Academic Research in iSchools: State and Implications

Dan Wu[1], Daqing He[2], Jiepu Jiang[2], Wuyi Dong[1], Kim Thien Vo[2]

[1] School of Information Management
Wuhan University
Wuhan, China 430072
{woodan, dongwy}@whu.edu.cn

[2] School of Information Sciences
University of Pittsburgh
Pittsburgh, USA 15260
{dah44, jij29, ktv2}@pitt.edu

ABSTRACT
As the information field rapidly evolves, so do the academic research programs in Information Schools (iSchools). In this paper, we examine the current academic research state of iSchools through quantitative study of publically-available online data related to the educational background, research interests, publications, research funding, and collaborations. Some important findings in our study include that iSchools are appropriate institutions for integrating researchers from diverse disciplines; the intersection of information, technology, and users has been established as the core research focus of iSchools; iSchools are developing ways to understand, integrate, and model the interaction among related disciplines; iSchools are attracting external support from a diverse group of funding agencies; and iSchools have forged strong connections and collaborations in order to build one discipline.

Categories and Subject Descriptors
K.3.2 [**Computer and Information Science Education**]: Self-assessment

General Terms
Measurement, Human Factors, Performance

Keywords
iSchools, Academic Research, Interdisciplinary

1. INTRODUCTION
With the fast pace of development in information and Web technologies, the information field is rapidly evolving. Librarians and libraries were traditionally viewed as the major forces and places for providing professional information services. However, the study of information is now widely regarded as interdisciplinary; although library science and computer science continue to be the core disciplines of iSchools, other fields such as education, psychology, business, management, medical and health related domains all have an increasing influence. It was under these circumstances that the iSchools organization was established in 2005. The creation of iSchools drew great interest and memberships from traditional library and information science (LIS) schools, computer and information science schools, and a number of business and management schools.

During their studies on the future of LIS schools, Van House and Sutton [6] recommended that LIS schools should change their focus at the institutional level, should be more information-centered, and should focus on specialization and hybridization. This is reflected in the vision of iSchools. From the very beginning, iSchools (as stated on the homepage), focused on "the intersection of information, technology, and people, which requires a broad interdisciplinary approach to those phenomena, the relationship between them, and their relationships to other aspects of culture and human endeavor." Over the past five years, iSchools have been deepening some of their traditional strengths, expanding into new research directions, and reshaping obsolete areas. Overall, iSchools are on the fast track to changing, defining, and redefining themselves.

In this paper, we report on a study examining the state of academic research at iSchools over the past five years. Specifically, our examination of iSchools' academic research status includes aspects such as educational background of iSchool faculty, research interests, research projects, publications, research funding agencies, and collaborations. The goal of the study was to create a snapshot of research at the iSchools' over the past five years, and to reflect on the formation of iSchools identity, the connections among iSchools and beyond, and the emerging research areas and directions. Our study was mainly quantitative, and concentrated on using publicly-available online resources.

The remainder of the paper is organized as follows. We will first review the related work on iSchools research in Section 2; then discuss our research methods, topics and the corresponding experiment settings in Section 3. In Section 4, we will present data analysis and discussions. Finally, in Section 5, we conclude with our projections regarding academic research within iSchools.

2. RELATED WORK
Since the formation of the iSchool Caucus, the identity and mission of iSchools have been the central point of discussion. It became a consensus within iSchools that only a solid interdisciplinary approach would make the iSchools movement successful. Fonseca *et al.* [4] pointed out that iSchools should develop information science as a sustainability science by staying at the intersection of more traditional research areas as well as by developing ways to understand, integrate, and model the interaction between nature and society. They also opted to use a philosophical point of view to understand the implications of

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combining society and nature in a single model for iSchools. Day and Ma [3] employed a philosophical-historical approach toward understanding Library and Information Science (LIS) as both a social and a technological science. Wiggins [7] proposed an empirical study of the interdisciplinary diversity in iSchools with the expectation of providing insights into the relationship between the interdisciplinarity of intellectual inputs and scholarly outputs in iSchools. Wiggins *et al.* [8] examined a hiring network for iSchools and found that the perception of prestige among iSchools, as represented by the *US News & World Report* (USNWR) graduate school ratings, may be improved by strengthening connections within iSchools and increasing the diversity of sources for new faculty. They also explored the relationship between peer prestige and community identity by comparing hiring networks for iSchools to the academic hiring network for the more established computer science discipline.

As a developing community, it is necessary to analyze iSchools in terms of scholarly communications and emerging (as well as established) specialties associated with individual iSchools. Chen [2] used author-concept maps to depict published topics by iSchools authors, and used citation maps to reveal the highly-regarded publications from faculty in iSchools. Karunakaran *et al.* [5] analyzed the co-authorship network within iSchools by grouping the faculty members into different clusters according to parameters such as the educational backgrounds, affiliations with research centers/labs, and h-indices. Based on this classification, they tried to understand the relationship among social identity, group affiliation and academic collaborations. Bar-Ilan [1] also studied iSchool publications which were indexed by Web of Science under the information science and library science categories between 2000 and 2009.

However, the aforementioned works are either limited to theoretical discussions or citation analysis. Our study is different because we work on a variety of data and aim to establish a comprehensive picture of research in iSchools.

3. METHODOLOGY

3.1 Research Method and Data Set

Our study relied mainly on public data available from two sources. The first one included iSchool Web pages, which contain the research interests, publications, projects and other related information about the faculty. We also visited faculty members' personal homepages, when available. The second source was the Thompson ISI Web of Science collection, in which we searched the SCI and SSCI databases to look for journal publications by iSchool faculty between 2005 and 2009. We acknowledge that this data collection method may suffer from missing data as there is no guarantee for data completeness. Quantitative analysis was used on the data collected.

3.2 iSchools Categories

As of July 2010, the iSchools has 27 members. Based on their history, their major research focus and directions, we classified iSchools into three categories: library and information science (LIS), computer science (CS), and business and management (BM). As shown in Table 1, 19 iSchools belong to the LIS category, in which 14 are American schools and one is a Canadian school. All of these 15 iSchools are accredited by the American Library Association. The remaining iSchools in the LIS category are top LIS schools in China, Germany, Denmark and United Kingdom. Numbers 20 to 23 are four iSchools which belong to the CS category, all of which have strong computer science programs. The last four iSchools are those which mainly focus on business and management.

Table 1. iSchools Categories

No.	School	Category
1	University of California, Los Angeles	Library and Information Science
2	Drexel University	
3	Florida State University	
4	University of Illinois	
5	Indiana University (School of Library and Information Science)	
6	University of Maryland	
7	University of Michigan	
8	University of North Carolina	
9	University of North Texas	
10	University of Pittsburgh	
11	Rutgers, the State University of New Jersey	
12	Syracuse University	
13	University of Texas, Austin	
14	University of Washington	
15	University of Toronto (Canada)	
16	Wuhan University (China)	
17	Humboldt-Universität zu Berlin (Germany)	
18	Royal School of Library and Information Science (Denmark)	
19	University of Sheffield (UK)	
20	University of California, Irvine	Computer Science
21	Georgia Institute of Technology	
22	Indiana University (School of Informatics and Computing)	
23	The Pennsylvania State University	
24	Carnegie Mellon University	Business and Management
25	University of California, Berkeley	
26	University of Maryland, Baltimore County	
27	Singapore Management University (Singapore)	

3.3 Research Questions

In order to meet the goal of determining the state of research in iSchools, we developed three research questions:

(1) What is iSchools research state in terms of educational background of the faculty, research interests, research projects, publications, research funding agencies, and collaborations, respectively?

(2) Are some aspects of the research state influenced by iSchools categories?

(3) Based on the analysis of iSchool research, what insights can be gleaned about the future of iSchools?

4. DATA ANALYSIS AND DISCUSSIONS

Due to language difficulties, we could not find adequate faculty information for the Royal School of Library and Information Science, Denmark and Humboldt-Universität zu Berlin. Therefore, the data analysis below only examines the remaining 25 iSchools.

4.1 Research Interests

Our study of iSchools' research interests concentrated on the educational background of faculty and their research interests. We believe that this would reveal to us the diversity and focuses of research topics at iSchools.

4.1.1 Faculty Backgrounds

As stated, information about the faculty's educational background was collected from their homepages and CVs. To aggregate among different domains, we identified 13 categories to cover the possible interdisciplinary educational backgrounds. Table 2 shows that iSchools, indeed, are interdisciplinary institutions. Many faculty join iSchools with backgrounds in computer science, business, engineering, or education.

When looking at all 25 iSchools, which are shown in the far right-hand column of Table 2, the number of faculty with a computer science degree are equal to those with LIS degree. In total, degrees in Computer Science account for 57% of faculty degrees in iSchools. It seems that these two disciplines are still the leading suppliers of faculty in iSchools. The remaining top disciplines are business and management, engineering, education, and art and humanities.

However, among the 19 LIS iSchools, LIS degrees are clearly the dominant degrees (42%) earned by faculty, whereas computer science is the distant second (13%). Education (9%), and art and humanities (7%) are even less represented among the faculty. As for CS iSchools, the majority have computer science backgrounds (59%). Then, the other disciplines represented are mathematics and physics, engineering, psychology, business and economic and library and information science. Inside BM iSchools, computer science (48%) is again predominant; then, business and economics (25%), and engineering (13%).

Overall, although LIS and CS are the two major disciplines from which iSchool faculty come, iSchools in different categories all have their own unique educational background distribution.

4.1.2 Research Focuses

We identified a total 46 different areas to capture the research focuses of iSchool faculty. Because of space limitations, only the top 10 research areas for each iSchool category – as well as for the group as a whole -- are shown in Table 3. When considering all iSchools, "human computer interaction and human centered design" is the most mentioned research area. This can be seen as a commitment to exploring and understanding the role of information in human endeavors. "Information theory, culture, reading, information literacy," which is a traditional social science area of iSchools, is in second place. Then the third most popular, "social Web, collaborative work," is an emerging area related to Web 2.0.

Within LIS iSchools, "education theory and practice, LIS education" is the most popular topic. However, we do acknowledge that this might be influenced by the fact that we did not know how to further categorize the research areas for the iSchools at University of California Los Angeles and University of North Texas, which both have strong education departments as well as LIS departments. "Information theory, culture, reading, information literacy" is in second place, which is followed by core LIS research focuses such as "library management, information resource management, organizational management" and "information retrieval".

Within CS iSchools, "intelligent systems, adaptive systems, user modeling, decision support system, neural network" is the most noted subject area, with "HCI, human centered design" as the next. Since both topics are related to users, it shows that CS iSchools are different when compared to more traditional computer science schools, which would have more systems-related topics for research. Business iSchools list the most popular topics as "e-commence", "HCI, human centered design" and "social Web, collaborative work".

These results confirm that iSchool research topics are indeed focused on the relationship between information, people and technology. Researchers in iSchools are interested in all forms of information required for advancing science, business, education, and culture. This includes understanding the uses of information and the users of information, as well as information technologies and their applications.

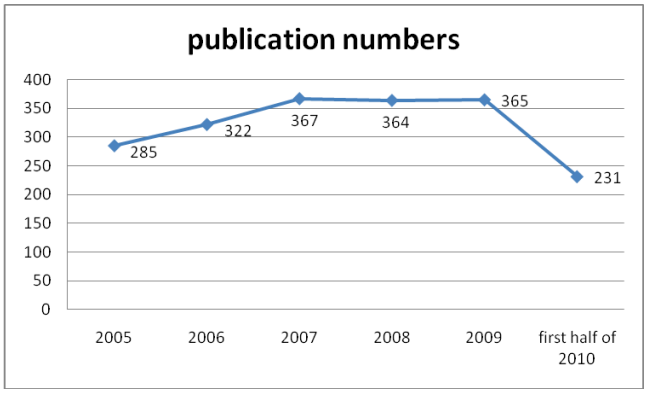

Figure 1. Numbers of publications by year

4.2 Research Productivity

4.2.1 Numbers of Journal Publications

We believe that research papers published in top-quality journals (such as those indexed by SCI and SSCI of Thompson ISI) are an important factor reflecting research productivity. As shown in Figure 1, there is a clear increase in the number of research papers published from 2005 to 2007, and then the number is relatively stable around 365 per year for the next three years. Although the number for 2010 is incomplete, that number is already over 231. It

is interesting to see that this time frame coincides with the establishment of the iSchool Caucus.

4.2.2 Top Journals

We then calculated the journal publication venues for iSchools faculty members. Again, these are all top-quality journals indexed by SCI and SSCI. As shown in Table 4, the journal most frequently published in by iSchool faculty is the *Journal of the American Society for Information Science and Technology* (JASIST), with *Library and Information Science Research* and *Information Processing and Management* being in the 2nd and 3rd places. Among the top 20 ranked journals, 9 of them are clearly related to library and information science, 6 are related to computer science. This shows that iSchools researchers mainly publish papers in journals which focus on these two areas.

Table 4. Top 20 Source Journals

Journal Name	Fre.
Journal of The American Society for Information Science And Technology	140
Library & Information Science Research	49
Information Processing & Management	46
Communications of The ACM	37
Library Trends	34
Library Quarterly	28
Journal of Documentation	26
Journal of Chemical Information and Modeling	24
IEEE Transactions on Knowledge and Data Engineering	23
Government Information Quarterly	21
Concurrency and Computation-Practice & Experience	20
Computer	19
IEEE Transactions on Visualization and Computer Graphics	19
Journal of Information Science	19
IEEE Security & Privacy	18
Information Research-An International Electronic Journal	18
Proceedings of the National Academy of Sciences	17
Decision Support Systems	17
Scientometrics	17
Bioinformatics	17

4.2.3 Journal Categories

SCI and SSCI databases provide category information for each journal, and a journal can be classified into multiple categories. As shown in Table 5, it is not surprising that the most frequent category identifying iSchool research is "information science and library science", but there are many other categories as well. This confirms again that iSchools are conducting research in a variety of areas. Another interesting observation is that iSchools researchers also work in multiple subcategories of computer science. In fact, combining all of the computer science subcategories would generate the category with the highest number of iSchools journal papers (total 457). This confirms that most iSchools research is related to information science & library science and computer science.

Table 5. Top 20 Source Journal Categories

Journal Category	Freq.
information science & library science	308
science	292
engineering	129
computer science, theory & methods	127
computer science, software engineering	106
telecommunications	90
information systems	85
communication	80
computer science, information systems	72
engineering, electrical & electronic	69
management	59
electronic	58
computer science, cybernetics	55
computer science, interdisciplinary applications	53
methods	52
operations research & management science	49
computer science, artificial intelligence	44
ergonomics	40
physics, atomic, molecular & chemical	34
mathematics, applied	29
medical informatics	29
multidisciplinary sciences	29

4.2.4 Paper Keywords Frequency

SCI and SSCI databases store the keywords assigned by the authors to each paper. Using these keywords, we can see which research topics have been studied most often by iSchool researchers. Table 6 shows a very diverse range of research topics. For example, the top 50 keywords not only cover a very wide range of topics, but their frequency counts are relatively low considering that they are generated from approximately 2000 articles. "Information retrieval", "algorithms", "knowledge management" and "human-computer interaction" are traditional LIS and CS topics, but we do see "security", "privacy" and "social networks" becoming very popular as well.

4.3 Research Funding

iSchools are attracting diverse external funding to incentivize faculty and to create signature areas of research to attract more funding. To achieve such a goal, the faculty and administration have to carefully consider the long-term interests of the federal agencies, emerging research directions, and the needs expressed by industry. Here, we collected data on funded projects from 2005

to 2010, and divided the 25 iSchools into 21 US schools, and 4 schools from China, Canada, Singapore and UK.

Table 6. Top 50 Paper Keywords

Keywords	Freq.	Keywords	Freq.
performance	27	information visualization	8
design	27	game theory	8
information retrieval	25	digital libraries	8
security	24	worldwide web	8
privacy	24	human factors	8
algorithms	24	citation analysis	8
internet	19	spatial databases	8
knowledge management	14	e-government	8
human-computer interaction	13	bibliometrics	7
query processing	13	access control	7
web services	13	algorithm	7
social networks	13	networks	7
experimentation	13	children	7
theory	12	search engines	7
evaluation	12	semantic web	7
measurement	11	technology	7
data mining	11	qualitative research	7
visualization	10	distributed systems	7
languages	10	china	7
markov chain monte carlo	10	peer-to-peer networks	7
collaboration	10	human-robot interaction	7
grid computing	9	digital divide	7
ontology	9	information management	7
authentication	9	trust	6
information technology	9	ethnography	6

As illustrated in Figure 2, we classified the US funding agencies into federal funding agencies, state funding agencies, non-governmental organizations (NGO), individual companies, and organizations outside of the US. It is no surprise that funding from federal agencies is the primary source (604 projects), with private companies at a distant second, and NGO in third. Funding from states and outside of US is relatively small.

Table 7 shows the top agencies in each category. NSF is the agency that supports the greatest number of research projects. IMLS and NIH/NLM are in second and third places in terms of the number of projects. There are many federal agencies related to military/defense and medical/health. In total, 54 non-governmental organizations appeared in our results, among which the top six are from well-known foundations and LIS associations. There are also 35 individual companies supporting iSchools research. Most of them are big IT companies such as Microsoft, IBM, Google, Intel, HP, etc. US iSchools have also been successful in attracting foreign funding. There are a total of 22 projects supported by foreign funding, a much higher number than the state supported projects.

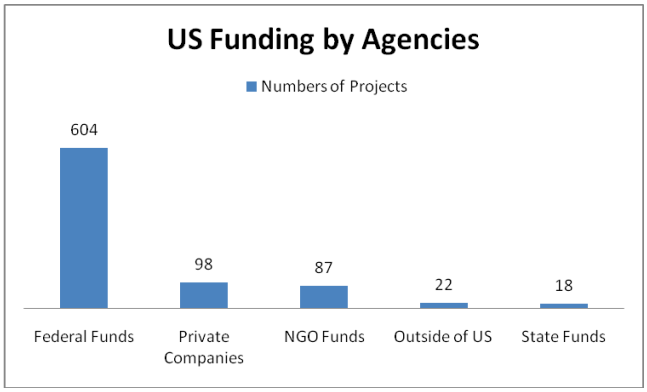

Figure 2. US Funding by Agencies

With regard to the four iSchools from China, Canada, Singapore and UK, they all have their own research support. Wuhan University hosted approximately 150 funded projects over the past five years. One third of them are funded by the National Natural Science Foundation of China (NSFC) and National Social Science Foundation(China); another third is from the Ministry of Education, and the rest is from other national departments, provincial governments, and enterprises. In Canada, Toronto University received a majority of research funds from Social Sciences and Humanities, Research Council of Canada, and several US foundations such as IMLS and ALISE. Singapore Management University has 13 projects funded by the Singapore government, and the rest are funded by private companies such as Microsoft, IBM, and Nokia. In the UK, Sheffield University receives most of its funding from UK organizations as HEA, AHRC, AHB, MLA, etc.

4.4 Research Collaboration

The fourth aspect of research we examined was the collaboration among iSchools. Specifically, we looked at the collaborative relationships expressed as co-author relationships in publications and Co-PI relationships in research projects.

Figure 3 shows that all of the iSchools are connected via co-author relationships, which indicates that there are strong collaborative ties between the iSchools. In addition, some iSchools establish stronger connections, such as between University of Maryland and Florida State University, and between Syracuse University and Penn State University, etc.

Figure 4 visualizes research collaboration by looking at the Co-PI relationship in research projects. This diagram again shows that there are strong collaborations among iSchools; however, because less data are available for analysis, it appears that some of the iSchools are isolated.

Table 7. Major US Funding Agencies

	Funding Agency	No.
Federal Funding Agency	NSF	369
	IMLS	62
	NIH/NLM	61
	Department of Education	13
	Department of Homeland Security	11
	DARPA	8
	Library of Congress	7
	NASA	6
	Department of Defense	6
	National Cancer Institute	6
State Funding Agency	North Carolina Office of the President Grant	2
	Maryland State Board of Election	2
	PA Department of Education, school libraries	2
NGO	MacArthur Foundation	11
	Andrew W. Mellon Foundation	6
	OCLC	5
	ALA	4
	The Bill & Melinda Gates Foundation	3
	Media Democracy Fund	3
Private Company	Microsoft	16
	IBM	15
	Google	11
	Intel	9
	HP	5
	Nokia	5
Outside of US		22

5. CONCLUSIONS

In this paper, we presented a study of academic research in iSchools by examining publically-available online data. Through this study, we summarize the current research state of iSchools as: 1) reflected by faculty's educational backgrounds, iSchools are the appropriate institutions for integrating researchers from diverse disciplines; 2) revealed by faculty's research interests, information, technology, and users have been established as the core research focus of iSchools; 3) based on journal category and keywords, iSchools are developing ways to understand, integrate, and model the interaction among related disciplines; 4) *JASIST* seems to be a core journal for iSchools researchers; 5) iSchools are attracting diverse external funding; however, federal agencies are still playing the major funding role; and 6) although iSchools can be classified into three categories based on the history and specific research fields, they have crafted strong connections and collaborations to build one discipline. Thus, we anticipate that, although the challenges and opportunities for each iSchool will be increasingly diverse and different, the core focus of iSchools as the whole will still be the relationship among information, technology and user. This helps to define the identity of our profession.

One future work will include more consideration of the high quality conferences, especially for those areas that are related to HCI, CSCW, ICSE. Another direction is to conduct more citation analysis on the publications, and more detailed examination of the collaboration not only within iSchools, but also outside of the iSchools.

6. ACKNOWLEDGMENTS

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Table 2. iSchools Faculty Backgrounds

Library and Information Science iSchools (17)		Computer Science iSchools (4)		Business iSchools (4)		Overall iSchools (25)	
Background	**No.**	**Background**	**No.**	**Background**	**No.**	**Background**	**No.**
library and information science	223	computer science	129	computer science	33	computer science	232
computer science	70	mathematics and physics	22	business and economics	17	library and information science	231
education	49	engineering	20	engineering	9	business and economics	58
art and humanities	36	psychology	8	psychology	2	Engineering	55
business and economics	33	business and economics	8	other science	2	education	51
engineering	26	art and humanities	8	law	2	art and humanities	45
communication	26	library and information science	7	library and information science	1	psychology	31
psychology	21	medical and public health	4	social science	1	mathematics and physics	30
social science	15	other science	4	medical and public health	1	communication	28
mathematics and physics	8	social science	3	art and humanities	1	social science	19
other science	8	law	3	education	0	other science	14
law	7	education	2	mathematics and physics	0	law	12
medical and public health	4	communication	2	communication	0	medical and public health	9

Table 3. Top 10 iSchools Faculty Research Focuses

R	Library and Information Science iSchools (17)		Computer Science iSchools (4)		Business iSchools (4)		Overall iSchools (25)	
	Research Focuses	**N**	**Research Focuses**	**N**	**Research Focuses**	**N**	**Research Focuses**	**N**
1	education theory and practice, LIS education (in short *Education*)	78	intelligent systems, adaptive systems, user modeling, decision support system, neural network (in short as *Intelligence Related*)	48	e-commence	18	HCI, human centered design	111
2	information theory, culture, reading, information literacy (in short *Information Theory*)	71	HCI, human centered design	45	HCI, human centered design	13	*Information Theory*	90
3	Library & organization management, information resource management, (in short *Library Management*)	65	network technology	42	social Web, CSCW	12	social Web, CSCW	89
4	information retrieval	58	medical informatics	34	*Intelligence Related*	11	*Education*	87
5	social Web, CSCW	54	software engineering	31	security	10	*Intelligence Related*	82

6	HCI, human centered design	53	security	26	software engineering	9	medical informatics	71
7	information organization	48	social Web, CSCW	23	information retrieval	8	information retrieval	70
8	information behavior	46	visualization	18	network technology	7	network technology	68
9	digital library	42	data mining, text mining	17	data mining, text mining	7	*Library Management*	66
10	information policy	38	*Information Theory*	16	database	6	security	52

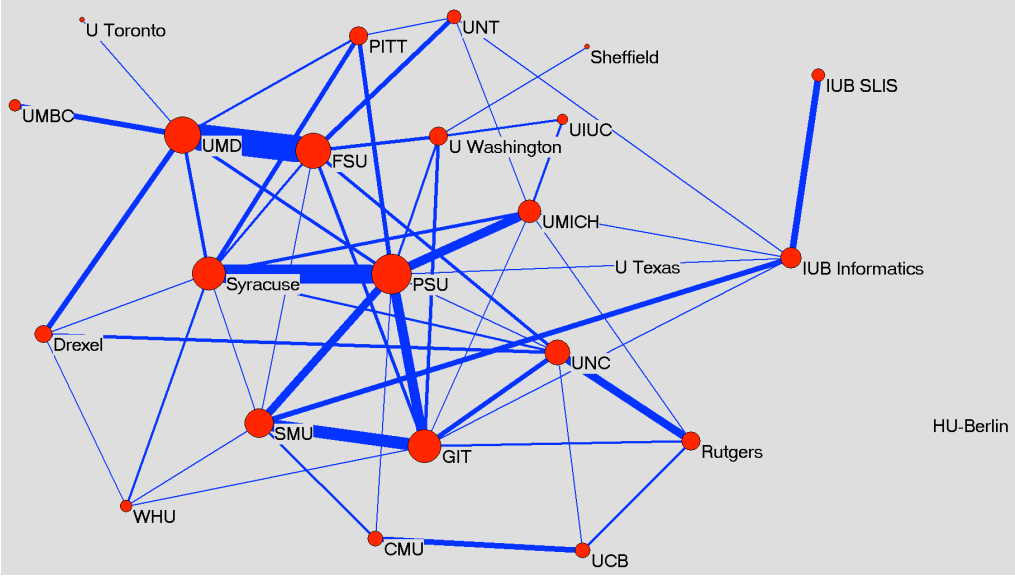

Figure 3. Co-Author of iSchools

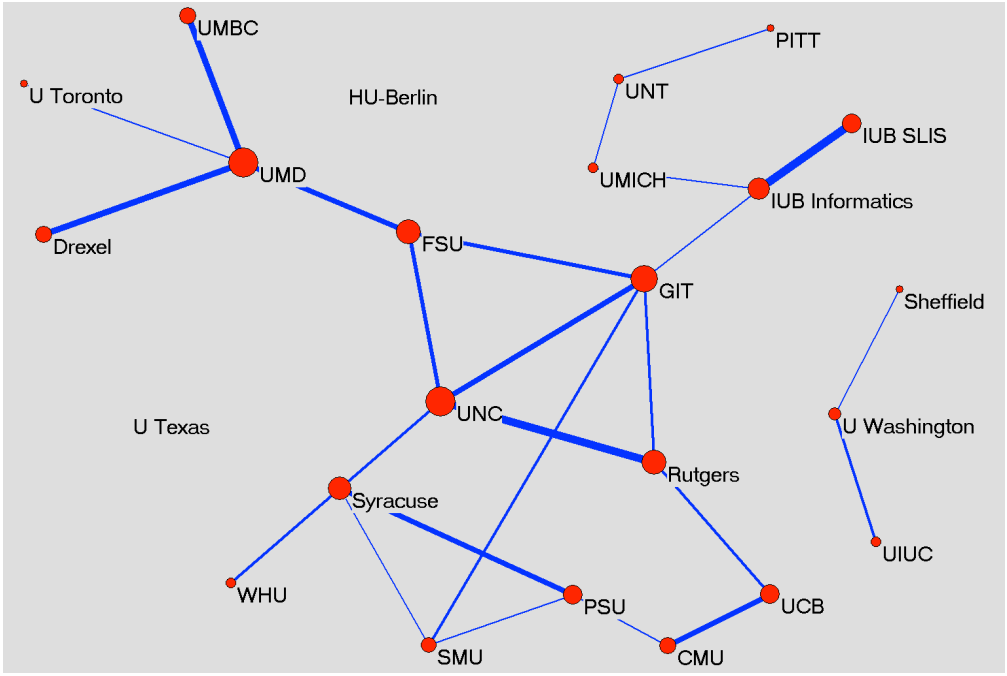

Figure 4. Co-PI of iSchools