Scientometrics (2018) 116:1589–1613
https://doi.org/10.1007/s11192-018-2822-7

Examining interdisciplinarity of library and information science (LIS) based on LIS articles contributed by non-LIS authors

Yu-Wei Chang[1,2]

Received: 13 November 2017 / Published online: 26 June 2018

Abstract
This study investigated the external contributors of library and information science (LIS) knowledge who were unaffiliated with LIS-related institutions but published their research results in LIS journals. Differences between the contributors to library science (LS) and contributors to information science (IS) were considered. Articles published in 39 strongly LIS-oriented journals indexed in the Web of Science database between 2005 and 2014 were analyzed. The results demonstrated that 46.5% of the LIS articles were written by at least one non-LIS author; authors' backgrounds ranged across 29 disciplines. An increasing trend was observed in degrees of interdisciplinarity of LS and IS. An increase in proportion of articles by LIS and non-LIS authors was identified in LS and IS as well. Those with medical backgrounds were the primary non-LIS authors contributing to the LS field and collaborated the most frequently with LIS authors. Those with computer science backgrounds were the most prevalent non-LIS contributors to the IS field and preferred to publish individually. A critical difference was also identified in research topics between LS and IS. The foundations of LIS and scientometrics were the largest research topics in LS and IS, respectively.

Keywords Library and information science · Library science · Information science · Authorship · Interdisciplinarity · Research topic

Introduction

Although scientific knowledge is divided into disciplines, the boundaries between disciplines are unclear and have even become more obscure over time (Porter and Rafols 2009). One of the reasons for this is the prevalence of scientific collaboration across disciplines

✉ Yu-Wei Chang
yuweichang2013@ntu.edu.tw

[1] Department of Library and Information Science, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan

[2] Center for Research in Econometric Theory and Applications, National Taiwan University, Taipei, Taiwan

(Bellotti et al. 2016; Săvoiu 2014), which has been furthered through being valued and encouraged in the scientific community. The growth of various forms of interdisciplinary activities has led to interdisciplinarity becoming a basic characteristic of some disciplines (Alvargonzález 2011). Disciplines have also become more interdisciplinary in subject matter over time (Levitt et al. 2011). Common interdisciplinary activities, such as citing literature outside of one's own discipline and interdisciplinary coauthorship (Pierce 1999), have become the common method of exploring the interdisciplinary characteristics of a given discipline.

LIS, which consists of library science (LS) and information science (IS), is a typical interdisciplinary field (Lugya 2014). The interdisciplinarity of LIS has been a focus of LIS research. The perspective of the origin and diffusion of knowledge is the most frequently used method of observing connections among disciplines (Rodriguez 2017; Yan 2016). Citing relationships among disciplines is the most commonly used method for examining the interdisciplinary characteristics of LIS. Studies on the interdisciplinarity of LIS can be enriched by using other perspectives. Some studies that have examined the references listed in LIS publications have reported that LIS publications cite literature from numerous disciplines as well as heavily cite LIS publications (Chang and Huang 2012; Jabeen et al. 2015). Some studies have analyzed the citations of LIS publications to reveal the disciplinary influence of LIS (Erfanmanesh et al. 2010; Hessey and Willett 2013). Other studies have further compared the differences between disciplines cited by LIS studies and disciplines citing LIS studies (Odell and Gabbard 2008).

Authorship is another common perspective for demonstrating the interdisciplinary characteristics of a specific discipline. A relatively high level of disciplinary maturity is typically reflected by a high proportion of contributing authors belonging to the discipline because disciplinary development relies on contributions by the discipline's own researchers (Beattie and Goodacre 2004). In contrast, a high proportion of contributing authors belonging to various disciplines is typical for a discipline with a high degree of interdisciplinarity. Most authorship studies have analyzed the keywords included in institutional names with which authors are affiliated (Bordons et al. 1999; Enger 2015; Qiu 1992).

Although authors crossing over disciplinary boundaries are not a dominant group of knowledge contributors for a given discipline, their existence indicates that they have influenced part of the foundation of a given discipline. The character of any given discipline is affected by other disciplines. Authors not only transfer their knowledge to other disciplines but also expand their academic visibility across disciplines. As the interaction frequency between disciplines increases, an increasing degree of interdisciplinarity can be anticipated for a discipline. Common research interests among disciplines can justify interdisciplinary collaboration. Furthermore, the commonality of research interests implies that studies related to interdisciplinary topics can be published in journals covered by more than one discipline, such as information behavior studies (Chang 2011). The increase in the number of contributing authors from outside a given discipline might gradually change the discipline's characteristics including its research topics.

Research topics reflect the research interests in a given discipline. The popularity of research topics may reflect the relevance of the topics in current society. Therefore, research topics are an essential indicator for researchers when planning their research careers. Although numerous studies have explored LIS research topics, most have focused on a limited number of LIS publications in scant journals or that were published by a country or in specific publication years (Paul-Hus et al. 2016; Xiao et al. 2015). Some studies on LIS research topics have also identified all the research topics in LIS or changes

in LIS research topics during different phases (Chang et al. 2015; Enger 2015; Gonzalez-Alcaide et al. 2008; Sugimoto et al. 2011; Tuomaala et al. 2014).

To fill the research gap, this study used authorship analysis and content analysis to focus on the LIS research topics contributed to by non-LIS authors. The external influence brought by non-LIS authors on LIS research topics was examined. Although non-LIS authors contributing to LIS journal articles have been investigated before (Aharony 2012; Chang and Huang 2012; Paul-Hus et al. 2016; Prebor 2010; Walters and Wilder 2016), most studies only identified the numbers and proportions of non-LIS authors and their disciplinary attributes. The influences of non-LIS authors on the LIS discipline have not been explored. This study focused on the LIS articles contributed to or written by non-LIS authors. Regardless of the reasons that non-LIS authors hold for publishing articles in LIS journals, non-LIS authors contribute to LIS knowledge. To examine the interactions between LIS and non-LIS authors, this study investigated collaborations between LIS and non-LIS authors. Although LS and IS have merged to form the LIS discipline, the differences in disciplinary natures between LS and IS as determined by several studies (Åström 2007; Chang and Huang 2012; Yang et al. 2016) were considered. Comparisons of the results were based on distinctions between LS and IS journal articles.

Related studies have revealed that the topic of non-LIS authors publishing in LIS journals has not been widely explored. Most related studies have identified the numbers and proportions of non-LIS authors contributing to the LIS field and their disciplinary attributes. Several topics must be further addressed to facilitate a better understanding of the characteristics of non-LIS authors who contribute to LIS articles and the articles themselves. To explore the contributions made by non-LIS authors to LIS, the research questions addressed in this study were as follows: (1) Are increasing trends observed in LIS articles by non-LIS authors? (2) What is the distribution of disciplinary attributes of non-LIS authors? As well, what is the difference in disciplinary attributes of non-LIS authors who contribute to LS journals as compared with those who contribute to IS journals? (3) Do non-LIS authors tend to collaborate with LIS authors to publish LIS articles? (4) Do LS and IS journal articles by non-LIS authors tend to be contributed to equally by authors representing various disciplines? (5) What are the research topics of LIS articles by non-LIS authors? What is the difference between the research topics of articles by non-LIS authors that contribute to LS journals and the topics of those that contribute to IS journals? What is the difference between the research topics of articles written only by non-LIS authors and the topics written by both non-LIS and LIS authors?

Methodology

Data collection

To collect bibliographic records of articles by non-LIS authors published in LIS journals, the Web of Science (WoS) and Scopus, two large interdisciplinary databases, were used. LIS journals analyzed in this study were listed under the subject category of "Information science & library science" of the 2014 edition of the Journal Citation Reports (JCR). Each journal indexed by WoS was assigned at least one subject category according to journal classification schemes devised by the JCR. LIS journals with two or more subject categories were considered interdisciplinary and were expected to publish more articles by non-LIS authors than other LIS journals. Because the results related to interdisciplinary characteristics of LIS interdisciplinary journals would be affected by which

interdisciplinary-oriented journals were studied, only strongly LIS-oriented journals were considered as the sample journals of this study. These strongly LIS-oriented journals were identified as such from among LIS journals indexed by the JCR if they met additional requirements. Because of the possibility of databases inconsistently identifying the disciplinary attributes of a specific journal, journals were considered to be strongly LIS-oriented journals only if they had been recognized as LIS journals by several databases. This required being assigned to the LIS subject category by the Ulrichweb database and being indexed by the database of Library and Information Science Abstracts. At this stage, 42 journals were identified. After examining the 42 journals, the following 3 journals were considered strongly interdisciplinary and were thus excluded: *The Information Society* (media studies–oriented), *International Journal of Information Management* (business–oriented), and *Scientometrics* (research evaluation–oriented).

Table 1 lists the 39 LIS journals selected in this study. Although LS and IS have been incorporated into LIS for decades, the differences in disciplinary characteristics between LS and IS still exist and were emphasized (Åström 2007; Wang and Wolfram 2015). To reveal more interdisciplinary characteristics of LIS, this study focuses on differences between LS and IS. The extent of differences in interdisciplinary characteristics between LS and IS could signal whether dividing LIS into LS and IS is necessary for future studies exploring the interdisciplinary characteristics of LIS. Therefore, 39 LIS journals were further divided into 26 LS journals and 13 IS journals.

The categorization of LS and IS journals was conducted by an LIS researcher who referred to the subject scope stated in journal websites and research topics of articles analyzed in this study. Journals focusing on librarianship, such as *The Journal of Academic Librarianship* and *Library Trends*, were classified as LS journals. Journals highlighting the interests of information scientists and applications of information technology, such as the *Journal of Information Science* and *Knowledge Organization*, were classified as IS journals. For journals with a wide subject scope including both librarianship and information science, the topics of published articles were further examined. Journals publishing more articles on librarianship were deemed LS journals, and other journals were labeled as IS journals. Some researchers have reported that the LIS journals indexed by the JCR represent several fields and are not limited to LS and IS journals (Abrizah et al. 2015; Ni et al. 2013). This indicates that some journals have different designations as LS or IS journals. Because 39 LIS journals were divided into only two broad groups, journals with topics similar to LS, such as publishing, were regarded as LS journals, and those on information systems and management were classified as IS journals. Additionally, studies have employed various classifications (Abrizah et al. 2015; Ni et al. 2013), which indicates that no agreement has been reached on the attributes of some journals. Therefore, LS and IS journals were classified based on the aforementioned requirements and did not precisely follow the LS and IS journal lists from prior studies.

Regarding the LIS documents published in the 39 LIS journals, because of the differences in functions and characteristics of various document types and amounts of data as well as because of language barriers, the scope of bibliographic records collected for this study was limited to English research articles published between 2005 and 2014. If journal title names changed during the period of study, they were represented by the latest names. The same number of journals was analyzed each year of the study period. The bibliographic records of affiliation information retrieved from the WoS were in abbreviated form. Furthermore, all authors affiliated with the same institution were grouped and placed before the institution name. Names of multi-institutional authors appeared at least twice. This form of bibliographic record is inefficient for author coding. Therefore, Scopus, which

Table 1 Journal list

No.	Journal title	Only non-LIS authors (*a*)	Non-LIS and LIS authors (*b*)	Only LIS authors	Un-identified authors	Total (c)	*a*/*c*	(*a* + *b*)/*c*
LS1	African Journal of Library Archives and Information Science	6	6	64	1	77	7.8	15.6
LS2	Australian Academic and Research Libraries	15	20	59	24	118	12.7	29.7
LS3	Australian Library Journal	15	6	48	23	92	16.3	22.8
LS4	Canadian Journal of Information and Library Science	21	10	63	16	110	19.1	28.2
LS5	College and Research Libraries	6	25	188	20	239	2.5	13.0
LS6	Health Information and Libraries Journal	129	58	121	38	346	37.3	54.0
LS7	Information and Culture	22	1	37	37	97	22.7	23.7
LS8	Information Technology and Libraries	16	10	97	15	138	11.6	18.8
LS9	The Journal of Academic Librarianship	54	57	495	47	653	8.3	17.0
LS10	Journal of Librarianship and Information Science	35	24	99	9	167	21.0	35.3
LS11	Journal of Scholarly Publishing	32	5	29	113	179	17.8	20.7
LS12	Journal of the Medical Library Association	45	109	239	9	402	11.2	38.3
LS13	Law Library Journal	28	2	73	3	106	26.4	28.3
LS14	Learned Publishing	107	17	94	62	280	38.2	44.3
LS15	Library and Information Science Research	54	37	194	9	294	18.4	31.0
LS16	Library and Information Science	6	9	51	5	71	8.5	21.1
LS17	Library Collections, Acquisition and Technical Services	15	6	105	15	141	10.6	14.9
LS18	Library Quarterly	12	8	112	22	154	7.8	13.0
LS19	Library Hi Tech	66	24	266	34	390	16.9	23.1
LS20	Library Resources and Technical Services	4	3	103	10	120	3.3	5.8
LS21	Library Trends	46	22	171	91	330	13.9	20.6
LS22	Libri	35	27	128	6	196	17.9	31.6
LS23	Malaysian Journal of Library and Information Science	41	47	91	6	185	22.2	47.6

Table 1 continued

No.	Journal title	Only non-LIS authors (*a*)	Non-LIS and LIS authors (*b*)	Only LIS authors	Un-identified authors	Total (c)	*a*/*c*	(*a* + *b*)/*c*
LS24	Portal: Libraries and Academy	8	14	123	45	190	4.2	11.6
LS25	Reference and User Services Quarterly	5	17	141	23	186	2.7	11.8
LS26	Serials Review	29	14	228	30	301	9.6	14.3
IS1	Aslib Journal of Information Management	88	51	184	18	341	25.8	40.8
IS2	Electronic Library	128	58	290	8	484	26.4	38.4
IS3	Information Development	78	23	90	17	208	37.5	48.6
IS4	Information Processing and Management	484	111	151	17	763	63.4	78.0
IS5	Information Research	104	53	189	14	360	28.9	43.6
IS6	Information Technology and People	134	13	8	22	177	75.7	83.1
IS7	Journal of Documentation	66	46	257	21	390	16.9	28.7
IS8	Journal of Information Science	245	35	161	35	476	51.5	58.8
IS9	Journal of Informetrics	273	87	81	23	464	58.8	77.6
IS10	Journal of the Association for Information Science and Technology	771	262	521	62	1616	47.7	63.9
IS11	Knowledge Organization	42	12	81	11	146	28.8	37.0
IS12	Online Information Review	252	24	142	29	447	56.4	61.7
IS13	Program	54	27	112	14	207	26.1	39.1
	Total	3571	1380	5686	1004	11,641	30.7	42.5

met the requirements for coding, was used as the source for bibliographic records. The bibliographic record of each article published in 38 LIS journals was taken from Scopus. Only bibliographic records of articles from *Information & Culture* were obtained from the WoS, because they were not available from Scopus. Information obtained from the bibliographic records of Scopus and the WoS were title, author name, author affiliation, journal source, volume and number, pages, publication year, abstract, and author keywords.

Data processing

For identification of articles by non-LIS authors, the disciplinary attribute of each author was recognized. LIS authors were defined as authors affiliated with LIS-related institutions, such as libraries, LIS departments, schools, institutes affiliated with colleges and universities, and LIS associations. Various names of LIS departments, schools, and institutes required further examination. Higher-education institutions offering LIS courses and programs were regarded as LIS-related institutions. The *Directory of American Library Association-Accredited and Candidate Programs in Library and Information Studies* (http://www.ala.org/CFApps/lisdir/index.cfm), other LIS directories, and institutional websites were referenced. Non-LIS authors were coded by discipline according to their affiliation information. The disciplinary attributes of most authors were determined based on keywords within their affiliation information, such as "computer science" and "medicine." Authors without complete or clear affiliation information were defined using relevant information from the Internet. Articles by at least one unidentified author were excluded, because this type of article does not support analyses based on coauthored articles. Among 11,641 articles examined, 5686 articles were published by only LIS authors and 1004 articles by at least one unidentified author. The remaining 4951 articles by at least one non-LIS author were further analyzed in this study.

The disciplinary attributes of authors were used for classifying articles as being by only non-LIS authors and as being coauthored by non-LIS and LIS authors. The disciplinary combination of coauthors of each coauthored article was coded, such as the combination of computer science and computer science, which indicated collaboration between computer science authors. In addition, the degree of interdisciplinarity of each article was calculated using the Shannon–Wiener diversity index. The formula of this Shannon–Wiener diversity index is $-\sum P_i(\ln P_i)$ (Spellerberg and Fedor 2003), in which P_i indicates the proportion of observations in category i. In this study, P_i indicated the proportion of authors in discipline i. Various indicators are used to measure degree of interdisciplinarity (Chang and Huang 2012; Rafols and Meyer 2010).

The Shannon–Wiener diversity index was used to measure interdisciplinarity because it is unaffected by sample size, can be easily calculated, and meets the characteristics of coded data in this study. The degree of interdisciplinarity of each LIS article was measured from the perspective of authorship by considering the number of author disciplines and the percentage of authors in each discipline rather than only emphasizing the existence of non-LIS authors. This index was sensitive to differences in parity. When the number of authors was two or more, the authors represented at least two disciplines, and the number of authors of each discipline was equal, the value of the Shannon–Wiener diversity index was maximized. This means that an article was contributed to equally by authors representing different disciplines. Research topics were associated with the disciplinary attributes of the authors. If most authors of an article were associated with the field of computer science, the research topic of the article tended to be a computer science–oriented topic. Therefore, this index reveals whether LS or IS research topics tend to have a stronger degree of interdisciplinarity and indicates whether authors from various non-LIS disciplines are often involved in LS and IS research. From the 10,637 articles in which all authors' disciplinary attributes were identified (5686 articles by only LIS authors and 4915 articles by at least one non-LIS author), the cumulative number of non-LIS authors was 10,970 and that of LIS authors was 12,502.

The characteristics of authors were further revealed through analyses of the types of institution with which they were affiliated. Institutions types were universities, companies, research institutions, hospitals, and others. Hospitals affiliated with universities were coded as hospitals not universities. Additionally, four types of research collaborations employed in coauthored articles, namely intradepartmental, interdepartmental, interinstitutional, and international, were demonstrated. Except for international collaboration, all collaborations were considered domestic.

The research topics of articles by non-LIS authors were coded through two methods: expert judgment and word frequency analysis. Because only 54.7% of articles included author keywords representing the research topics, expert judgment replaced author keyword analysis to ensure one main research topic was assigned to each article. An LIS researcher (the author of this study) determined the single main research topic of each article after reading the titles, abstracts, author keywords, or full texts. To enhance the precision of determination of a research topic for each article, topic assignment per article was performed at least twice. Approximately 1.1% of articles assigned different research topics between the two coding tasks were examined before determining their final research topics. The number and names of research topics were kept revising during the coding task. LIS research topics classification schemes proposed by Aharony (2012), Tuomaala et al. (2014) and Yang et al. (2016) were referred to.

Identical or similar category names were identified from prior studies. Therefore, original category names formed the temporary topic names. Furthermore, the scope and definition of some research topics related to information technology were verified using references, resources, or experts. Numerous original research topics, such as cloud computing versus the Internet, information search versus information seeking, and reading versus e-learning, exhibited close relationships and often appeared together in the same articles. Therefore, during the classification process, some categories with higher granularity were incorporated into broader categories. After numerous revisions of category names, a total of 14 research topics were determined: (1) customer studies: customer satisfaction and customer surveys; (2) e-resources: e-books, e-newspapers, and Internet resources; (3) foundations of LIS: IS theories, history of LIS, history of libraries, librarians, library services and activities, and LIS education; (4) information behavior: information seeking, information needs, and information use; (5) information ethics and laws: copyrights, digital security, information access, and information policies; (6) information management: e-business and knowledge management; (7) information society: digital divides, digital society, e-learning, and information literacy; (8) information technology: artificial intelligence, communication technology, data mining, human–computer interaction, information systems, multimedia, programming languages, and technology adoption; (9) Internet: social media, virtual communities, and websites; (10) knowledge organization and information retrieval (KO and IR): online searching, ontology, classification schemes, indexing, metadata, and the semantic web; (11) organizational culture and characteristics: teamwork and specific industries (12) publishing: e-publishing, open access publishing, and book history; (13) scientometrics: bibliometrics, informetrics, webmetrics, research evaluation, and scholarly communication; (14) other.

The expert judgment for determining a broad research topic for each article was a subjective method. To reduce the level of subjectivity and to identify topics with higher granularity that were embedded in an article, word frequency analysis was used as another method of determining research topics. The frequency numbers of single and plural forms of the same words were counted together (e.g., library and libraries). Word frequency analysis was conducted based on text included in the title and abstract of each article. For

the 5.6% of articles lacking abstracts, author keywords were added for word frequency analysis if available. Approximately 3.9% of articles were analyzed for word frequency by using titles only, because they lacked both abstracts and author keywords. Finally, the differences in proportions of various types of articles, differences in disciplinary distributions of non-LIS authors, differences in proportions of research topics written about between LS and IS studies, and the differences in proportions of research topics between articles by only non-LIS authors and articles by LIS and non-LIS authors, were examined using Chi squared tests.

Results

Trend in LIS articles by non-LIS authors

This study observed that the number of articles by only LIS authors (5686 articles) was lower than that by at least one non-LIS author (4951 articles). Non-LIS authors contributed or wrote 46.5% of LIS articles studied, indicating substantial contributions made by non-LIS authors to LIS. Figure 1 demonstrates a decreasing trend in articles by only LIS authors. An increasing proportion of LIS articles by non-LIS authors was confirmed. After further dividing articles by non-LIS authors into articles by only non-LIS authors and articles by LIS and non-LIS authors, increasing trends in the two types of articles by non-LIS authors were observed. In addition, a large discrepancy in the annual proportion of articles between those by only non-LIS authors and those by LIS and non-LIS authors was revealed. Substantial differences in annual proportions of the three types of articles between LS and IS journals were further revealed. Most LS articles, ranging between 65.3 and 75.2% of all LS articles, were written by only LIS authors, whereas 32.6–44.8% of IS articles were written by only LIS authors. Approximately 45.8% of IS articles were generated by only non-LIS authors, for which an increasing trend was identified. The changes

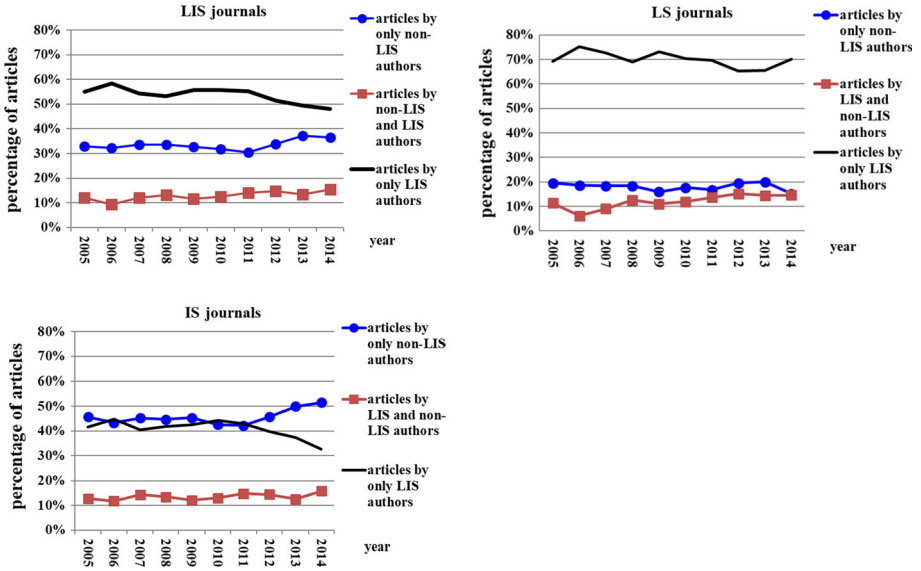

Fig. 1 Trends in authorship of the three types of LIS articles by year

in annual percentages of articles by LIS and non-LIS authors were similar for LS and IS; an increasing trend was observed for both.

Among the 4951 articles by at least one non-LIS author studied, coauthored articles outnumbered single-author articles. Articles by two authors accounted for the largest proportion (32.8%), followed by articles with three authors (25.4%), and articles with one author (20.7%). The upper half of Table 2 indicates that most coauthored articles were contributed to by authors representing more than one discipline and that they were approximately two times more numerous than coauthored articles by authors from the same discipline. A significant difference in proportions of the three types of articles between LS journals and IS journals was observed using the Chi squared test ($p < 0.05$). Most articles from LS journals were coauthored by authors representing more than one discipline, whereas most articles from IS journals were coauthored by authors within the same discipline. The lower half of Table 2 indicates that the proportion of articles by only non-LIS authors dominated in both LS and IS journals. The proportion of articles by only non-LIS authors of IS journals was much higher than that of LS journals (77.0 vs. 58.6%). A significant difference was identified between articles by only LIS authors and articles by both LIS and non-LIS authors ($p < 0.05$).

The upper half of Table 3 shows the distribution of types of authors' affiliated institutions across four types of articles. For all four types of articles, most articles were contributed by authors affiliated with only universities. Articles by authors affiliated with universities and other types of institutions accounted for the second largest portion. The lower half of Table 3 indicates that articles resulting from interinstitutional collaboration dominated LS journal articles (31.0%) and articles coauthored by LIS and non-LIS authors (45.0%), whereas articles resulting from intradepartmental collaboration dominated IS journal articles (29.4%) and articles coauthored by only non-LIS authors (33.9%). The proportions of the six types of articles differed significantly between LS journals and IS journals ($p < 0.05$) and between articles by only LIS authors and articles by both LIS and non-LIS authors ($p < 0.05$).

Table 2 Comparison of article distribution by type between LS and IS journals

Type of article	LS journals		IS journals		Total	
	No. of articles	%	No. of articles	%	No. of articles	%
Single-authored articles	356	27.1	669	18.4	1025	20.7
Coauthored articles by authors within the same discipline	305	23.2	1606	44.1	1911	38.6
Coauthored articles by authors from two or more disciplines	652	49.7	1363	37.5	2015	40.7
Total	1313	100.0	3638	100.0	4951	100.0
Articles by only non-LIS authors	769	58.6	2802	77.0	3571	60.0
Articles by LIS and non-LIS authors	544	41.4	836	23.0	1380	40.0
Total	1313	100.0	3638	100.0	4951	100.0

Table 3 Article distribution by type of institution and collaboration among four types of articles

Type of institution and collaboration	LS journals		IS journals		Articles by only non-LIS authors		Articles by LIS and non-LIS authors	
	No. of articles	%	No. of articles	%	No. of articles	%	No. of articles	%
Universities	1008	71.8	2891	79.6	2913	81.6	986	71.4
Universities and other type of institution	200	14.3	449	12.7	311	8.7	338	24.5
Companies	59	4.2	36	1.0	88	2.5	7	0.5
Research institutions	48	3.4	135	5.2	168	4.7	15	1.1
Hospitals	31	2.2	1	0.2	18	0.5	14	1.0
Other	57	4.1	36	1.2	73	2.0	20	1.4
Total	1403	100.0	3548	100.0	3751	100.0	1380	100.0
Intra-departmental	271	19.3	1044	29.4	1209	33.9	106	7.7
Inter-departmental	183	13.0	237	6.7	149	4.2	271	19.6
Inter-institutional	435	31.0	913	25.7	727	20.4	621	45.0
International	133	9.5	710	20.0	461	12.9	382	27.7
Single-authored articles	381	27.2	644	18.2	1025	28.7	0	0.0
Total	1403	100.0	3548	100.0	3571	100.0	1380	100.0

Disciplinary distribution of non-LIS authors

Table 4 demonstrates that non-LIS authors represented 29 disciplines. Over half of non-LIS authors were affiliated with institutions related to computer science (47.4%) and business and economics (20.6%). This result was primarily affected by the disciplinary distribution of non-LIS authors of IS journals because the number of non-LIS authors publishing in IS journals was three times the number of non-LIS authors publishing in LS journals. Although business and economics authors were the second largest and computer science authors the third largest number of authors in LS journals, their proportions were much lower than were those in IS journals. The results based on a Chi squared test revealed a significant difference in non-LIS authors by discipline between LS and IS journals ($p < 0.05$).

Authors were limited to five disciplinary attributes per article. A total of 95.2% of articles were written by authors representing one or two disciplines. According to the proportion of authors by discipline, the average diversity degree per LS article was 0.32, which was higher than that per IS article (0.25). LS held a stronger interdisciplinarity than did IS. Articles by LIS and non-LIS authors exhibited stronger interdisciplinarity than did articles by only non-LIS authors (0.67 vs. 0.12). This trend also held true for both LS and IS articles analyzed separately. Figure 2 indicates the increasing trends observed for the average degree of interdisciplinarity by year in both LS and IS. The growth speed of the average degree of interdisciplinarity by year in LS was faster than that in IS. In addition, an increasing trend also appeared in the average degree of interdisciplinarity by year in articles by only non-LIS authors. No increasing or decreasing trend was observed in the average degree of interdisciplinarity by year in articles by only-LIS authors. A

Table 4 Comparison of disciplinary distributions of non-LIS authors between LS and IS journals

No.	Discipline	LS journals		IS journals		Total	
		No. of authors	%	No. of authors	%	No. of authors	%
1	Medicine	841	31.4	248	3.0	1089	9.9
2	Business and economics	356	13.3	1709	20.6	2065	18.8
3	Computer science	321	12.0	3930	47.4	4251	38.8
4	Education	170	6.3	151	1.8	321	2.9
5	General science	154	5.7	364	4.4	518	4.7
6	Engineering	152	5.7	555	6.7	707	6.4
7	Communication	95	3.5	194	2.3	289	2.6
8	Law	57	2.1	20	0.2	77	0.7
9	Psychology	52	1.9	102	1.2	154	1.4
10	General social science	56	2.1	158	1.9	214	2.0
11	Linguistics	48	1.8	47	0.6	95	0.9
12	Sociology	44	1.6	90	1.1	134	1.2
13	History	41	1.5	12	0.1	53	0.5
14	Physics	34	1.3	149	1.8	183	1.7
15	Mathematics	33	1.2	116	1.4	149	1.4
16	Political science	31	1.2	71	0.9	102	0.9
17	Literature	29	1.1	9	0.1	38	0.3
18	Earth science	28	1.0	60	0.7	88	0.8
19	Arts	27	1.0	51	0.6	78	0.7
20	Architecture	28	1.0	12	0.1	40	0.4
21	Biology	23	0.9	74	0.9	97	0.9
22	Agriculture	14	0.5	59	0.7	73	0.7
23	Chemistry	11	0.4	21	0.3	32	0.3
24	Zoology and botany	7	0.3	11	0.1	18	0.2
25	Humanities	7	0.3	17	0.2	24	0.2
26	Anthropology	7	0.3	11	0.1	18	0.2
27	Energy	6	0.2	23	0.3	29	0.3
28	Philosophy and religion	5	0.2	20	0.2	25	0.2
29	Tourism	2	0.1	7	0.1	9	0.1
	Total	2679	100.0	8291	100.0	10,970	100.0

considerable difference in the average degree of interdisciplinarity existed between articles by only non-LIS authors and articles by LIS and non-LIS authors.

Collaborations of non-LIS authors

The non-LIS authors preferred to collaborate with other non-LIS authors (see Table 2), despite publishing their results in LIS journals. To identify the backgrounds of article collaborators, the disciplinary combinations of 3926 coauthored articles were analyzed. A total of 362 disciplinary combinations of authors were identified. Although non-LIS authors collaborated with other authors from various disciplines, most disciplinary

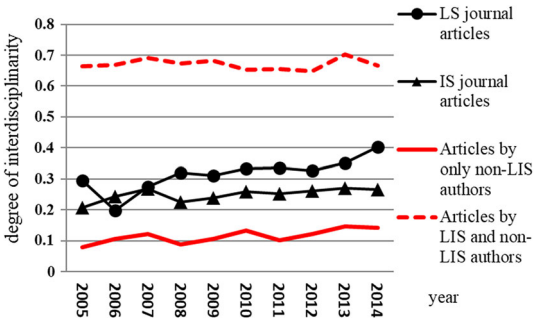

Fig. 2 Comparison of average degree of interdisciplinarity by year among four types of articles

combinations of authors (88.4%) were uncommon, comprising less than 10 articles. Coauthored articles by only computer science authors accounted for the most articles (23.0% of 3926 articles), followed by coauthored articles by only business and economics authors (11.6%). However, the number of disciplinary combinations in LS was much lower than that in IS (181 vs. 288). Table 5 indicates that collaboration between LIS and medical authors resulted in the largest number of articles (14.1% of 1022 coauthored articles) in LS, followed by collaboration among only medical authors (11.4%). LIS authors were observed to prefer collaborating with medical, computer science, or business and economics authors. In IS, collaboration among only computer science authors was the most prevalent (29.4% of 2904 IS coauthored articles). Collaboration among only business and economics authors was the second largest disciplinary combination (13.4%). LIS authors frequently collaborated with computer science, business and economics, or engineering authors.

Research topics

Table 6 lists the three most common topics contributed by non-LIS authors based on expert judgment: "scientometrics" (25.2%), "KO and IR" (18.2%), and "information technology" (14.0%). Differences in the main research topics between LS and IS journals were

Table 5 Ten most common disciplinary combinations in LS and IS

Rank	LS journals		IS journals	
	Disciplinary combination	%	Disciplinary combination	%
1	LIS, medicine	14.1	Computer science	29.4
2	Medicine	11.4	Business and economics	13.4
3	Business and economics	6.3	LIS, computer science	8.5
4	LIS, computer science	5.9	Business and economics, computer science	4.1
5	LIS, business and economics	5.8	General science	2.8
6	LIS, education	4.6	LIS, business and economics	2.7
7	Computer science	3.9	Engineering	2.4
8	General science	2.1	LIS, engineering	2.2
9	LIS, communication	1.9	LIS, medicine	1.9
10	LIS, engineering	1.8	Computer science, engineering	1.5

Table 6 Topic distributions by article type

No.	Topic	Total	%	LS journal articles		IS journal articles		Articles by only non-LIS authors		Articles by LIS and non-LIS authors	
				No. of articles	%	No. of articles	%	No. of articles	%	No. of articles	%
1	Scientometrics	1246	25.2	135	9.6	1111	31.3	911	25.5	335	24.3
2	KO and IR	902	18.2	112	8	790	22.3	690	19.3	212	15.4
3	Information technology	693	14.0	101	7.2	592	16.7	566	15.8	127	9.2
4	Foundations of LIS	468	9.5	394	28.1	74	2.1	232	6.5	236	17.1
5	Internet	424	8.6	75	5.3	349	9.8	330	9.2	94	6.8
6	Information behavior	341	6.9	121	8.6	220	6.2	205	5.7	136	9.9
7	Information society	229	4.6	134	9.6	95	2.7	145	4.1	84	6.1
8	Publishing	205	4.1	177	12.6	28	0.8	174	4.9	31	2.2
9	Information management	171	3.5	15	1.1	156	4.4	139	3.9	32	2.3
10	Information ethics and laws	124	2.5	62	4.4	62	1.7	74	2.1	50	3.6
11	e-resource	52	1.1	25	1.8	27	0.8	32	0.9	20	1.4
12	Other	44	0.9	28	2	16	0.5	30	0.8	14	1.0
13	Customer studies	36	0.7	17	1.2	19	0.5	28	0.8	8	0.6
14	Organizational culture and characteristics	16	0.3	7	0.5	9	0.3	15	0.4	1	0.1
	Total	4951	100.0	1403	100.0	3548	100.0	3571	100.0	1380	100.0

observed. The three most common LS research topics were "foundations of LIS" (28.1%), "publishing" (12.6%), and "scientometrics" (9.6%), whereas the three most common IS research topics were "scientometrics" (25.5%), "KO and IR" (19.3%), and "information technology" (15.8%). A substantial difference in the proportions of research topics existed between LS and IS based on Chi squared tests ($p < 0.05$). A significant difference in the distribution of research topics was also identified between whether collaborators of non-LIS authors included LIS authors ($p < 0.05$). "Scientometrics" was the most prevent research topic in the two types of articles. "KO and IR" was the second most common research topic of articles by only non-LIS authors (19.3%), followed by "Information technology" (15.8%). The second most common research topic of articles by LIS and non-LIS authors was "foundations of LIS" (17.1%). The third largest research topic was "KO and IR" (15.4%).

Table 7 lists the 30 most frequent words, excluding stop words and general words such as "results," "findings," and "study." Each word represented one minor topic identified from titles and abstracts of articles. Besides one specific word, "citation(s)," 11 general words that frequently appeared in the four types of articles were "analysis/analyses," "article(s)," "data," "development(s)," "impact(s)," "information," "knowledge," "paper(s)," "search(es)," "social," and "user(s)." Differences in the 30 most frequent words between LS and IS journal articles revealed that "librarian(s)," "services," "literacy," "learning," "health," and "medical" topics were more strongly associated with LS. Topics highly connected with IS were "digital," "system(s)," "web," "model(s)," "retrieval," "query/queries," and "network." Additionally, the number of identical words between the 30 most frequent words of LS and IS journal articles was 17, which was lower than the 20 identical words identified from articles by non-LIS authors and by LIS and non-LIS authors. This indicates that the difference in minor topics between articles by only non-LIS authors and those by LIS and non-LIS authors was not larger than that between articles in LS journals and those in IS journals. Most highly used words were identical between articles by only non-LIS authors and those by LIS and non-LIS authors. However, some words did not represent clear topics (e.g., "article(s)" and "social"). Various combinations of two or more words constituted topics such as "social media" and "social influence.

Discussion

This study determined that although LIS authors were the primary knowledge creators for LIS knowledge in terms of number of authors (46.7% of 23,472 authors), non-LIS authors were involved in 46.3% of 10,601 LIS articles studied. Non-LIS authors had substantial influence on the interdisciplinarity of LIS. However, the amounts of non-LIS authors and their articles were underestimated because over half of LIS journals (53%) indexed by the JCR were excluded in this study. Those excluded LIS journals were not typical LIS-oriented journals and were excluded because other databases do not regard them as LIS journals. This means if those excluded LIS journals had been included in the target journals, a higher proportion of non-LIS authors and their articles would have been revealed, which would have affected the results related to interdisciplinary characteristics and degrees of LIS. This indicates that the journal selection for exploring interdisciplinary characteristics is an essential process (Moya-Anegón et al. 2006).

The influence of non-LIS authors on LIS has already been established. The findings of this study are consistent with those of related studies that have reported that non-LIS authors belonging to numerous disciplines have contributed to LIS knowledge and have

Table 7 Comparison of the 30 most frequent words among four types of articles

Rank	LS journal articles	No.	IS journal articles	No.	Articles by only non-LIS authors	No.	Articles by LIS and non-LIS authors	No.
1	Information	1955	Information	5576	Information	4995	Information	2536
2	Library/libraries	1891	Citation(s)	3628	Paper(s)	3089	Library/libraries	1617
3	Journal(s)	883	Paper(s)	2913	Web	3042	Paper(s)	972
4	Health	739	System(s)	2660	User(s)	2399	User(s)	849
5	Student(s)	689	Data	2484	System(s)	2208	Data	831
6	Article(s)	620	Web	2432	Data	2080	Journal(s)	828
7	Service(s)	560	Search(es)	2052	Search(es)	1874	Citation(s)	779
8	Librarian(s)	512	Analysis/analyses	1944	Library/libraries	1857	Analysis/analyses	751
9	Paper(s)	492	Model(s)	1803	Method(s)	1737	Search(es)	721
10	University/universities	460	User(s)	1790	Knowledge	1673	System(s)	695
11	Data	427	Knowledge	1781	Approach(es)	1653	Web	678
12	Access	418	Library/libraries	1583	Model(s)	1626	Article(s)	640
13	Literacy	415	Journal(s)	1560	Journal(s)	1615	Method(s)	588
14	User(s)	414	Social	1472	Analysis/analyses	1597	Student(s)	506
15	Academic	405	Query/queries	1387	Document(s)	1405	Model(s)	502
16	Public	381	Science(s)	1246	Social	1405	University/universities	483
17	Citation(s)	368	Retrieval	1201	Citation(s)	1369	Knowledge	466
18	Science(s)	367	Impact(s)	1071	Article(s)	1347	Scientific	455
19	Search(es)	347	Performance	1036	Query/queries	1177	Health	451
20	Analysis/analyses	345	Online	1024	Online	1004	Approach(es)	444
21	Learning	329	Document(S)	1004	Process(es)	995	Number(s)	418
22	Knowledge	329	Digital	954	Term(s)	990	Digital	417
23	Development(s)	318	Number(s)	901	Retrieval	982	Academic	405
24	Social	297	Term(s)	856	Service(s)	982	Access	404
25	Publication(s)	292	Process(es)	841	Science(s)	979	Resource(s)	399
26	Online	287	Article(s)	797	Factor(s)	964	Impact(s)	392

Table 7 continued

Rank	LS journal articles	No.	IS journal articles	No.	Articles by only non-LIS authors	No.	Articles by LIS and non-LIS authors	No.
27	Survey(s)	327	Development(s)	773	Impact(s)	950	Social	386
28	Literature	277	Factor(s)	769	Technology/technologies	939	Author(s)	370
29	Impact(s)	271	Work	767	Number(s)	902	Document(s)	351
30	Medical	267	Author(s)	767	Performance	890	Development(s)	329

No. indicates the number of appearances

been collaborators with LIS authors (Aharony 2012; Chang and Huang 2012; Paul-Hus et al. 2016; Prebor 2010; Qiu 1992; Walters and Wilder 2016). A further finding demonstrated that the percentage of IS journal articles by only non-LIS authors is much higher than that of LS journal articles (50.3 vs. 15.1%). The percentage of articles by only non-LIS authors per IS journal ranged between 16.9 and 80.3%, whereas a narrower range between 2.7 and 38.2% was observed per LS journal. Although numerous journals belong to the same discipline (LS or IS), each journal has its own subject scope and characteristics. In particular, some journals are interdisciplinary; the *Journal of Information Science* is classified as both an LIS and computer science journal by the JCR and Ulrichweb. This explains the difference in interdisciplinary characteristics between journals in the same discipline. In this study, five journals were identified as having more than 50% of articles by only non-LIS authors. Both were IS– and computer science–oriented journals.

The development of IS was confirmed to be affected by a substantial number of non-LIS researchers. Although the proportion of non-LIS authors in IS was much higher than that in LS, non-LIS authors contributing to IS tended to collaborate with other authors belonging to specific disciplines. This caused the degree of interdisciplinarity of IS to be lower than that of LS and a flat trend in degree of interdisciplinarity. This is inconsistent with the study of Huang and Chang (2012). The inconsistent result may be because of differences in journal selection, the period of study, and types of articles. However, one consistent finding between the present study and Huang and Chang (2012) is an increase in the degree of interdisciplinarity of LS and IS. Both the LS and IS fields have been becoming less reliant on their own researchers. However, this study proved that IS articles tend to be dominated by specific disciplines, not contributed to equally by all disciplines involved in IS research.

In addition to differences in the proportions of non-LIS authors, the differences in disciplinary characteristics between LS and IS can be observed in the main research topics investigated by non-LIS authors. The results obtained using expert judgment demonstrated that main research topics in IS include scientometrics and KO and IR. Information technology and the Internet are also the focus of IS. These IS-oriented research topics are consistent with findings of related studies on the intellectual structure of IS (Åström 2007; Zhao and Strotmann 2014) and the main research topics of LIS (González-Alcaide et al. 2008). Therefore, a higher percentage of computer science authors can be anticipated to contribute toward IS articles. Business and economics authors have also been primary non-LIS authors of IS articles. Among them, information management authors are the link between management and information science (Rodionov and Tsvetkova, 2015). The computer science authors had concentrated on publishing in *Journal of the Association for Information Science and Technology* (*JASIST*) and *Information Processing and Management*, whereas the business and economics authors had concentrated on publishing in *JASIST* and *Online Information Review*. The higher proportion of computer science and business and economics authors is consistent with prior studies reporting the increase in influence of computer science and business disciplines on LIS (Prebor 2010; Walters and Wilder 2016). In LS, medical authors were the predominant of the non-LIS authors and had concentrated on publishing in two medical-related journals, *Health Information and Libraries Journal* and *Journal of the Medical Library Association*. This is consistent with the findings that health information and services has emerged as a new research topic (Ni et al. 2013; Yan 2014). However, the main research topic in LS was "foundations of LIS," not a medical topic. This indicates that some typical and basic topics remain essential to LIS knowledge, and their importance has not faded.

Disciplinary proximity can explain why computer science, education, and communication authors are interested in LIS research topics, as indicated by related studies (Buttlar

1999; Chang and Huang 2012). A strong connection between LS and medicine was not anticipated. However, numerous LIS research topics are interdisciplinary, such as information services provided by medical libraries. In addition to health science librarians, medical professionals also serve medical libraries or submit suggestions for improving information services. Information is a broad concept and connects with many disciplines. This is similar to how the Internet, information technology, and management have permeated into many disciplines. Odell and Gabbard (2008) mentioned that the growth of information technology has resulted in more IS-oriented journals being categorized as LIS journals and expanded readership. This justifies why information-related researchers outside LIS have become involved in LIS research. The boundary of research topics has become obscured because of the interdisciplinary activities of researchers with diverse academic backgrounds.

Identifying LIS research topics is a long-term concern among LIS researchers. Several methods have been applied to topic analysis, including expert judgment (Tuomaala et al. 2014; Tveit 2017), keyword analysis (González-Alcaide et al. 2008; Mondal et al. 2017; Xiao et al. 2015), controlled subject term analysis (Shu et al. 2016), coword analysis (Milojević et al. 2011), cocitation analysis (Åström 2007; Klavans and Boyack 2011), and topic modeling (Sugimoto et al. 2011; Yan 2014). Despite changes in numbers and names of topics in related studies using these methods, the main research topics of LIS, such as information behavior, information retrieval, and bibliometrics, remain identifiable. Each method of topic analysis has advantages and disadvantages and reflects different perspectives. Therefore, two methods were adopted in this study, namely word frequency analysis and expert judgment. Word frequency analysis is a statistical method and reveals minor topics embedded in articles. Although word frequency analysis is simple and fast using word analysis software, a weaker relationship exists between words and a specific topic because of a lack of clear context. Expert judgment assigns a single main topic to each article by examining titles, abstracts, author keywords, or full texts. Results from word frequency analysis and expert judgment are complementary.

The differences in expert judgement and word frequency analysis between LS and IS and between articles by only non-LIS authors and articles by LIS and non-LIS authors indicate that the relationships between research topics, non-LIS authors, and disciplines (LS and IS) should be further explored. Table 8 indicates substantial differences in the percentages of LS articles by only non-LIS authors and by LIS and non-LIS authors regarding "foundations of LIS" and "publishing." The typical LS topic still relies on contributions from LIS authors. Publishing topics were primarily of interest to business and computer science authors, because the publishing industry mainly consists of commercial publishers and responds to the trends of digital publishing and e-commerce (Hall 2016; Zhang 2017). The transformation of the publishing industry relies on information and management professionals. In IS, the largest difference was observed in "information technology" (18.5 vs. 10.7%), indicating that non-LIS authors tended to collaborate with each other to explore information technology topics. In fact, this phenomenon is more prevalent in coauthored articles by only non-LIS authors. The relationships between research topics, LIS and non-LIS authors, and disciplines (LS and IS) obtained using word frequency analysis are shown in Table 9. In both LS and IS, the small differences in the 30 most frequent topics were identified between articles by only on-LIS authors and those by LIS and non-LIS articles. This indicates that collaboration with LIS authors in the same discipline (LS or IS) does not greatly affect the research topics of non-LIS authors.

There were two limitations to this study. First, although LIS consists of two main subfields, LS and IS, the difference in subject scope of each journals and the number of

Table 8 Relationships between research topics, LIS and non-LIS authors, and disciplines obtained using expert judgment

Topic	LS journals		IS journals	
	Articles by only non-LIS authors (%)	Articles by LIS and non-LIS authors (%)	Articles by only non-LIS authors (%)	Articles by LIS and non-LIS authors (%)
Foundation of LIS	23.2	35.3	1.4	4.4
Publishing	18.2	4.4	0.8	0.7
Scientometrics	10.6	8.1	30.1	35.5
Information society	8.9	10.6	2.6	3.0
KO and IR	8.6	7.1	22.6	21.2
Information technology	7.3	7.1	18.5	10.7
Information behavior	7.2	10.8	5.3	9.2
Internet	6.0	4.4	10.2	8.5
Information ethics and laws	4.1	4.9	1.5	2.7
Other	2.0	1.9	0.5	0.4
e-resource	1.2	2.6	0.8	0.6
Customer studies	1.1	1.4	0.7	0.0
Information management	1.0	1.2	4.8	3.1
Organizational culture, structure	0.6	0.2	0.3	0.0
Total	100.0	100.0	100.0	100.0

articles published in each year may affect the results. The number of IS journal articles analyzed was approximately four times that of LS journal articles. The difference in productivity between LS and IS reveals that IS is growing faster than LS. This is consistent with the findings of Shu et al. (2016) that IS has become the dominant research subfield in LIS. The larger proportion of IS journal articles explains why the interdisciplinary characteristics of LIS were similar to those of IS. In particular, journals with a large number of articles dominated the interdisciplinary characteristics of their disciplines. This study revealed that many authors were concerned with scientometric studies. Scientometrics articles strongly affected the interdisciplinary characteristics of IS. Second, each journal was assigned to LS or IS oriented in this study. This process helps us observe the differences in characteristics between LS and IS. However, distinguishing LS and IS journals is challenging, because classification is subjective. Journals were used as a proxy to explore the characteristics of a given discipline. All articles published in the same journal were regarded as belonging to the same discipline. This indicates that journal selection and classification greatly affected the results. Although differences in disciplinary attributes existed between articles published in the same journal, the determination of disciplinary attributes remains subjective, because an article may be relevant to several topics across disciplines. Furthermore, large numbers of articles make classification laborious. This may explain why journals are still widely used as a proxy for disciplines.

Table 9 Relationships between research topics, LIS and non-LIS authors, and disciplines obtained using word frequency analysis

Rank	LS journals				IS journals			
	Articles by only non-LIS authors	No.	Articles by LIS and non-LIS authors	No.	Articles by only non-LIS authors	No.	Articles by LIS and non-LIS authors	No.
1	Information	1047	Library/libraries	946	Information	3998	Information	1635
2	Library/libraries	968	Information	940	Paper(s)	2762	Paper(s)	806
3	Journal(s)	606	Student(s)	375	User(s)	2199	Library/libraries	685
4	Health	415	Health	331	System(s)	2040	User(s)	662
5	Article(s)	354	Journal(s)	287	Model(s)	1945	Data	646
6	Paper(s)	327	Librarian(s)	283	Web	1919	Citation(s)	628
7	Student(s)	320	Service(s)	268	Data	1844	System(s)	620
8	Service(s)	292	Article(s)	266	Method(s)	1594	Analysis/analyses	588
9	Search(es)	249	University/universities	239	Search(es)	1568	Web	549
10	Data	240	Access	205	Approach(es)	1524	Journal(s)	547
11	Academic	232	Public	197	Knowledge	1443	Search(es)	491
12	Literacy	230	User(s)	194	Analysis/analyses	1412	Science(s)	450
13	Knowledge	230	Data	188	Document(s)	1353	Article(s)	374
14	University/universities	225	Literacy	186	Social	1213	Knowledge	367
15	User(s)	224	Journal(s)	186	Citation(s)	1194	Approach(es)	340
16	Access	217	Science(s)	186	Query/queries	1157	Document(s)	337
17	Citation(s)	214	Academic	181	Journal(s)	1022	Digital	313
18	Publication(s)	213	Learning	177	Article(s)	994	Impact(s)	293
19	Practice(s)	208	Survey(s)	172	Retrieval	952	Social	282
20	Development(s)	200	Search(es)	162	Term(s)	875	Model(s)	280
21	Analysis/analyses	194	Citation(s)	159	Citation(s)	869	Author(s)	269
22	Resource(s)	194	Analysis/analyses	153	Online	853	Retrieval	253
23	Social	192	Development(s)	142	Performance	846	University/universities	246
24	Public	188	Literature	141	Impact(s)	836	Factor(s)	245

Table 9 continued

Rank	LS journals				IS journals			
	Articles by only non-LIS authors	No.	Articles by LIS and non-LIS authors	No.	Articles by only non-LIS authors	No.	Articles by LIS and non-LIS authors	No.
25	Science(s)	181	Skill(s)	132	Document(s)	824	Source(s)	244
26	Online	168	Paper(s)	131	Network(s)	815	Query/queries	234
27	System(s)	168	Medical	129	Technology/technologies	809	Academic	229
28	Learning	165	Web	129	Science(s)	801	Publication(s)	220
29	Education	142	Online	124	Rights	728	Number(s)	214
30	Process(es)	142	Education	121	Number(s)	701	Term(s)	213

Conclusion

This study examined the interdisciplinary characteristics of LIS by focusing on non-LIS contributing authors and their articles. The findings contribute to the literature because a neglected perspective was adopted for exploring the interdisciplinarity of LIS. Earlier studies have identified non-LIS authors as LIS knowledge creators, but this study extended the literature on the characteristics of non-LIS authors and their articles. The high proportion of LIS articles by non-LIS authors confirms that LIS knowledge is substantially affected by other disciplines. In particular, the decreasing trend in articles by only LIS authors reveals that LIS authors prefer to collaborate with non-LIS authors. An increasing trend in articles by only non-LIS authors was observed. This type of article does not involve direct interaction between LIS and non-LIS authors, which is typical of interdisciplinary collaboration. Because most non-LIS authors do not hold LIS-related credentials, their ever-increasing involvement in LIS research will likely change the academic landscape of LIS. In particular, a substantial proportion of articles were written by only non-LIS authors. Non-LIS authors tended not to collaborate with LIS authors. Although some non-LIS authors collaborated with LIS authors, research topics of those articles were similar to those by only non-LIS authors. In addition, the differences in disciplinary characteristics between LS and IS were proven. This is consistent with the claims of prior studies (Åström 2007; Wang and Wolfram 2015), despite LS and IS being incorporated into LIS for decades. A comparison made between LS and IS revealed detailed information about LIS interdisciplinarity. Future research on the interdisciplinarity of LIS must consider the differences in disciplinary characteristics between LS and IS.

Acknowledgements This research was financially supported by a grant from the Ministry of Science and Technology of Taiwan (MOST 105-2410-H-002-117) and by the Center for Research in Econometric Theory and Applications (Grant no. 107L900204) from The Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan, and by the Ministry of Science and Technology (MOST), Taiwan, under Grant No. MOST 107-3017-F-002-004-.

References

Abrizah, A., Noorhidawati, A., & Zainab, A. N. (2015). LIS journals categorization in the Journal Citation Report: A stated preference study. *Scientometrics, 102*(2), 1083–1099.

Aharony, N. (2012). Library and Information Science research areas: A content analysis of articles from the top 10 journals 2007-8. *Journal of Librarianship and Information Science, 44*(1), 27–35.

Alvargonzález, D. (2011). Multidisciplinarity, interdisciplinarity, transdisciplinarity, and the sciences. *International Studies in the Philosophy of Science, 25*(4), 387–403.

Åström, F. (2007). Changes in the LIS research front: Time-sliced cocitation analyses of LIS journal articles, 1990–2004. *Journal of the American Society for Information Science and Technology, 58*(7), 947–957.

Beattie, V., & Goodacre, A. (2004). Publishing patterns within the UK accounting and finance academic community. *British Accounting Review, 36*(1), 7–44.

Bellotti, E., Kronegger, L., & Guadalupi, L. (2016). The evolution of research collaboration within and across disciplines in Italian Academia. *Scientometrics, 109*(2), 783–811.

Bordons, M., Zulueta, M. A., Romero, F., & Barrigón, S. (1999). Measuring interdisciplinary collaboration within a university: The effects of the multidisciplinary research programme. *Scientometrics, 46*(3), 383–398.

Buttlar, L. (1999). Information sources in library and information science doctoral research. *Library and Information Science Research, 21*(2), 227–245.

Chang, Y. W. (2011). A comparative study of the research literature on information needs and information seeking: A bibliometric and social network analysis. *Journal of Educational Media and Library Science, 48*(3), 347–380.

Chang, Y. W., & Huang, M. H. (2012). A study of the evolution of interdisciplinarity in library and information science: Using three bibliometric methods. *Journal of the American Society for Information Science and Technology, 63*(1), 22–33.

Chang, Y. W., Huang, M. H., & Lin, C. W. (2015). Evolution of research subjects in library and information science based on keyword, bibliographical coupling, and co-citation analyses. *Scientometrics, 105*(3), 2071–2087.

Enger, K. B. (2015). Understanding the development of disciplines and the ways they contribute to knowledge and reflect practice: An analysis of articles published in higher education and library and information science. *Advances in Library Administration and Organization, 24,* 1–51.

Erfanmanesh, M. A., Didegah, F., & Omidvar, S. (2010). Research productivity and impact of library and information science in the web of science. *Malaysian Journal of Library and Information Science, 15*(3), 85–95.

Gonzalez-Alcaide, G., Castello-Cogollos, L., Navarro-Molina, C., Aleixandre-Benavent, R., & Valderrarna-Zurian, J. C. (2008). Library and information science research areas: Analysis of journal articles in LISA. *Journal of the American Society for Information Science and Technology, 59*(1), 150–154.

Hall, F. (2016). Digital change and industry responses: Exploring organizational and strategic issues in the book-publishing industry. *Logos (Netherlands), 27*(2), 19–31.

Hessey, R., & Willett, P. (2013). Quantifying the value of knowledge exports from librarianship and information science research. *Journal of Information Science, 39*(1), 141–150.

Huang, M. H., & Chang, Y. W. (2012). A comparative study of interdisciplinary changes between information science and library science. *Scientometrics, 91*(3), 789–803.

Jabeen, M., Yun, L., Rafiq, M., & Jabeen, M. (2015). Research productivity of library scholars bibliometric analysis of growth and trends of LIS publications. *New Library World, 116*(7–8), 433–454.

Klavans, R., & Boyack, K. W. (2011). Using global mapping to create more accurate document-level maps of research fields. *Journal of the American Society for Information Science and Technology, 62*(1), 1–18.

Levitt, J. M., Thelwall, M., & Oppenheim, C. (2011). Variations between subjects in the extent to which the social sciences have become more interdisciplinary. *Journal of the American Society for Information Science and Technology, 62*(6), 1118–1129.

Lugya, F. K. (2014). What counts as a science and discipline in library and information science? *Library Review, 63*(1/2), 138–155.

Milojević, S., Sugimoto, C. R., Yan, E., & Ding, Y. (2011). The cognitive structure of library and information science: Analysis of article title words. *Journal of the American Society for Information Science and Technology, 62*(10), 1933–1953.

Mondal, D., Kanamadi, S., & Das, K. (2017). Contribution by Indian authors in foreign origin library and information science journals during 2006–2015: A scientometrics study. *DESIDOC Journal of Library and Information Technology, 37*(6), 396–402.

Moya-Anegón, F., Herrero-Solana, V., & Jiménez-Contreras, E. (2006). A connectionist and multivariate approach to science maps: The SOM, clustering and MDS applied to library and information science research. *Journal of Information Science, 32*(1), 63–77.

Ni, C., Sugimoto, C. R., & Cronin, B. (2013). Visualizing and comparing four facets of scholarly communication: Producers, artifacts, concepts, and gatekeepers. *Scientometrics, 94*(3), 1161–1173.

Odell, J., & Gabbard, R. (2008). The interdisciplinary influence of library and information science 1996–2004: A journal-to-journal citation analysis. *College and Research Libraries, 69*(6), 546–565.

Paul-Hus, A., Mongeon, P., & Shu, F. (2016). Portraying the landscape of Canadian library and information science research. *Canadian Journal of Information and Library Science, 40*(4), 332–346.

Pierce, S. J. (1999). Boundary crossing in research literatures as a means of interdisciplinary information transfer. *Journal of the American Society for Information Science, 50*(3), 271–279.

Porter, A. L., & Rafols, I. (2009). Is science becoming more interdisciplinary? Measuring and mapping six research fields over time. *Scientometrics, 81*(3), 719–745.

Prebor, G. (2010). Analysis of the interdisciplinary nature of library and information science. *Journal of Librarianship and Information Science, 42*(4), 256–267.

Qiu, L. (1992). A study of interdisciplinary research collaboration. *Research Evaluation, 2*(3), 169–175.

Rafols, I., & Meyer, M. (2010). Diversity and network coherence as indicators of interdisciplinarity: Case studies in bionanoscience. *Scientometrics, 82*(2), 263–287.

Rodionov, I. I., & Tsvetkova, V. A. (2015). Information management in information science. *Scientific and Technical Information Processing, 42*(2), 73–77.

Rodriguez, J. M. (2017). Disciplinarity and interdisciplinarity in citation and reference dimensions: Knowledge importation and exportation taxonomy of journals. *Scientometrics, 110*(2), 617–642.

Săvoiu, G. (2014). The impact of inter-, trans-and multidisciplinarity on modern taxonomy of sciences. *Current Science, 106*(5), 685–690.

Shu, F., Larivière, V., Mongeon, P., Julien, C. A., & Piper, A. (2016). On the evolution of library and information science doctoral dissertation topics in north America 1960–2013. *Journal of Education for Library and Information Science, 57*(2), 131–142.

Spellerberg, I. F., & Fedor, P. J. (2003). A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon-Wiener' Index. *Global Ecology and Biogeography, 12*(3), 177–179.

Sugimoto, C. R., Li, D., Russell, T. G., Finlay, S. C., & Ding, Y. (2011). The shifting sands of disciplinary development: Analyzing North American library and information science dissertations using latent Dirichlet allocation. *Journal of the American Society for Information Science and Technology, 62*(1), 185–204.

Tuomaala, O., Jarvelin, K., & Vakkari, P. (2014). Evolution of library and information science, 1965–2005: Content analysis of journal articles. *Journal of the Association for Information Science and Technology, 65*(7), 1446–1462.

Tveit, A. K. (2017). A celebration of diversity: LIS research in the Nordic countries as shown by PhD dissertations 2005–2014. *Journal of Education for Library and Information Science, 58*(2), 64–76.

Walters, W. H., & Wilder, E. I. (2016). Disciplinary, national, and departmental contributions to the literature of library and information science, 2007–2012. *Journal of the Association for Information Science and Technology, 67*(6), 1487–1506.

Wang, F., & Wolfram, D. (2015). Assessment of journal similarity based on citing discipline analysis. *Journal of the Association for Information Science and Technology, 66*(6), 1189–1198.

Xiao, X., Zhang, F., & Li, J. (2015). Library and information science research in China: A survey based analysis of 10 LIS educational institutes. *Journal of Academic Librarianship, 41*(3), 330–340.

Yan, E. (2014). Research dynamics: Measuring the continuity and popularity of research topics. *Journal of Informetrics, 8*(1), 98–110.

Yan, E. (2016). Disciplinary knowledge production and diffusion in science. *Journal of the Association for Information Science and Technology, 67*(9), 2223–2245.

Yang, S., Han, R., Wolfram, D., & Zhao, Y. (2016). Visualizing the intellectual structure of information science (2006–2015): Introducing author keyword coupling analysis. *Journal of Informetrics, 10*(1), 132–150.

Zhang, J. (2017). The integration of technology and the publishing industry in China. *Publishing Research Quarterly, 33*(2), 173–182.

Zhao, D., & Strotmann, A. (2014). The knowledge base and research front of information science 2006–2010: An author cocitation and bibliographic coupling analysis. *Journal of the Association for Information Science and Technology, 65*(5), 995–1006.