Library Association* (changed its name as *Journal of the Medical Library Association* in 2002) aims to advance the practice and research knowledge base of health sciences librarianship.

No.	Journal title and number of papers published by the journal	Subject scope
1	<i>D-Lib Magazine</i> ; 90	R&D on new technologies, applications, contextual and economic issues of digital libraries
2	<i>Library Hi Tech</i> ; 45	Integrated library systems, networking, strategic planning, security, automation systems, the role of consortia resources access initiatives, architecture and technology, electronic publishing, library-related web sites, user perspectives on technology
3	<i>Advanced Technology Libraries</i> ; 40	Integrated library systems, the latest electronic products and online services for public, academic and special libraries, intellectual freedom
4	<i>IATUL Proceedings (New Series)</i> ; 38	Library development, information technology
5	<i>Electronic Library</i> ; 36	Libraries and the web, digital library, software and hardware development, user interfaces, library networking and automation, the latest products, trends and services
6	<i>Journal of the American Society for Information Science and Technology</i> ; 32	Generation, recording, distribution, storage representation, retrieval and dissemination of information, social impact and management of information agencies. New information technologies in text analysis, retrieval systems
7	<i>Ariadne (Online)</i> ; 26	Information service development, information networking issues, current digital library initiatives, progress and development within the UK
8	<i>Library Journal</i>	News, features, analysis of public policy, technology and management developments
9	<i>Journal of Academic Librarianship</i> ; 24	Policies, practices, issues, trends and speculates about the future of academic librarianship
10	<i>Library Hi Tech News</i> ; 22	Current development news of librarianship
11	<i>Computers in Libraries</i> ; 22	Impact of emerging computer technologies on library systems, services and the library community
12	<i>Journal of Library Administration</i> ; 19	Management, historical perspectives and future projections, latest technology, evaluation and measurement of performance services
13	<i>Bulletin of the Medical Library Association</i> ; 18	Organization, delivery, use and impact of information in health care, biomedical research, and health professionals education
14	<i>Biblioteche Oggi (Libraries Today)</i> ; 17	Management and development of the libraries in the modern society of the information
15	<i>Bibliotheksdienst (Library Service)</i> ; 17	All ranges of the library work
16	<i>DF Revy</i>	Multi-subject coverage
17	<i>Journal of Information, Communication and Library Science</i> ; 16	Information science, communication, librarianship
18	<i>Journal of the China Society for Scientific and Technical Information</i> ; 16	Information acquisition, storage, dissemination; information economy, information management and information policy

Subject change
between citing
and cited

707

Table II.
Subject scope of core
journals for citing
literature

From 1960 to 2002, 13 out of the 18 citing core journals are English journals and published in the USA (eight journals) or the UK (5 journals). Significantly, five of the citing core journals are non-English journals. All of them are ranked on the bottom of the core journal list. *Biblioteche Oggi* (an Italian journal), *Bibliotheksdienst* (a German publication), and *DF Revy* (published in Demark) are multi-subject coverage and not restricted only to the area of digital library. *Journal of Information, Communication and Library Science* is published in Taiwan. It is a bilingual (Chinese/English) publication, which devotes to the study of library science, information science, communication, bibliography and documentation. Another Chinese journal that is published in China is *Journal of the China Society for Scientific and Technical Information*. It focuses on information acquisition, storage and dissemination, information economy, information organization, information management and information policy. This shows that these five countries had begun to pay much attention to the research of digital libraries in the area of library and information science and most of the articles published in these journals are likely to be contributed by their domestic researchers (although verifying that was outside the scope of this study). It is also interesting to note that among the specialty journals in the field of digital libraries, only two have found their place within the core, namely, *D-Library Magazine* and *The Electronic Library*.

In summary, most of the core journals in the citing literature on digital libraries are devoted to the subjects of the application of computer and information technology to library implementation. This is consistent with the essence of definition of digital libraries as stated by Borgman (1999). As discussed previously in the Introduction section, the scope of digital libraries involves full life cycle of creating, searching and using information. The application of computer and information technology is certainly very crucial.

Nature of core journals for cited literature

Six core journals in cited literature on digital libraries have been identified from the Bradford zone analysis. Table III shows that these six core journals publish 36-181 articles, cover 33.4 per cent of the articles on digital libraries. All of them are either USA or UK publications. As the title suggested, *D-Library Magazine*, devoting itself

Table III.
Core journals for cited
literature

No.	Journal	Articles
1	<i>D-Lib Magazine</i>	181
2	<i>Journal of the American Society for Information Science and Technology</i>	90
3	<i>Communications of the ACM</i>	66
4	<i>Information Processing and Management</i>	42
5	<i>College and Research Libraries</i>	36
6	<i>Computer</i>	36
7	<i>Ariadne (Online)</i>	27
8	<i>Information Technology and Libraries</i>	24
9	<i>Library Journal</i>	24
10	<i>Electronic Library</i>	22
11	<i>Library Hi Tech</i>	22
12	<i>Journal of Academic Librarianship</i>	19
13	<i>Library Trends</i>	19

entirely to digital libraries as discussed previously, ranks number one. The number two journal, *JASIST*, has a strong emphasis on new information technologies and methodologies in text analysis, and computer-based retrieval systems as indicated by the new title (changed in 2002) that adds an additional word, “technology”. In addition, as listed in its aims and scope, “digital libraries” is one special issue of the applied information science. Other than these two journals, the rest of the core journals in cited literature do not appear in the list of the citing core journals. These four journals include *Communications of the ACM*, *Information Processing and Management*, *College and Research Libraries* and *Computer*. Among them, *Information Processing and Management* includes subject areas of information processing, information systems performance, characteristics and properties of information and knowledge, information policies, management and economics of information and information systems. *College and Research Libraries* devotes to all aspects, including application of information technology of academic and research librarianship. Moreover, the second half of Table III shows seven journals that publish 19-27 papers relating to the digital library and may constitute part of the second zone of cited core journals. Five of them are included in the citing core journal list, which will be explained more in the next section.

Comparison of citing and cited core journals

Comparison of Tables II and III shows that *D-Library Magazine* and *JASIST* appeared in both citing and cited core journal list simultaneously. Five citing core journals are dispersed into the second zone of Bradford distribution for cited literature. These five journals are: *Ariadne (Online)*, *Library Journal*, *The Electronic Library*, *Journal of Academic Librarianship*, and *Library Hi Tech*. For the 13 most cited journals, six are not included in the citing core journal list. They are *Communications of the ACM*, *Information Processing and Management*, *College and Research Libraries*, *Computer*, *Information Technology and Libraries*, and *Library Trends*. *Information Processing and Management* may be treated as another version of *JASIST* in terms of all areas of information science life cycle. The aim and scope of *College and Research Libraries* are similar to that of *Journal of Academic Librarianship*. *Information Technology and Libraries* may be categorized into the same group of *Library Hi Tech*, *Advanced Technology Libraries*, and *Computers in Libraries*.

Clearly, two citing core journals namely *Communication of the ACM* (a publication of the Association of Computing Machinery) and *Computer* (published by IEEE Computer Society) are computer science orientation journals and cover all aspects of computing, such as, artificial intelligence, programming, human and social aspects of computing, operations research and management applications. The subject areas of cited core journals have been dispersed into non-library and information science. In summary, cited literature on digital libraries is distributed mainly into four types of journals as follows:

- (1) digital library orientation, e.g. *D-Library Magazine* and *The Electronic Library*;
- (2) general library and information science, e.g. *JASIST* and *Library Journal*;
- (3) new development in librarianship, e.g. *Ariadne (Online)*, *Journal of Academic Librarianship*; and
- (4) library technology, e.g. *Computers in Libraries*.

Four citing core journals, i.e. *Biblioteche Oggi*, *Biblotheksdienst*, *DF Revy*, *Journal of the China Society for Scientific and Technical Information* are not included in the list of cited core journals probably due to the language barrier of non-English articles published. On the other hand, *Advanced Technology Libraries* is a citing core journal that offers concise reviews and current news, activities of information technology relevant to libraries and, therefore, is not an academic orientated journal. *Communications of the ACM* and *Computer* are two cited core journals and are not included in the list of citing core journals. These two journals, though not covered by LISA, devote much technology knowledge relating to digital libraries. *Communications of the ACM* was also found by Herring (2000, p. 41) being the top-ranking journal that published 24 articles on digital libraries during the period of 1992-1997.

Subject terms of core journals for citing and cited literature

To examine the subject terms of core journals for citing and cited literature, the descriptor field of each record in LISA and INSPEC was analyzed. INSPEC (IEE, 2004) was used through OVID to identify the subject terms of cited literature in *Communications of the ACM* and *Computer*, which are two of the six cited core journals. The descriptors of both journals are unavailable in LISA. Table IV illustrates the percentage difference, in descending order, of frequency for subject terms on digital libraries between citing and cited core journal literature. For the citing core journal literature, "digital library" is associated most frequently with the following seven subject terms: digital libraries (in 419 papers, 16.2 per cent of all papers), university libraries (93 papers, 3.6 per cent), library technology (82 papers, 3.2 per cent), electronic library concept (75 papers, 2.9 per cent), virtual library concept (68 papers, 2.6 per cent), electronic media (67 papers, 2.6 per cent), world wide web (WWW) (64 papers, 2.5 per cent).

Generally, most citing core journal articles are highly relevant to digital libraries (or the electronic library concept or virtual library concept), university libraries, electronic media, library technology and WWW. This finding agrees with Herring's (2000, p. 42) study. She showed that the most frequently indexed terms on digital libraries of 232 articles during 1992-1997 are virtual library and virtual libraries (98 times) and digital libraries (68 times). Other majority indexing terms (appearing more than 11 times and less than 29 times) she found include libraries, information systems, internet, electronic publishing, automation of library processes, information retrieval and WWW.

In addition to core journal literature, other than the 167 subject terms with percentage difference less than or equal to 0.5 per cent, shown in Table IV, appeared in both citing and cited literature, 490 subject terms (74.6 per cent of total subject terms in citing literature) of citing literature are never used by cited core journal literature. Among these subject terms, six are included in more than ten citing literature, namely, Denmark (14 papers), Germany (14 papers), medical libraries (12 papers), public libraries (12 papers), University of Wisconsin at Madison (12 papers), organizations (11 papers). The subjects of Denmark, Germany and medical libraries are mainly included in three particular journals: *DF Revy*, *Biblotheksdienst* and *Bulletin of the Medical Library Association*, all published by a specific country or a library association. On the other hand, *Library Hi Tech* reported the development of digital library projects that were initiated by the University of Wisconsin at Madison in 1998; consequently, the University of Wisconsin at Madison shows up. The organization subject explores specific institution, e.g. Scholarly Publishing and Academic Resources

Percentage difference between citing and cited literature	Per cent	Citing core journal literature	Subject term	Cited core journal literature	Per cent
9.6	16.2	419	Digital libraries	89	6.6
2.8	2.9	75	Electronic library concept	1	0.1
2.7	3.2	82	Library technology	7	0.5
-2.7	0.5	12	Searching	43	3.2
-2.7	1.9	48	Internet	62	4.6
2.6	3.6	93	University libraries	14	1.0
2.1	2.6	68	Virtual library concept	7	0.5
-2.1	0.5	14	Electronic publishing	35	2.6
-1.5	0.3	7	Full text databases	25	1.8
-1.5	0.6	15	Periodicals	28	2.1
-1.4	0.1	2	Information work	20	1.5
-1.4	0.5	14	Online information retrieval	26	1.9
-1.2	0.1	2	Indexing	18	1.3
-1.1	1.0	26	Academic libraries	28	2.1
1.1	1.8	47	USA	9	0.7
-1.0	0.2	5	Links	16	1.2
-1.0	0.7	18	Archives	23	1.7
-1.0	0.3	9	User interface	17	1.3
-0.9	0.6	16	Articles	23	1.7
0.8	1.2	32	Cooperation	6	0.4
-0.8	0.3	7	Scholarly publications	15	1.1
-0.7	0.3	7	Preprints	14	1.0
-0.7	0.0	1	Digital object identifiers	10	0.7
-0.7	0.3	9	Evaluation	14	1.0
0.6	1.3	33	Library materials	9	0.7
-0.6	2.6	67	Electronic media	43	3.2
-0.6	2.5	64	World wide web	42	3.1
0.6	1.0	25	Networks	5	0.4
0.6	0.7	17	Research	1	0.1
Other	25.0	645	138 subject terms	452	33.4
Total	72.9	1,879	167 subject terms	1,102	81.5

Table IV.
Subject terms, percentage
of total subject frequency
and percentage difference
of frequency for subject
terms on digital libraries
of citing and cited core
journal literature

Coalition, that deals with digital libraries. All these topics pertain very little with digital libraries.

On the other hand, 254 subject terms (60.3 per cent of total subject terms in cited literature) are not referred in the citing core journals. Among them, ten subject terms, mainly dealing with information retrieval, are cited at least ten times, namely, library automation (32 papers), information retrieval (27), information services (18), subject indexing (17), information storage and retrieval (16), technical services (12), research initiatives (11), computerized information storage and retrieval (10), relevance (10), and thesauri (10). This suggests that the cited literature on digital library deals with information retrieval, while these works were not directly cited in the literature on digital libraries. Significantly, these subject terms are referenced in the six core cited journals. Among them, *D-Library Magazine* published only one article on computerized information storage and retrieval. Specifically, the subject terms of library automation, information retrieval and information services are cited mostly in two non-library and non-information science journals, namely, *Communication of the ACM* and *Computer*.

Computer publishes many papers on digital library initiative projects. The other six subject terms are displayed quite frequently on *Information Processing and Management* and *JASIST*. Excluding library automation, information retrieval articles associate strongly with digital libraries on cited literature. In general, the subject terms of cited literature disperse more scattering than that of the citing literature.

Comparison of subject terms between citing and cited core journal literature

Listing subject terms that included in both citing and cited core journal list may deepen our understanding on the subject changes between citing and cited core journal literature. Four most common subject terms in citing and cited journal literature are digital libraries (419 vs 89), electronic media (67 vs 43), WWW (64 vs 42) and internet (48 vs 62). "Digital library" is the most referred subject term in both citing and cited literature, while the frequency in citing literature is much greater than that for cited literature. The concepts of electronic library and virtual library appear very frequently in citing literature, 75 and 68, respectively, but quite rarely in cited literature, 1 and 7 times, respectively. This shows that these two subject terms were not adopted in the early stage of the digital library research, and, therefore, not cited. Subject of WWW associates more articles (64) than internet (48) does on citing literature. The situation is reversed for cited literature, where internet (62) is referred more than WWW (42) is. The change of use frequency for WWW and internet demonstrates that WWW is becoming the main stream of digital library research instead of internet.

Similarly, library technology, network and university library are investigated extensively in citing literature, 82, 25 and 93 times, respectively, but are cited rarely in cited literature, 7, 5, and 14 times, respectively. Conversely, academic library, which includes university library, is the only one subject that receives almost same frequency in both citing and cited literature, 26 and 28 times, respectively, though significant difference in percentage. This may attribute to the development of digital library projects were mostly initiated by the university and university/academic library.

Searching is the third most cited subject term (43 times) while it is not addressed quite frequently (12 times) in citing literature. Searching techniques should be designed to support the information seeking needs of digital library users. However, it does not receive extensive studies in recent literature on digital libraries. Another similar case is the subject of electronic publishing. In addition, four other subject terms that are used more in cited literature than in citing literature are full-text databases, online information retrieval, indexing and information work. As indicated by Borgman (1999, pp. 237-8), some databases, especially full-text databases, that exist on CD-ROMs, the WWW and the internet and those provided by online searching service, such as Nexis, STN and Dialog can be treated as digital libraries. That is why online information retrieval and full-text databases are two major subject terms of cited literature that make influence on later digital library researches. With regard to subject of indexing, using indexing techniques for organizing digital resources becomes more important in a digital environment. Therefore, in recent years, increasing attention has been put on the researches of indexing information based on earlier studies.

Significantly, the subject of library automation appears only in cited literature. Borgman (1997, p. 242) pointed out all automated libraries face the challenge of global interoperability. The globalization of library service requires extensive previous researches on library automation and therefore more cited works appeared on this subject.

In summary, digital library, electronic media and WWW are the three subjects in common for both citing and cited core journal literature on digital libraries. They also constitute the core subjects for digital library literature. Academic libraries and library technology are also highly relevant to digital libraries. Searching, electronic publishing, full-text databases, online information retrieval, library automation and indexing are used more frequently in cited literature but rarely in citing literature. On the other hand, the concepts of electronic library and virtual library, library technology, network, and university library appear very frequently in citing literature but quite rarely in cited literature. This demonstrates the subject change from cited literature to citing literature on digital libraries.

Conclusions

This study investigates the subject change for both citing and cited literature on digital libraries. The results of the present work provide significant insights into the evolution of digital libraries by identifying the core journals, examining their characteristics, as well as subject changes for both citing and cited literature using some bibliometric techniques. The following conclusions may be drawn from the analysis of this work.

A total of 18 core journals were identified from the first Bradford zone of the citing literature on digital libraries. These core journals publish 515 (31 per cent) out of 1,479 citing articles. On the other hand, there were six cited core journals based on the same Bradford approach. These six cited core journals contribute 33.4 per cent of the articles on digital libraries. Only two journals, namely, *D-Library Magazine* and *JASIST*, appear in both lists of citing and cited core journals. Most of the citing core journals on digital libraries devote to the subject of the application of computer and information technology to library implication. The cited literature on digital libraries distributes mainly into four types of journals:

- (1) digital library orientation;
- (2) general library and information science;
- (3) new development in librarianship; and
- (4) library technology.

In general, most citing core journal articles are highly relevant to digital libraries, university (or academic) libraries, electronic media, library technology, and WWW. On the other hand, cited core journal literature employs quite frequently the following subject terms: digital libraries, internet, electronic media; searching, WWW, electronic publishing, and library automation. Digital libraries, electronic media and WWW are the three most frequently used subject terms for both citing and cited core journal literature. They also constitute the core subjects for the literature in digital libraries.

The analyses of the present study demonstrate that the digital library researches are built upon related works on searching, full-text databases, online information retrieval, indexing, electronic publishing and library automation and network. The change of highly used subject terms, such as WWW, internet, library technology, network, university or academic library, from cited to citing literature suggests that these subjects are becoming the main stream of researches in digital libraries.

Generally, technical issues to be addressed by digital libraries include resource discovery, distributed processing, information storage, information organization,

information retrieval, user interface, databases, networks and dissemination of digital materials. (Chowdhury and Chowdhury, 1999. p. 412) Most subject terms of this study for both citing and cited literature in digital libraries such as electronic media, electronic periodical, searching, indexing, WWW, internet, networks, user interface, online information retrieval, full text databases, etc. could be categorized into the technical issues that call for the development of more researches.

It is anticipated that this study could provide a broad understanding of researches in digital libraries and their applications that were investigated before 2002. However, until the completion of the present study, from the subject terms on both highly citing and cited literature in digital libraries, other related issues dealing with copyright, charging and authenticity; social issues; quality of preservation and availability; use and user study; economic issues; education and promotion are still not popular research areas yet. The digital library is an ongoing and rapidly-developing research area and, therefore, a large amount of publications on different issues pile up accordingly. It will be very interesting and significant to keep the up-to date research to explore the emergence of a variety of issues on digital libraries.

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Subject change
between citing
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715

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