The interdisciplinarity of iSchools: An analysis and visualization of research publications

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ABSTRACT

Based on the papers published in journals indexed by SCI/SSCI between 2008 and 2012, we studied the interdisciplinarity of iSchools and visualized publication portfolios among different journals and clusters. The findings indicate that the iSchools can be seen as interdisciplinary environments from a macroscopic perspective, but each individual iSchool has its own strengths and specializations. In many cases, the 'i' in the individual 'iSchool' can only be interpreted as 'information' not 'interdisciplinary'. The results also show that LIS-related journals still occupy the most important position in the research output of iSchools, although some iSchools with strong computer science background are members of this organization. This work is compared to earlier analyses and provides a different view of the state of the interdisciplinarity of iSchools.

Keywords: iSchools; interdisciplinarity; Overlay map; Publication portfolio; Visualization

INTRODUCTION

Along with the rapid increase of information, it has become more important for accessing and using information in people's work and everyday life. As the core of information era, the library and information science (LIS) discipline is continually evolving, as Cronin (2007) had claimed in an article published in 1983 and republished in 2007 that: 'at a time of rapid change it is important that professional groups are at least willing to consider the implications of changes'. In the past decade, the iSchool movement has played a significant role and attracted lots of discussions in LIS. Founded in 2005, by a collective consortium of information schools dedicated to advancing the information field in the 21st century, the iSchool community has 52 members as of October 2013.

While each individual iSchools has its own strengths and specializations, together they share a fundamental interest in the relationship between information, people, and technology (iSchools Organization, 2015). The faculty members of iSchools come from various disciplinary backgrounds such as computing, information science, library science, management and education. The richness and diversity of these broad disciplinary domains make an important contribution to the community and scholarship (Wiggins and Sawyer 2012). From faculty members' current research interests described by the individuals themselves, the iSchools still contain many dominant themes from library and information science (e.g., bibliometrics, information retrieval, and information seeking behaviour), but have an expanded conceptual landscape with the introduction of new iSchools (Holmberg, Tsou and Sugimoto 2013). Based on faculty members' publications, the pattern of interdisciplinary integration could also be found (Chen 2008). The ‘i’ in ‘iSchools’, in some ways, can be interpreted as either ‘information’ or ‘interdisciplinary’ (Wu et al. 2012).

However, simply saying that an iSchool is interdisciplinary does not make it so. True interdisciplinarity requires that intellectually diverse faculty members set aside critical, discipline-based assumptions regarding what work is worth doing, how work is to be evaluated and the importance of consistency in the focus of the scholar over time (King 2006). In this article, we report on a study examining the state of academic research at iSchools. The study addresses the following research questions:

a) What is the state of the interdisciplinarity of iSchools from a macroscopic perspective?
b) Which iSchools are more interdisciplinary than others?
c) Is there correlation between the interdisciplinarity and the number of publications or the number of journals?
d) Is there a significant difference in the distribution of disciplines between individual iSchools?

The remainder of the article is organized as follows. We first review related work in, and then discuss the research design. Next we present the results of the study and discuss the insights we gained. Finally, we conclude with ideas for future work.

LITERATURE REVIEW

The iSchools

Although the general discussion, that LIS education needs to further substitute an information-centered focus for its traditional institutional focus, has a longer history (Williams 1978; House and Sutton 1996), the so-called information school movement started to be the focus when the organization called iSchools was established in 2005. Bruce (2006) identified iSchools as information-centered, connecting people to information with the help of technology, multidisciplinary, independent, and research and education balanced schools. Graduates of iSchools are faring well in the job market, landing a variety of jobs in academic, nonprofit, government, and industry sectors. iSchool faculty are contributing research that is well respected in their home country, as well as in the information sphere (Olson and Grudin 2009).

The most remarkable thing about the iSchools is the variety of their origins and the broad embrace of their intellectual interests (King 2006). As a developing community, it is necessary to analyze the iSchools in terms of research and education programs associated with each individual iSchool. Zhang, Yan and Hassman (2013) studied the first five iSchools (Pittsburgh, Syracuse, Drexel, Michigan and Washington) and found the information field (iField) is interdisciplinary as demonstrated by knowledge contributors coming from a very diverse set of disciplines; conducting research with very diverse emphases within very diverse contexts and at various levels of analysis; and publishing in journals that belong to many different disciplines. Wu et al. (2012) examined the state of academic research and graduate education at 25 iSchools between 2005 and 2010, found iSchools share the same vision and mission - working on relationships between information, people and technology, and have established themselves as the appropriate institutions for researchers from diverse subject areas to study this interdisciplinary integration.

Interdisciplinarity

Interdisciplinarity is a key element in the advancement of science with the ability to make breakthroughs in modern science (Morillo, Bordons and Gomez 2003) and necessary to answer the complex questions of contemporary research (Klein 1990). Interdisciplinary research is not only increasing imperative to addressing many intellectual, social and practical problems, but also challenging existing structures (Klein 1990; Facilitating Interdisciplinary Research 2005). The majority of studies investigating interdisciplinary have used Web of Science (WoS) as a data source, and citations between journals as indicators of interdisciplinary. All kinds of classification schemes, such as Journal Citation Reports (JCR) subject categories (Liu and Wang 2005; Cronin and Meho 2007; Leydesdorff 2007a, 2007b; Leydesdorff and Rafols 2009; Porter and Rafols 2009; Rafols and Meyer 2010), Dewey Decimal Classification (DCC) (Allan 1980), Library of Congress Classification (LCC) (Sugimoto 2011), and National Science Foundation (NSF) disciplinary classifications (Larivière and Gingras 2010) are used to assign disciplinary.

Interdisciplinarity in LIS and iSchool

LIS has been thought as interdisciplinary “by nature” (Prebor 2010) or “predetermined” (Saracevic 1999). As with other disciplines, the majority of studies of interdisciplinarity in LIS have used intercitations between journals as indicators (Tang 2004; Odell and Gabbard 2008). Direct citation is also a commonly adopted method for analyzing the distribution across disciplines (Huang and Chang 2011; Huang and Chang 2012). Other metrics have included using keywords and concepts in articles (Baradol and Kumbar 1998), citation patterns in dissertations (Sugimoto 2011), and the disciplinary background of advisors and committee members (Sugimoto et al. 2011).

Wiggins and Sawyer (2012) have developed a classification of iSchool faculty members’ academic disciplinary training and education, which included nine broad disciplinary categories. Then information entropy measure was applied to the percentage of faculty with degrees in each disciplinary area and normalized to a *z*-score as an interdisciplinarity score. However, someone maybe doubt if the degrees of faculty members gained many years ago could accurately reflect the current research activities, and if the faculty members could represent the whole iSchool without considering Ph.D. students and postdoctoral researchers who play an important role in the research activities.

Unlike Wiggins and Sawyer’s research, our study focuses on the publications of iSchool members that include all faculty, lectures, postdoctoral researchers and students. Web of Science is used as the data source, and intercitations between journals as indicators of interdisciplinarity. Visualization techniques developed by Leydesdorff (Leydesdorff and Rafols 2012; Leydesdorff, Rafols and Chen 2013) for publication portfolios are applied to understand the interdisciplinarity and distribution of journals in a more intuitive method.

METHODOLOGY

Data collection

As of October 2013, the iCaucus had 52 members (iSchools – Apendix A). The online list of iSchools was used to retrieve data from Science Citation Index (SCI) and Social Science Citation Index (SSCI). The document types were restricted to article and review, and the time span was set between 2008 and 2012. Our research focus was at the iSchool level, rather than the LIS-related unit. For example, our analysis on the iSchool of Indiana

University, Bloomington (IUB) and University of California, Los Angeles (UCLA) was based on the whole school, in which LIS was just one department. Therefore, the result retrieved from SCI and SSCI consisted of all papers published on diverse journals, not only journals in the LIS field. Based on the papers' distribution across the journals, the interdisciplinarity of iSchools can be measured.

Based on the VOSViewer developed by Van Eck and Waltman (2010), Leydesdorff and his co-authors (Leydesdorff and Rafols 2012; Leydesdorff et al. 2013) developed toolkits for visualizing interactive global journal maps by focusing on the positions of journals in the multidimensional space spanned by the aggregated journal–journal citations. A base map was also generated based on the data from JCR 2011. These toolkits and base map provide an option of using any downloaded set from SCI and SSCI to visualize the set in terms of a global map of science. The interdisciplinarity in terms of citing or being cited can also be compared among document sets and across years.

The current study applied the above mentioned toolkits and base map to visualize publication portfolios of iSchools. The program "analyze.exe" developed by Leydesdorff and Rafols (2012) (available at http://www.leydesdorff.net/journals11/) was used to process the result file "analyze.txt" of the retrieval directly from the option "Analyze Results" in WoS. Output files were read into VOS Viewer to generate interactive overlays, which can be zoomed in or out. Either global or local maps of journal overlays can be obtained. In such a map, the size of nodes and fonts labeling journal titles correspond with the number of publications in relevant journals of the studied object, namely, a larger size of nodes and labels imply a higher number of publications, and the labels of nodes with fewer publications are faded for the sake of readability. However, one can zoom in and these labels will become readable again, or the user can move the cursor to a node and the label will appear in the box below. In fact, whether a journal title is displayed in a map depends on relative number of publications of the studied subject in a specific set. In other words, journal title A_i in area A is readable while journal title B_j in area B is faded- this does not always mean the number of publications of A_i is higher than the number of publications of B_j. The reason could be that more journals in area B published relatively a higher number of publications, which pushes B_j to fade into the background.

Measuring Interdisciplinarity

The interdisciplinarity of publication set of iSchools can be measured with the publication set's distribution across the journals in terms of their distances on the base map using Rao-Stirling diversity (Δ), as defined as follows:

$$\Delta = \sum_{ij} p_i p_j d_{ij}$$

where p_i is the proportion of elements assigned to category (journal) *i*, which means the relative frequency of each journal, and d_{ij} is a distance measure between two categories (journals) *i* and *j*.

The Rao-Stirling diversity was introduced by Rao (1982a and 1982b) and proposed as a general framework for measuring diversity in science technology and society by Stirling (2007). It measures not only the diversity of elements among categories, but also the distances among the categories. In our study, this distance can be calculated with the percentage of the maximum distance of the base map—that is, $\| x_i - y_i \|$ which x_i and y_i are two journals of the set. The diversity indicator between zero and one is defined by normalizing this distance against the maximum distance of the map.

Because the VOS Viewer already optimizes in terms of distances, Leydedorff, et al. (2013) directly used these distances between points for the computation of the Rao-Stirling diversity. After running the program "analyze.exe" provided by Leydesdorff and Rafols, a file "rao.txt" including the value of Rao-Stirling diversity measure is generated.

RESULTS

Overall performance

Table 1 shows the top 30 journals in which most iSchools published between 2008 and 2012. As shown in Table 1, the journal most frequently published in by iSchools is the *Journal of the American Society for Information Science and* Technology (JASIST), with *Journal of Documentation* and *Information Processing & Management* in second and third place respectively. Among the top 30 ranked journals, most of them are clearly related to LIS. In fact, nine of the top ten ranked journals are traditional journals classified as LIS. This shows that iSchool researchers mainly publish articles in journals which focus on LIS. However, there are also other journals relating to computer science, communication, medical and biology, even chemical science, as shown in Figure 1. From a macroscopic perspective, iSchools can be seen as an interdisciplinary environment.

Table 1: Thirty SCI and SSCI journals in which most iSchools publish between 2008 and 2012(P indicates the number of publications)

Rank	Journal name	Web of Science Category	P
1	Journal of the American Society for Information Science and Technology	Information Science & Library Science (SSCI) Computer Science, Information Systems (SCI)	236
2	Journal of Documentation	Information Science & Library Science (SSCI)	89
3	Information Processing & Management	Information Science & Library Science (SSCI) Computer Science, Information Systems (SCI)	64
4	Information Research: an International Electronic Journal	Information Science & Library Science (SSCI)	64
5	Library & Information Science Research	Information Science & Library Science (SSCI)	54
6	Aslib Proceedings	Information Science & Library Science (SSCI) Computer Science, Information Systems (SCI)	49
7	Scientometrics	Information Science & Library Science (SSCI) Computer Science, Interdisciplinary Applications (SCI)	49
8	Journal of Information Science	Information Science & Library Science (SSCI) Computer Science, Information Systems (SCI)	41
9	BMC Bioinformatics	Biochemical Research Methods; Biotechnology & Applied Microbiology; Mathematical & Computational Biology (SCI)	40
10	Library Quarterly	Information Science & Library Science (SSCI)	39
11	Plos One	Multidisciplinary Sciences (SCI)	39
12	Library Trends	Information Science & Library Science (SSCI)	37
13	Journal of Chemical Information and Modeling	Chemistry, Medicinal; Chemistry, Multidisciplinary; Computer Science, Information Systems; Computer Science, Interdisciplinary Applications (SCI)	36
14	Knowledge Organization	Information Science & Library Science (SSCI)	34

15	Electronic Library	Information Science & Library Science (SSCI)	30
16	IEEE Transactions on Knowledge and Data Engineering	Computer Science, Artificial Intelligence; Computer Science, Information Systems; Engineering, Electrical & Electronic (SCI)	26
17	Government Information Quarterly	Information Science & Library Science (SSCI)	24
18	Bioinformatics	Biochemical Research Methods; Biotechnology & Applied Microbiology; Mathematical & Computational Biology (SCI)	23
19	Decision Support Systems	Computer Science, Artificial Intelligence; Computer Science, Information Systems; Operations Research & Management Science (SCI)	23
20	Computer	Computer Science, Hardware & Architecture; Computer Science, Software Engineering (SCI)	22
21	Journal of Informetrics	Information Science & Library Science (SSCI)	22
22	Computers in Human Behavior	Psychology, Multidisciplinary; Psychology, Experimental (SSCI)	21
23	Journal of Academic Librarianship	Information Science & Library Science (SSCI)	21
24	Library Hi Tech	Information Science & Library Science (SSCI)	21
25	Personal and Ubiquitous Computing	Computer Science, Information Systems; Telecommunications (SCI)	21
26	Communications of the ACM	Computer Science, Hardware & Architecture; Computer Science, Software Engineering; Computer Science, Theory & Methods (SCI)	20
27	Journal of the American Medical Informatics Association	Computer Science, Information Systems; Science, Interdisciplinary Applications; Health Care Sciences & Services; Medical Informatics (SCI) Information Science & Library Science (SSCI)	20
28	Journal of Librarianship and Information Science	Information Science & Library Science (SSCI)	19
29	New Media &Society	Communication (SSCI)	18
30	BMC Genomics	Biotechnology & Applied Microbiology; Genetics & Heredity (SCI)	17

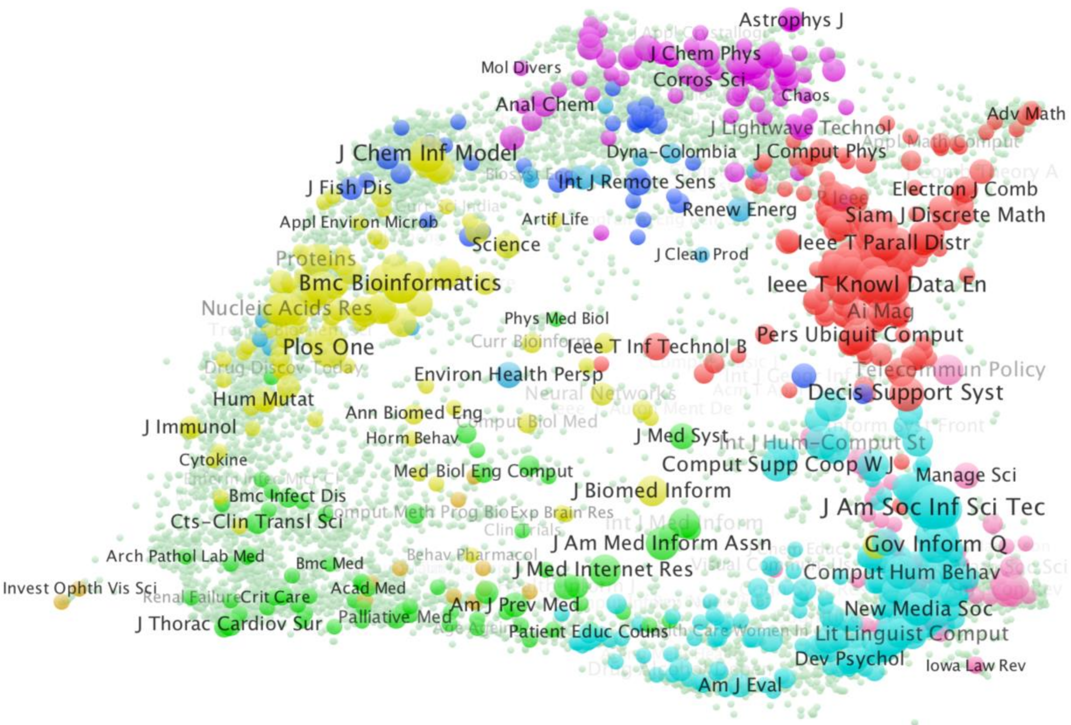

Figure 1: Overlay map of articles published by iSchools in SCI and SSCI journals between 2008- 2012

Individual iSchools' publications and interdisciplinarity

Table 2 shows number of publications and journals published by iSchools. Indiana University published the most number of papers, followed by the iSchool of Georgia Institute of Technology. These two iSchools published significantly more papers than any other iSchool. In fact, all top four iSchools have strong computer science background, with a large number of faculties.

Table 2: Number of publications and journals published by iSchools between 2008-2012

iSchool	P	J	PPJ	iSchool	P	J	PPJ
Indiana University	553	241	2.29	University of Texas, Austin	53	28	1.89
Georgia Institute of Technology	409	221	1.85	Syracuse University	51	39	1.31
Pennsylvania State University	197	128	1.54	University of Melbourne	50	40	1.25
University of California, Irvine	154	102	1.51	University of Kentucky	46	29	1.59
University of Sheffield	151	73	2.07	University of Tsukuba	44	25	1.76
Singapore Management University	147	88	1.67	University of South Australia	41	36	1.14
University of California, Los Angeles	144	90	1.60	University of Missouri	39	33	1.18
Drexel University	131	75	1.75	University College London	36	19	1.89
University of Michigan	121	81	1.49	Charles Sturt University	35	16	2.19
Northumbria University	114	80	1.43	University of Tennesee, Knoxville	32	22	1.45

University of Washington	99	63	1.57	University of Wisconsin, Madison	30	19	1.58
University of Pittsburgh	96	75	1.28	Polytechnic University of Valencia	27	19	1.42
University of Maryland	86	43	2.00	University College Dublin	24	14	1.71
University of Wisconsin, Milwaukee	79	36	2.19	University of North Texas	24	16	1.50
Michigan State University	76	36	2.11	University of Porto	22	22	1.00
Rutgers, The State University of New Jersey	76	44	1.73	Carnegie Mellon University	21	20	1.05
University of Tampere	76	31	2.45	University of Amsterdam	20	17	1.18
University of California, Berkeley	62	49	1.27	Nanjing University	19	13	1.46
University of Maryland, Baltimore County	60	42	1.43	Florida State University	18	8	2.25
University of North Carolina	60	33	1.82	University of Boras	17	6	2.83
Wuhan University	60	32	1.88	University of British Columbia	15	10	1.50
NOVA University of Lisbon	59	43	1.37	Humboldt University of Berlin	13	7	1.86
University of Strathclyde	59	39	1.51	Open University of Catalonia	10	8	1.25
University of Toronto	57	35	1.63	Télécom Bretagne	6	6	1.00
University of Copenhagen	53	19	2.79	University of Glasgow	4	4	1.00
University of Illinois	53	30	1.77	University of Siegen	3	3	1.00

P- number of publications; J - number of journals; PPJ - number of publications per journal

Table 3 shows the interdisciplinarity of iSchools measured with Rao-Stirling diversity. Similar to the publications, the iSchool of Indiana University held the highest position. The iSchools of University of Sheffield and University of California at Irvine took the second and third place. Among the top-10 iSchools which published the most papers, there are five iSchools which also ranked top-10 on interdisciplinarity. As shown in Table 4, there are moderate correlations between the interdisciplinarity and both the number of publications and the number of journals for all iSchools. Moreover, there is a negative correlation between the interdisciplinarity and the number of publications per journal. It means that the interdisciplinarity will increases when the publications are more evenly distributed among journals.

However, it is not true to say all the iSchools with large number of publications have acted as high interdisciplinary. For example, Georgia Institute of Technology, which ranked second on the number of publications, only ranked 19th on interdisciplinarity. Singapore Management University and University of California at Los Angles (UCLA), which ranked 6th and 7th on the number of publications, ranked 40th and 30th on interdisciplinarity.

Table 3: Interdisciplinarity of iSchools, measured with Rao-Stirling diversity

iSchool	Interdisci-plinarity	iSchool	Interdisci-plinarity
Indiana University	0.2900	University of Toronto	0.1164
University of Sheffield	0.2587	University of Tennesee, Knoxville	0.1146
University of California, Irvine	0.2425	University of Kentucky	0.1103
University of Tsukuba	0.2216	University of California, Los Angeles	0.1083
NOVA University of Lisbon	0.2190	University of Tampere	0.1081
University of Michigan	0.2101	Rutgers, The State Univ. of New Jersey	0.1074
University of Melbourne	0.2094	University of Maryland	0.1000
Drexel University	0.2002	Wuhan University	0.0995
University of Strathclyde	0.1980	Polytechnic University of Valencia	0.0934
Open University of Catalonia	0.1931	University of British Columbia	0.0889
University of Maryland, Baltimore County	0.1915	University of Glasgow	0.0881
University of Washington	0.1912	University of North Texas	0.0858
University of Porto	0.1712	Syracuse University	0.0828
University of Pittsburgh	0.1705	Singapore Management University	0.081
University of California, Berkeley	0.1697	University of Amsterdam	0.0768
University of South Australia	0.1648	University of Wisconsin, Madison	0.0727
Northumbria University	0.1604	University of Texas, Austin	0.0725
Pennsylvania State University	0.1594	Michigan State University	0.0719
Georgia Institute of Technology	0.1578	University of Copenhagen	0.0696
Télécom Bretagne	0.1499	University College Dublin	0.0499
Nanjing University	0.1492	University of Wisconsin, Milwaukee	0.0473
University of Illinois	0.1378	University College London	0.0469
Carnegie Mellon University	0.1247	University of Boras	0.0444
University of North Carolina	0.1243	Florida State University	0.0358
University of Missouri	0.1234	University of Siegen	0.0273
Humboldt University of Berlin	0.1212	Charles Sturt University	0.0244

Table 4: Rank Order Correlations (Spearman's rho)

		P	J	PPJ
Interdisciplinary	Correlation Coefficient	.415**	.552**	-.299*
	Sig. (2-tailed)	.002	.000	.031
	N	52	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Journal distribution and visualization of individual iSchool

For each iSchool, an illustration is provided to visualize the distribution of journals. We selected four iSchools to illustrate the nature of the diversity in detail. The four chosen iSchools are Indiana University, Georgia Institute of Technology, University of California at Los Angeles and Singapore Management University. All the four iSchools rank in the top-10 iSchools publishing the most number of papers, but only the iSchool at Indiana University was also ranked top-10 in interdisciplinarity. We use Indiana University's iSchool as representation of more "interdisciplinary" and other three iSchools as representation of more "focused".

(i) Indiana University.

Publications from the iSchool at Indiana University were more evenly distributed among disciplines and journals than the other three iSchools (Figure 2). Among the top-10 journals publishing most of the papers, three (i.e., *JASIST, Scientometrics*, and *Journal of Information Science*) were traditional LIS journals and five could be classified to bioinformatics (Table 5). The last two respectively belonged to multidisciplinary journals (*Plos One*) and chemistry.

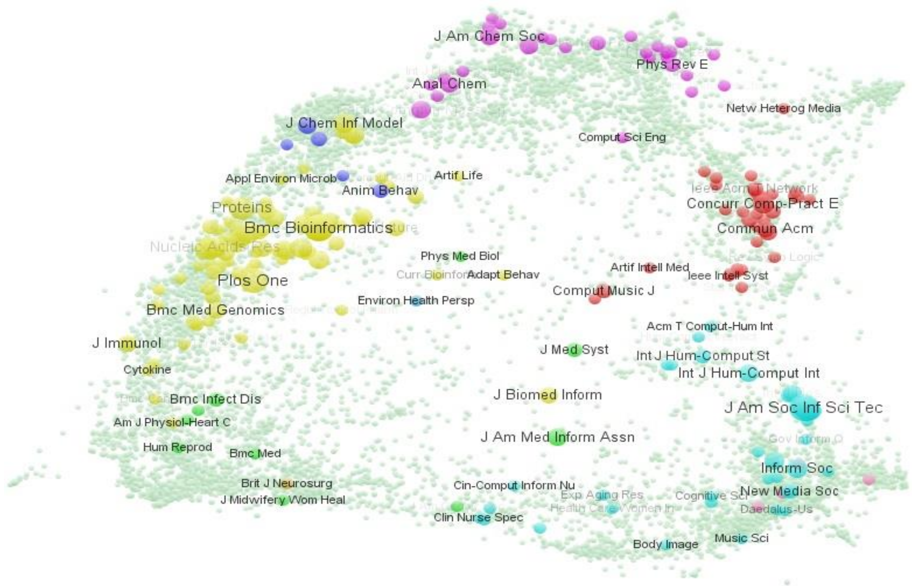

Figure 2: Journal distribution of publications of iSchool at Indiana University

Table 5: Top 10 journals publishing most papers of iSchool at Indiana University

Rank	Journal name	Web of Science Category	P
1	Journal of the American Society for Information Science and Technology	Information Science & Library Science (SSCI) Computer Science, Information Systems (SCI)	40
2	Plos One	Multidisciplinary Sciences (SCI)	25
3	BMC Bioinformatics	Biochemical Research Methods; Biotechnology & Applied Microbiology; Mathematical & Computational Biology (SCI)	22
4	Bioinformatics	Biochemical Research Methods; Biotechnology & Applied Microbiology; Mathematical & Computational Biology (SCI)	16
5	Proteins Structure Function and Bioinformatics	Biochemistry & Molecular Biology (SCI)	16
6	BMC Genomics	Biotechnology & Applied Microbiology; Genetics & Heredity (SCI)	14
7	Scientometrics	Information Science & Library Science (SSCI)	13

		Computer Science, Interdisciplinary Applications (SCI)	
8	Nucleic Acids Research	Biochemistry & Molecular Biology (SCI)	9
9	Journal of Information Science	Information Science & Library Science (SSCI) Computer Science, Information Systems (SCI)	8
10	Journal of Chemical Information and Modeling	Chemistry, Medicinal; Chemistry, Multidisciplinary; Computer Science, Information Systems; Computer Science, Interdisciplinary Applications (SCI)	7

(ii). Georgia Institute of Technology.

Publications from the iSchool at Georgia Institute of Technology were unevenly distributed among disciplines and journals (Figure 3). The majority of journals belong to the cluster of computer science (red color). Among the top-10 journals publishing most of the papers, nine were computer science journals (Table 6). The last one (*Siam Journal on Discrete Mathematics*) belonged to industry and applied mathematics which has a strong connection to computer science.

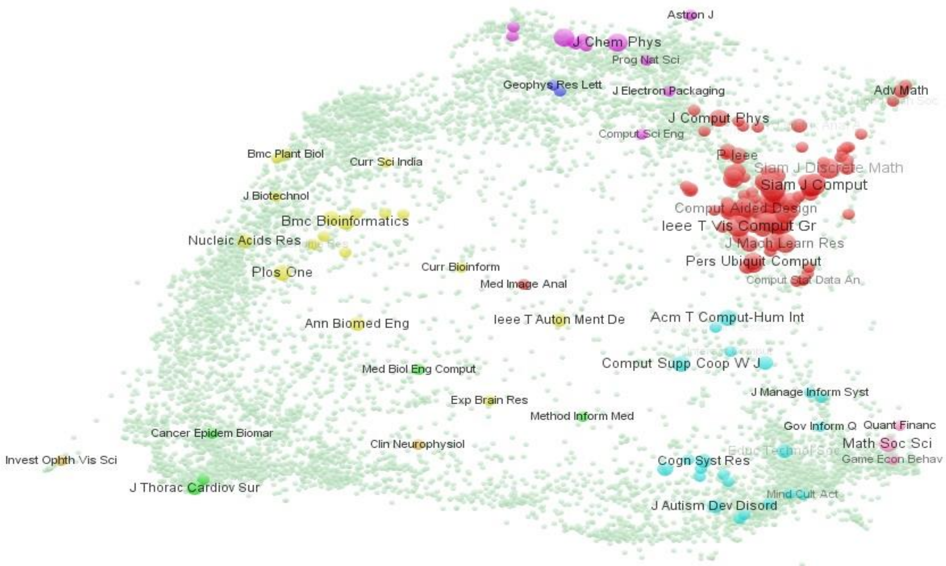

Figure 3. Journal distribution of publications of iSchool at Georgia Institute of Technology

Table 6: Top 10 journals publishing most papers of iSchool at Georgia Institute of Technology

Rank	Journal name	Web of Science Category	P
1	SIAM Journal on Computing	Computer Science, Theory & Methods; Mathematics, Applied (SCI)	11
2	IEEE Transactions on Parallel and Distributed Systems	Computer Science, Theory & Methods; Engineering, Electrical & Electronic (SCI)	10
3	IEEE Transactions on Visualization and Computer Graphics	Computer Science, Software Engineering (SCI)	10
4	SIAM Journal on Discrete Mathematics	Mathematics, Applied (SCI)	9
5	IEEE ACM Transactions on Networking	Computer Science, Hardware & Architecture; Computer Science, Theory & Methods; Engineering, Electrical & Electronic; Telecommunications (SCI)	8
6	Computer Aided Design	Computer Science, Software Engineering (SCI)	7
7	Journal of Machine Learning Research	Automation & Control Systems; Computer	7

		Science, Artificial Intelligence (SCI)	
8	ACMSIGPLAN Notices	Computer Science, Software Engineering (SCI)	6
9	Theoretical Computer Science	Computer Science, Theory & Methods (SCI)	6
10	IEEE Transactions on Pattern Analysis and Machine Intelligence	Computer Science, Artificial Intelligence; Engineering, Electrical & Electronic (SCI)	5

(iii). University of California at Los Angeles (UCLA).

Publications from the iSchool at UCLA were also unevenly distributed among disciplines and journals (Figure 4). The majority of journals belong to the cluster of education. Among the top-10 journals, eight were education science journals (Table 7). The last two respectively belonged to multidisciplinary journals (*American Journal of Evaluation*) and psychiatry (*Drug and Alcohol Dependence*).

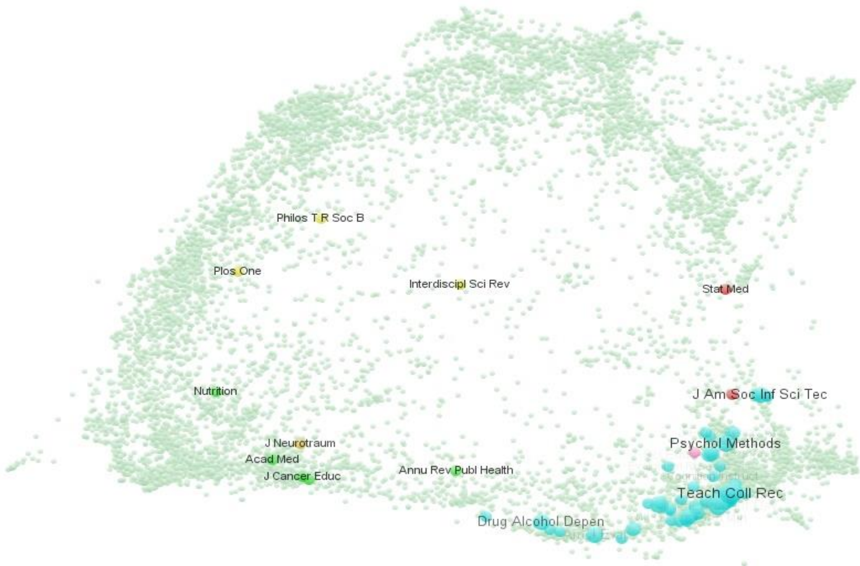

Figure 4. Journal distribution of publications of iSchool at UCLA

Table 7: Top 10 journals publishing most papers of iSchool at UCLA (P indicates the number of publications)

Rank	Journal name	Web of Science Category	P
1	Teachers College Record	Education & Educational Research (SSCI)	8
2	Journal of College Student Development	Education & Educational Research; Psychology, Applied (SSCI)	6
3	Games and Culture	Cultural Studies; Communication (SSCI)	5
4	Harvard Educational Review	Education & Educational Research (SSCI)	4
5	Journal of Autism And Developmental Disorders	Psychology, Developmental (SSCI)	4
6	Phi Delta Kappan	Education & Educational Research (SSCI)	4
7	American Journal of Evaluation	Social Sciences, Interdisciplinary (SSCI)	3
8	Drug and Alcohol Dependence	Substance Abuse; Psychiatry (SSCI& SCI)	3
9	Educational Leadership	Education & Educational Research (SSCI)	3
10	Higher Education	Education & Educational Research (SSCI)	3

(iv). Singapore Management University.

Similar to Georgia Institute of Technology and UCLA, publications from the iSchool at Singapore Management University were also unevenly distributed among disciplines and journals (Figure 5). Although the major area of journals of Singapore Management University are similar to Georgia Institute of Technology, there is significant difference between these two iSchools. Unlike Georgia Institute of Technology's computer science focus, the most important research area in Singapore Management University is obviously information systems. There are no shared journals in the top-10 list between the two iSchools (Table 8). Among the top-10 journals, nine relate to information systems. The tenth relates to computer science (*Journal of Computer Science and Technology*).

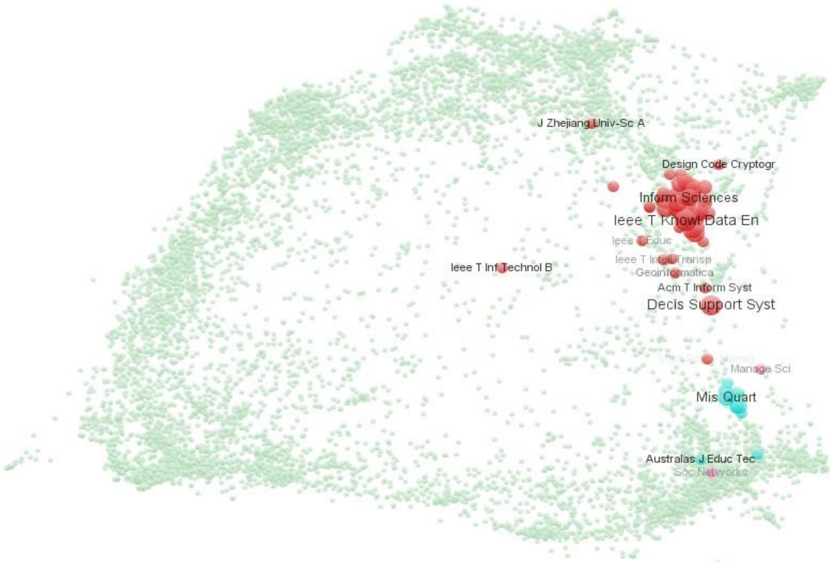

Figure 5: Journal distribution of publications of iSchool at Singapore Management University

Table 8: Top 10 journals publishing most papers of iSchool at Singapore Management University (P indicates the number of publications)

Rank	Journal name	Web of Science Category	P
1	IEEE Transactions on Knowledge and Data Engineering	Computer Science, Artificial Intelligence; Computer Science, Information Systems; Engineering, Electrical & Electronic (SCI)	12
2	Decision Support Systems	Computer Science, Artificial Intelligence; Computer Science, Information Systems; Operations Research & Management Science (SCI)	9
3	VLDB Journal	Computer Science, Hardware & Architecture; Computer Science, Information Systems (SCI)	5
4	Information Sciences	Computer Science, Information Systems (SCI)	4
5	Journal of Computer Science And Technology	Computer Science, Hardware & Architecture; Computer Science, Software Engineering (SCI)	4
6	Knowledge and Information Systems	Computer Science, Artificial Intelligence; Computer Science, Information Systems (SCI)	4
7	MIS Quarterly	Information Science & Library Science; Management (SSCI) Computer Science, Information Systems (SCI)	4

8	IEEE Transactions on Dependable and Secure Computing	Computer Science, Hardware & Architecture; Computer Science, Software Engineering ; Computer Science, Information Systems (SCI)	3
9	IEEE Transactions on Information Forensics and Security	Computer Science, Theory & Methods; Engineering, Electrical & Electronic (SCI)	3
10	IEEE Transactions on Mobile Computing	Computer Science, Information Systems; Telecommunications (SCI)	3

DISCUSSION

Wiggins and Sawyer (2012) had applied the information entropy measure to the percentage of faculty with degrees in each disciplinary area. The result was normalized to a *z*-score which indicated interdisciplinarity. To compare the results of our study with Wiggins and Sawyer's, we listed the interdisciplinarity (Rao-Stirling) score of the same iSchools as Wiggins and Sawyer's sample (Table 9). The School of Library and Information Science and the School of Informatics at Indiana University are measured separately to synchronize with previous research.

Table 9: Interdisciplinarity, measured with two different methods

School	Entropy (z-score)	Rao-Stirling
Florida State University	1.23	0.0358
Drexel University	1.13	0.2002
University of Michigan	1.00	0.2101
University of Washington	0.86	0.1912
Pennsylvania State University	0.84	0.1594
Syracuse University	0.54	0.0828
Indiana University, SLIS	0.48	0.1178
University of Maryland	0.47	0.1915
University of Toronto	0.47	0.1164
University of Pittsburgh	0.42	0.1705
University of Texas, Austin	0.36	0.0725
Rutgers, The State University of New Jersey	0.30	0.1074
University of Illinois	0.10	0.1378
University of California, Berkeley	0.01	0.1697
University of California, Los Angeles	−0.12	0.1083
University of North Carolina	−0.67	0.1243
Indiana University, Informatics	−0.70	0.2425
Carnegie Mellon University	−0.90	0.1247
Singapore Management University	−1.91	0.081
Georgia Institute of Technology	−1.95	0.1578
University of California, Irvine	−2.02	0.2425

As shown in Table 10, there is no significant correlation between Entropy and Rao-Stirling interdisciplinarity, suggesting that the measure of interdisciplinarity by doctoral degrees of the faculty at iSchools is different compared to the measure of interdisciplinarity by the number of papers published by individuals of the iSchools. As we know, the doctoral degree subject areas represent the academic training. Publications, however, may represent the current research areas. Furthermore, this could also be because Rao-Stirling interdisciplinarity involved all the people at iSchools, and the Entropy interdisciplinarity only involved current full-time professional faculty members at iSchools.

Table 10: Correlations between two different measurements of interdisciplinarity (Spearman's rho)

		Entropy (z-score)	Rao-Stirling
Entropy (z-score)	Correlation Coefficient	1.000	-.035
	Sig. (2-tailed)	.	.880
	N	21	21
Rao-Stirling	Correlation Coefficient	-.035	1.000
	Sig. (2-tailed)	.880	.
	N	21	21

CONCLUSION AND FUTURE WORK

From a macroscopic perspective, iSchools can be seen as interdisciplinary environments, not only because they are home of academics from multiple disciplinary backgrounds, but also because the research productivity distributes over journals and disciplines. LIS-related journals are still the first choice to publish articles, but there are also a large number of papers appearing in the journals classified to computer science, communication, medical, biology, and chemical sciences, which indicates the interdisciplinarity of iSchools.

There are moderate correlations between the interdisciplinarity and both the number of publications and the number of journals. However, it is not true to say all the iSchools with large number of publications have acted as highly interdisciplinary. Some iSchools such as Georgia Institute of Technology, Singapore Management University and UCLA are more “focused” on the major discipline, although they also published a large number of papers. This result confirms that each individual iSchool has its own strengths and specializations. The ‘i’ in ‘iSchools’ as a whole can be interpreted as either ‘information’ or ‘interdisciplinary’, but the ‘I’ in the individual ‘iSchool’ can only be interpreted as ‘information’ in many cases.

The results also show some differences compared to earlier research about iSchools’ interdisciplinarity (Wiggins and Sawyer 2012), possibly due to different indicators or as a result of the change over time of the iSchools faculty members’ research interest.

This study’s primary contribution is an empirical description of the interdisciplinarity and visualization of the journal distribution of the iSchools. In doing so we use publications as indicators of disciplinary diversity. Many other aspects, such as education and research projects, should also be integrated into future investigation. In addition, as a new phenomenon, much work remains to be documented to better understand the shared fundamental interest and individual specializations. Lastly, the data and findings reported here reflect only a brief history of the development of the iSchool community. Considering the value of longitudinal insight, it would seem interesting to continue investigating the community composition to support analysis of the change over time.

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APPENDIX A

List of iSchools[1]

No.	University	iSchool	Country
1	Carnegie Mellon University	School of Information Systems and Management, Heinz College	USA
2	Charles Sturt University	School of Information Studies	Australia
3	Drexel University	College of Computing & Informatics	USA
4	Florida State University	College of Communication and Information	USA
5	Georgia Institute of Technology	College of Computing	USA
6	Humboldt University of Berlin	Berlin School of Library and Information Science	Germany
7	Indiana University	School of Informatics and Computing	USA
8	Michigan State University	Department of Media and Information	USA
9	Nanjing University	School of Information Management	China
10	Northumbria University	Department of Mathematics and Information Sciences	UK
11	NOVA University of Lisbon	Information Management School	Portugal
12	Open University of Catalonia	Information and Communications Science Studies	Spain
13	Pennsylvania State University	College of Information Sciences and Technology	USA
14	Polytechnic University of Valencia	School of Informatics	Spain
15	Rutgers, The State University of New Jersey	School of Communication and Information	USA
16	Singapore Management University	School of Information Systems	Singapore
17	Syracuse University	School of Information Studies	USA
18	Télécom Bretagne	Department of Logic Uses, Social Sciences and Information	France
19	University College Dublin	School of Information and Library Studies	Ireland
20	University College London	Department of Information Studies	UK
21	University of Amsterdam	Graduate School of Humanities, Archives and Information Studies	Netherlands
22	University of Boras	The Swedish School of Library and Information Science	Sweden
23	University of British Columbia	School of Library, Archival and Information Studies	Canada
24	University of California, Berkeley	School of Information	USA
25	University of California, Irvine	The Donald Bren School of Information and Computer Sciences	USA
26	University of California, Los Angeles	Graduate School of Education and Information Studies	USA
27	University of Copenhagen	Royal School of Library and Information Science	Denmark
28	University of Glasgow	Humanities Advanced Technology and Information Institute	UK
29	University of Illinois	Graduate School of Library and Information Science	USA
30	University of Kentucky	College of Communication and Information	USA
31	University of Maryland	College of Information Studies	USA
32	University of Maryland, Baltimore County	Department of Information Systems	USA

[1]The data was retrieved in October 2013

33	University of Melbourne	Melbourne School of Information	Australia
34	University of Michigan	School of Information	USA
35	University of Missouri	School of Information Science and Learning Technologies	USA
36	University of North Carolina	School of Information and Library Science	USA
37	University of North Texas	College of Information	USA
38	University of Pittsburgh	School of Information Sciences	USA
39	University of Porto	Faculty of Engineering in cooperation with the Faculty of Arts	Portugal
40	University of Sheffield	Information School	UK
41	University of Siegen	School of Media and Information (iSchool)	Germany
42	University of South Australia	School of Information Technology and Mathematical Sciences	Australia
43	University of Strathclyde	Department of Computer and Information Science	UK
44	University of Tampere	School of Information Sciences	Finland
45	University of Tennessee, Knoxville	School of Information Sciences	USA
46	University of Texas, Austin	School of Information	USA
47	University of Toronto	Faculty of Information	Canada
48	University of Tsukuba	Graduate School of Library, Information and Media Studies	Japan
49	University of Washington	Information School	USA
50	University of Wisconsin, Madison	School of Library and Information Studies	USA
51	University of Wisconsin, Milwaukee	School of Information Studies	USA
52	Wuhan University	School of Information Management	China