Keynote 2

Developments in Education for Information: Will “Data” Trigger the Next Wave of Curriculum Changes in LIS Schools?

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The first university-level library schools were opened during the last quarter of the 19th century. The number of such schools has gradually increased during the first half of the 20th century, especially after the Second World War, both in the USA and elsewhere. As information has gained further importance in scientific endeavors and social life, librarianship became a more interdisciplinary field and library schools were renamed as schools of library and information science/ information studies/ information management/information to better reflect the range of education provided. In this paper, we review the major developments in education for library and information science (LIS) and the impact of these developments on the curricula of LIS schools. We then review the programs and courses introduced by some LIS schools to address the data science and data curation issues. We also discuss some of the factors such as “data deluge” and “big data” that might have forced LIS schools to add such courses to their programs. We conclude by observing that “data” has already triggered some curriculum changes in a number of LIS schools in the USA and elsewhere as “Data Science” is becoming an interdisciplinary research field just as “Information Science” has once been (and still is).

Keywords education for library and information science; curriculum changes; data science; data curation; big data; data deluge

Introduction

Information is the lifeblood of scientific discoveries, economic growth and social development. Concomitant with the emergence of the Internet, the Web and social networks, the amount of information increases geometrically, thereby changing the whole “information ecosystem”. In the past, the scarcity of information was usually the main problem whereas it is now the opposite: the abundance of information and the so called “data deluge” (Hey & Trefethen, 2003) need to be tackled first to carry out not only the mundane tasks but also the scholarly endeavors. The previous estimates of growth of information seem very modest in the age of “big data” (e.g., Lyman & Varian, 2003; Gantz et al., 2008). Recently, it is predicted that the digital universe will grow 50-fold between 2010 and 2020 and reach 40,000 Exabyte (or 40 trillion gigabytes) (Gantz & Reinsel, 2012).

Information is mostly created, stored and communicated in digital environments. For instance, “money” as the basis of the economy is no longer exchanged as a tangible matter (i.e., banknotes) only, but is increasingly being transformed to “bits” that are stored in computers and communicated or exchanged over the networks (Gleick, 2011, pp. 8-9).

Heavy use of information has changed the science paradigms, too. Many scientific disciplines have now become more “data intensive” (Hey, Tansley & Tolle, 2009). Science has been carried out by means of empirical data (experiments), models (theories) and simulation of complex phenomena in the past. Yet, these three methods have been combined nowadays and science is conducted through data exploration. Called “eScience”, the new method is based on processing of data (either gathered by means of scientific tools or created by simulators) through software and the analysis of databases/files by scientists using data analytics and statistical techniques (Gray, 2009, p. xviii).

Initially, “information science” as a discipline functioned as a bridge between mathematics and computer engineering whereas many disciplines such as biology, genetics, physics and economics have taken a genuine interest in information science lately. To some extent, these disciplines are converging to information science. Many such disciplines have either “computational” or “informatics” components as they have to deal with massive data and manage information effectively (e.g., computational neuroscience, computational materials science, bioinformatics, and ecoinformatics). In fact, “scientomics” has been proposed as a new, “genuine informational approach to science” (Del Moral, González, Navarro & Marijuán, 2011, p. 665).

In addition to the “data deluge”, the current information ecosystem offers more challenges. The convergence of memory institutions such as libraries, archives and museums radically changes the data and information management processes. The so-called “digital natives” demand more services available through mobile gadgets rather than through the intermediation of information professionals. They wish to (re-)use data in more creative ways regardless of its origin (e.g., library, archive or museum data).

Needless to say, educated and highly skilled data scientists, data curators, data archivists, information professionals and librarians are needed to tackle these challenges. Therefore, the schools of library and information science/studies revise their curricula so that their graduates will act as “agents for change” (Lyon & Brenner, 2015) to deal with the multitude of data and information management issues using technology.

In this paper, we review the developments that have had an impact on LIS and subsequent LIS curricular changes under three periods. These periods are roughly classified according to the dominant subjects that were taught at LIS schools in the respective time periods. In the first period (1887-1963), the concentration was on “information” and related subjects. In addition to information, “technology” related courses were added to the curricula in the second period (1964-1993). In the last period since 1994, LIS programs complemented the “information” and “technology” related courses with the ones on “people” as they increasingly see the field as a pyramid where information needs of people are satisfied with the help of technology. Finally, we look at the proliferation of “data” related courses in the curricula of LIS schools and speculate if this would trigger a new wave of restructuring the curricula of LIS schools.

A Brief Overview of the Developments in Library and Information Science Education

What follows is a brief overview of the major developments under each period, as indicated above, and their impact on the LIS curricula.

The First Period (1887-1963)

The first period started with the establishment of the first library school in Columbia University by Melvil Dewey in the USA. In parallel with this, the first cataloging and classification systems such as Dewey Decimal Classification (DDC), the Library of Congress Classification (LCC), and the Library of Congress Subject Headings (LCSH) were also developed during the last quarter of the 19th century along with the establishment of the American Library Association (ALA). Education for librarianship was primarily based on apprenticeship in large libraries at the beginning. Then, it was suggested in the first half of the 20th century that library science be taught at professional graduate schools and accredited (Crowbold, 1999). The School of Library Economy at Chicago University, established in 1926, was the first to offer Ph.D. degree in Library Science and it was accepted as a milestone development in the formation of modern librarianship (Bronstein, 2007, p. 60). As information became more important in scientific endeavors as well as in our daily lives, the number of such schools has gradually increased during the first half of the 20th century, especially after the Second World War, both in the USA and elsewhere (Crowbold, 1999).

The curricula of library schools were rather library-centric during the first period of the development of library schools between 1887 and 1963 in the USA. Courses were mainly on information organization (e.g., classification, cataloging and indexing). The use of technology was limited with the use of typewriters (to type catalog cards) and mechanical aids (to copy them). For instance, the School of Library Economy at Chicago University was not interested in technical subjects, technology and design until 1950s (Buckland, 2002).

The Second Period (1964-1993)

The so-called "information explosion" after the Second World War resulted in the proliferation of information sources. Large commercial companies such as IBM and Lockheed started to use computers in indexing and information retrieval performance evaluations (Luhn, 1960; Cleverdon, 1960; Salton, 1971). The MARC (Machine Readable Cataloging) format as an international data exchange standard was developed in 1960s by Henriette D. Avram of the Library of Congress. Computers were used for the first time by libraries in cataloging and indexing of materials as well as in distributing catalog cards through computer tapes. Commercial companies such as Dialog and Orbit offered online access to bibliographic databases of books and journal articles through communication networks in 1970s. Query languages based on Boolean logic were developed to search such databases.

In parallel with these developments, library schools put more emphasis on information and information technologies. New courses on information and communication technologies (ICT), computer programming languages, systems analysis, database management systems, and information retrieval were added to the curricula of library schools (Bronstein, 2007, pp. 64-65). Several models on information seeking, information seeking behaviors and information use (along with their cognitive aspects) have been developed (e.g., Taylor, 1968; Bates, 1979, 1989; Belkin, 1980; Kuhlthau, 1993, p. 45-51; Wilson, 1999). In addition, schools renamed themselves as schools of library and information science or library and information studies (LIS). The library school at Pittsburgh University was the first (1964) to do so, and by the end of 1980s, more than 80% of library schools changed their names (Bronstein, 2007, p. 60). This was the start of the second period of development of library schools.

It should be noted that the term "documentation", introduced and used by the continental European scholars such as Paul Otlet, Henri La Fontaine and Suzanne Briet ("Madame Documentation"), had also been used in the USA in the early years. The American Documentation Institute (ADI) was established in 1935 but changed its name to American Society for Information Science (ASIS) in 1968 when the term "information science" began to be used more often and library schools changed their names accordingly.

Changing the names of library schools matured them in that LIS schools approached libraries with a broader view so as to encompass not only libraries but also all types of archives, databases, and information retrieval systems as well as all information-bearing objects (Buckland, 1986, as cited in Bronstein, 2007, p. 60).

However, "survival" was the first item in the agenda of LIS schools in the United States (US) (Ceppos, 1992; Paris, 1990) during the second period between 1964 and 1993. As the research funds pumped to the universities had dwindled in 1970s and 1980s, a quarter of US LIS schools including the ones at Columbia and Chicago Universities were closed (Crowbold, 1999). Several schools were rather introvert and failed to realize the changing information paradigm and information ecosystem. Librarians and information professionals were no longer the sole custodians, organizers, and managers of information. LIS schools did not collaborate enough and failed to develop timely strategies to adapt to change, circumvent the impact of decreasing resources and competition. Consequently, they were affected by what is called "the Panda Syndrome" (Van House & Sutton, 1996; Sutton, 1999).

The Third Period (1994--)

The pace of scientific and technological developments has increased in 1990s. The introduction of the Internet, World Wide Web and the social media has created unprecedented changes in many scientific fields and professions. LIS and LIS schools are no exception. Libraries are no longer the "first stop" for many users seeking information. Instead, Google became the king of search and retrieval of almost any type of information on the Web. Users demand online and mobile information nowadays. Information seeking and information use models developed during the second period were far from satisfying the needs of "digital natives" who were born after the Internet and brought up with the Web and the social networks. "One size fits all" approach of the second period that aimed to serve all types of users equally well did not work for digital natives as they preferred customized and personalized information sources and services (Tonta, 2003). "If it is not online (or mobile), it doesn't exist!" is their new motto. Moreover, they wish to personalize library-supplied information by tagging, classifying and organizing according to their own systems but still keep that information on library systems and platforms. Libraries are therefore faced with intense competition from other online information providers that can deliver such services.

While the curricula of library schools of the first period concentrated on information and the ones in the second period did on information and technology, the emphasis in the third period has been on the information, people and the technology. Users' ability to interact with information (e.g., sharing, tagging, rating, commenting) became more important than their access to information.

The fast developments in ICT and social networks that are taking place in increasingly short intervals since 1990s shaped not only the way we use information but also the curricula of LIS schools. Some US schools stopped seeking ALA accreditation and devised new curricula to better reflect the impact of technological and societal changes therein. The School of Library and Information Studies at the University of California at Berkeley dropped the "L word" (Library) from its name altogether and was renamed as the School of Information Management and Systems in 1994. The school at the University of Michigan was simply renamed as the School of Information in 1996, which was followed since then by a number of other LIS schools in the USA and elsewhere.

The massive increase in the amount of available information motivated the deans of some LIS schools in the United States to get together regularly and address the educational needs of the information professionals who would face this problem when they join the workforce. The number of deans participating in these discussions has increased over the years and, consequently, the Organization of Information Schools (iSchools) was formed in 2005. iSchools Organization is composed of LIS schools that are committed to doing research on "the relationship between information, technology and people" and "learning and understanding the role of information in human endeavors". The iSchools believe that "expertise in all forms of information is required for progress in science, business, education and culture" and that "[t]his expertise must include understanding of the uses and users of information, as well as information technologies and their applications".1 They aim to "identify, clarify, and speak to the major issues, challenges and driving questions at the nexus of information, technology, and society."2

As of now, there are 65 iSchools in the world and they are based primarily in North America (30) and Europe (21). The rest are based in Asia (10), Australia (3) and Africa (1).3 Some members of iSchools changed their names to simply "Information School" (iSchool) while others continue to keep their original names (e.g., Information Science, Information Studies, Information Systems and Management, and LIS). A few schools of Computer Science and Informatics (along with schools of Mathematics and Information Sciences, Media and Information, Convergence Science and Technology, among others) are also members of iSchools.

That the emphasis in LIS curricula shifted first from librarianship to information science and then to information systems, information technologies and computer science, and that several LIS schools were consequently renamed as iSchools was seen by Cronin (2005) as an "I-dentity crisis" in library and information science. He thinks that as the boundaries of the field of information science expand, there exists a risk that some traditional LIS schools might be overshadowed by the new iSchools. Moreover, he cautions that some strong LIS schools might abandon the center for the periphery as the intellectual focus of the domain of information science shifts (Cronin, 2002, p. 6). Comprehensive studies have yet to be carried out on this subject. However, a co-citation map of "library and information science" and "computer science" shows that there are some topics that are predominantly studied by either LIS researcher (e.g., information behavior) or computer science researchers (e.g., data mining, image processing, artificial intelligence, fuzzy logic, technology acceptance model, organizational technology, and computer-mediated communication) (Yu & Baeg, 2012) (Fig. 1). Yet, researchers in both disciplines study topics such as information retrieval, information systems, social informatics, citation analysis, informetrics and scientometrcis. The so-called emerging "iField" (Information Field) seems to be situated at the intersection of both literatures.

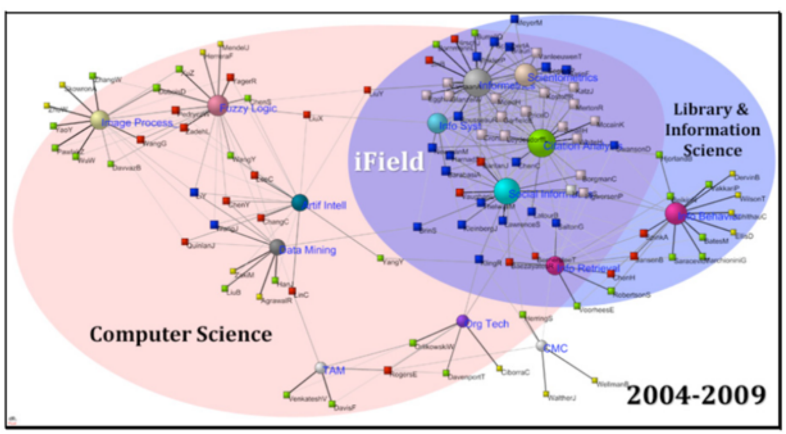

Figure 1. A co-citation map of Library and Information Science and Computer Science (2004-2009). *Source*: Yu and Baeg (2012, p. 549).

A more recent study based on the co-word analysis of more than 6,700 keywords representing self-described research interests of over 1,100 iSchools faculty members provides a more detailed view of the intellectual landscape of the "iField" (Holmberg, Tsou & Sugimoto, 2013). "Human-computer interaction", "information retrieval", "digital libraries", "information technology", "information systems", "data mining", and "social media" are at the top of the most frequently occurring keywords in researchers' profiles (Fig. 2).

"Human-computer interaction" as a research interest takes the central place in the iSchool curriculum model (Seadle & Greifeneder, 2007). Further analysis of the more tightly connected keywords identified seven subfields that represent the core research interests of the iSchools faculty members: computer information (including human-computer interaction and computing information, e.g., informatics); information retrieval and data mining; social media and information systems; education and information technology; information seeking and digital libraries; libraries and library services; and data analytics and computing.

The composition of the iSchools faculty members reflects, to some extent, the interdisciplinarity of the iField. Almost one third (30%) of a total of 769 faculty members working full-time at 21 iSchools in 2009 received their Ph.D. degrees in computer science, 11% in information, 10% in librarianship, 10% in social and behavioral sciences, 9% in management and politics, 9% in science and engineering, 8% in education, 7% in humanities and 5% in communication (Wiggins & Sawyer, 2012). Such a mixture of expertise is needed in iSchools to educate the "blended information professionals" who are skilled and knowledgeable.

Figure 2. Co-word map of the research interests at iSchools.

Source: Holmberg, Tsou and Sugimoto (2013).

What is Next?

We briefly touched upon the exponential growth of information at the beginning of this paper. Recall that by 2020, the digital universe will expand to 40,000 exabytes as the "Internet of Things" will generate exabytes of data each second. For instance, the Square Kilometer Array radio telescope alone, due to be ready by 2020, will produce 700 terabytes of data each second, which "will, after just a few days, eclipse the current size of the Internet" (Mattmann, 2013, p. 474).

In order to conduct "data intensive" science (Hey, Tansley & Tolle, 2009), researchers not only need science and computing skills but also big data handling skills. Big data is defined as "high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of processing that enable enhanced insight, decision-making, and process automation".4 Mattmann (2013, p. 474) thinks that "archives and science-computing facilities must merge" as dealing with big data seems to have created its own field (data science) and new breed of scientists (data scientists). Data science is defined as "*the transformation of data using mathematics and statistics into valuable insights, decisions, and products*" (Foreman, 2014, p. xiv, italics original) and the "data scientist" is considered to be "the sexiest job of the 21st century (Davenport & Patil, 2012). Data scientists will assume stewardship of data and "develop bespoke algorithms for analysis and adapt file formats" (Mattmann, 2013, p. 474).

The distinction between the boundaries of information and data gets blurred and they tend to converge in the big data era. Perry, Roderer and Assar (2005, p. 204) noted that ". . . boundaries are disappearing among the published literature, research data, research databases, and clinical patient data. As research literature increasingly exists alongside repositories of source evidence, large bodies of data can be used to support individual, clinical, or scientific decisions. These datasets may be incorporated and manipulated into knowledge sources through creating application-focused databases."

In addition to data scientists, big data created new professional roles such as data curators, data librarians, data archivists and data journalists to manage this complex information ecosystem (Lyon, 2012). However, there is a big shortage of professionals in the United States with data analytics skills (circa 140,000). About 1.5 million managers and analysts are needed "to analyze big data and make decisions based on their findings". This is the case for the United Kingdom, too, as there is "a severe shortage of UK data talent" (Lyon & Brenner, 2015, p. 113).

The total amount of data in its variant forms can be likened to a pyramid and divided into three tiers (Fig. 3). The top tier (the tip of the iceberg) represents the rather limited data that is contained in published literature whereas the middle tier contains more data that needs to be derived, recombined, analyzed and visualized before it becomes part of the published literature. Furthermore, the bottom tier (the base of the pyramid) has massive amount of raw data that needs computational processing first (Gray, 2009, p. xxviii).

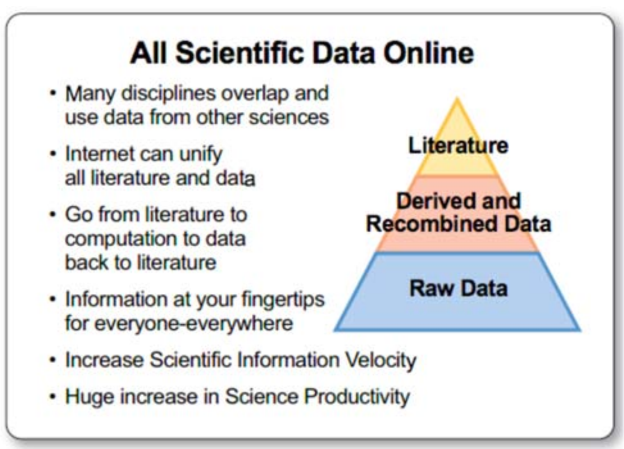

Figure 3. Data pyramid. *Source*: Gray (2009, p. xxvi)

Stewardship of big data is not easy. Data scientists may have science knowledge and computing skills but might lack the knowledge and skills of data curation and management. Studies integrating data curation and cyberinfrastructure into curricula to educate eScience professionals are few (e.g., Kim, Addom & Stanton, 2011). New interdisciplinary courses on big data techniques need to be introduced for computer scientists as well as natural scientists, as University of California at Berkeley and Stanford University did recently (Mattmann, 2013, p. 475).

The opposite is usually the case for information professionals who lack domain knowledge but are more familiar with data curation, organization, maintenance and management techniques. However, the traditional LIS curricula included more courses up until now on the organization and management of printed and online information rather than data. Therefore, current information professionals usually lack needed knowledge and skills to properly deal with the organization and management of data contained in the middle and bottom tiers of the pyramid in Fig. 3.

Information professionals involved in eScience projects have more pressing needs in that they have to deal with capturing, cleansing, processing and management of large amount of unstructured research data. Research data management is seen as a “wicked” problem such as climate change. “A wicked problem . . . is one that is unique and highly complex whose definition itself is disputed by those involved, and whose solution is likely to remain unclear” (Cox, Pinfield & Smith, 2014, p. 2). In addition to the “wicked” problem of research data management, “open data and open science, big data and disciplinary data diversity” are underlined as three key data trends to pay attention to (Lyon & Brenner, 2015, p. 112).

Weber, Palmer and Chao (2012) reviewed the current trends and future directions in data curation research and education. They observed that the lack of consistent vocabulary to describe the data curation functions and activities (e.g., “data science” and “data curation”) restricts effective and productive communication among the various stakeholders. LIS schools are trying to diversify their curricula to adapt to the changing ecosystem by adding more courses on data science, data management and data curation. But few LIS schools offer specific programs on data curation in general5 (Keralis, 2012; Varvel, Bammerlin & Palmer, 2012). Recently, the iSchool of University of California at Berkeley has started a new online masters program in information and data science.6 Data workforce needs based on a limited number of data curation placements in the United States as well as filling the workforce gap in data science and data analytics are reviewed recently (Palmer, Thompson, Baker & Senseney, 2014; Blake, Stanton & Saxenian, 2013).

On the other hand, several LIS schools both in the United States (e.g., North Carolina, Illinois and Michigan) and in the United Kingdom (e.g., Sheffield) have embedded data informatics courses in their curricula (Lyon, 2012). One third of the LIS schools offer courses on data curation (Harris-Pierce & Liu, 2012; Corrall, Kennan & Afzal, 2013). More than half (54%) the courses offered are not data-centric or data inclusive but only provide introduction to important topics (Varvel, Bammerlin & Palmer, 2012). “Only 13 (22%) of LIS programs currently offer a course focused on the management and curation of research data” (Creamer et al., 2012).

Conclusion

It appears that “data” has already triggered some curriculum changes in LIS schools. LIS schools in the United States are in the process of devising new data science and data curation programs and incorporating such new courses into their existing programs to educate the future data workforce so that the big data and research data management issues can be tackled.

Although LIS professionals seem eager to adopt new roles and engage in eScience and research data management, most LIS schools have yet to have specific data curation programs or separate courses solely focused on research data management. More LIS schools will need to adapt their curricula in order to help students and practicing professionals develop the needed competencies in research data curation and management.

It is likely that the number of LIS schools introducing curricular changes to address the data issues will continue to increase. It is hoped that the existing research communities at iSchools interested in information retrieval and data mining, data analytics and computing, and informatics (Holmberg, Tsou & Sugimoto, 2013) will initiate more data science courses and programs dealing with both technical and social aspects of data curation, retrieval, management, and archiving. However, it is too early to say if some iSchools will add the “D” (data) word to their names to reflect the interdisciplinary data science and data curation programs offered.

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