The Evolution of Information Science as a Discipline: How universities dealt with it globally and what Bangladesh can learn

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Abstract

This inquiry identifies the major benchmarks in the advancement of *Information Science* as an organized discipline and how universities across the world historically dealt with it. It also captures how the discipline still continues to change its trajectory in coherence with the dramatic change in the information and communication technologies (ICTs) worldwide with considerable differences in the regional market dynamics of North America, Europe and Asia Pacific regions. By briefly analyzing how Bangladeshi Universities have already been responding to the global trends of this subject, at the end, we provoke discussions around deciding strategic priorities to design more useful and relevant degree programs or courses in the country.

Background

The concept of 'Information' responds to the question of "What an entity is" by defining its essence and characteristics; and 'Information Processing' indicates any identifiable change in information which includes everything, from describing the change of position of a rock to printing digital texts from computers (Luciano Floridi, 2010). Discourses around information and information processing may be divided into two broad categories: a) the critical investigation of the conceptual nature and basic principles of information, and b) the elaboration and application of information theories and computational methodologies (Luciano Floridi, 2010). The first category of discourses contributed to the origin of educational disciplines like Cognitive Science (Learning Psychology, Child Development etc.) and Information Science, while the second category contributed to the origin of Computer Science and Engineering and other IT related disciplines.

In this work, we are particularly concerned with Information Science as an organized educational discipline. There are existing literatures on how Information Science has been historically evolving and experiencing a changing nature as an interdisciplinary subject from its inception (Tefko Saracevic, 1979 and Xue-Shan Yan, 2011). However, literature weakly captures how technological disruption and market needs have influenced the educational institutions to roll out this pedagogical change across the world in different timelines. At the same time, analyzing the current trend of this discipline is also important, since it is highly contributing as a body of knowledge for any country in this digital age (often interchangeably called as information age).

Objective

The objective of this brief research is to:

a) capture how Information Science as an organized discipline has evolved with the changes of information and communication technologies (ICTs),
b) analyze the current global and regional trends of this discipline,
c) identify how newer degree programs like ICT for Development (ICTD) have been emerging and evolving within and outside this particular disciplinary umbrella, and
d) provide a brief situational analysis of how Bangladeshi Universities are responding to the global trends.

Study Methods and Coverage

To understand the history and advancement of Information Science discipline, we have used a university-oriented lens in this work. These are the sequential units that we have observed:

a) University: We have considered those educational institutions which are comprised of several faculties/colleges and offer at least bachelor degrees on diverse subjects.
b) Faculty/College: A Faculty is a certain body in a university that specializes on a several subjects that are closely related to one another. A faculty is usually comprised of several departments or schools. American universities sometimes name this institutional sub-division 'college'. (Faculties are often referred to academics/ professors. In this work we do not use the word in that meaning.)
c) School/Department: A school/ department refers to a sub-organization within a faculty/ college in the university which focuses on a particular field of knowledge. Several departments usually form a school or faculty.
d) Degree Program: Degree programs in a department are integrated courses of study in leading to an academic degree which may or may not require the declaration of a specialization.
e) Streams: Sometimes departments offer group of unique courses under declared (i. e. major/ minor) or undeclared areas of specific interests within a degree program to help students to customize their education. We refer these special interests / areas of degree programs as "streams".

In Cornell University, for example, one of eight *colleges/faculties* is College of Computing and Information Science. This college is home to the three academic *departments*: Computer Science, Information Science, and Statistics and Data Science. The Department of Information Science have several *degree programs* in undergraduate, masters and PhD level. For example, in master's level, the department offers: Master of Professional Studies, MS in Connective Media, and MS in Health Tech degrees. Students of these degree programs can specialize in different *streams*, such as, machine learning, artificial intelligence, human-computer interaction, ubiquitous computing, user-experience design, and tech-law policy.

For this particular work, we have collected data from the websites of 121 Information Science schools across five regions of the world. In North American region, we have considered universities from USA and Canada, and From South American Region, we have considered universities of Colombia and Brazil. In European Region, we have looked at universities from the UK, Germany, France, Denmark, Netherlands, Israel, Sweden, Spain, Switzerland, Portugal, and Finland. From Asia Pacific (Asia and

Australia) Region, we have considered universities from China, Australia, Korea, Japan, Thailand, Taiwan, and Malaysia. All these schools are part of iSchool (Information Science School) consortium.

We present our overall observations in this study in the following four sections: a) Historical Evolution of Information Science, b) Current trends of this discipline, c) Emergence of ICTD, and d) Bangladesh situation analysis.

For the first section, we have analyzed the historical information collected from the university websites from our sample and later sharpened the concepts by reviewing relevant literatures.

For the second section, we have systematically analyzed the faculty orientation of the schools, courses they offer, and the currently focused streams within their curriculums to notice the similarities, as well as important differences or contradictions.

For the third section, beyond the schools of the previous sections, we have analyzed the data collected from the websites of more 28 specialized ICTD graduate programs in different universities across the world.

Finally, for the fourth section, we have considered 15 universities of Bangladesh with a healthy balance of Public - Private and Tech – Non-Tech institutions and looked at the curriculum of 33 different degree programs of different faculties within those universities to search for courses closely related to the current global streams of Information Science.

Section 1: Historical Evolution of Information Science

Different bodies of knowledge have contributed to the emergence of Information Science as an independent discipline. Library/ Archival Science is the major knowledge stream that contributed to the origin of this subject. Later, in different period of time, it interacted and converged with Cognitive Science (Psychology/Education/Language), Communication/Cultural Studies, and Computer Science/ STEM related disciplines. Figure 1 summarizes our observations.

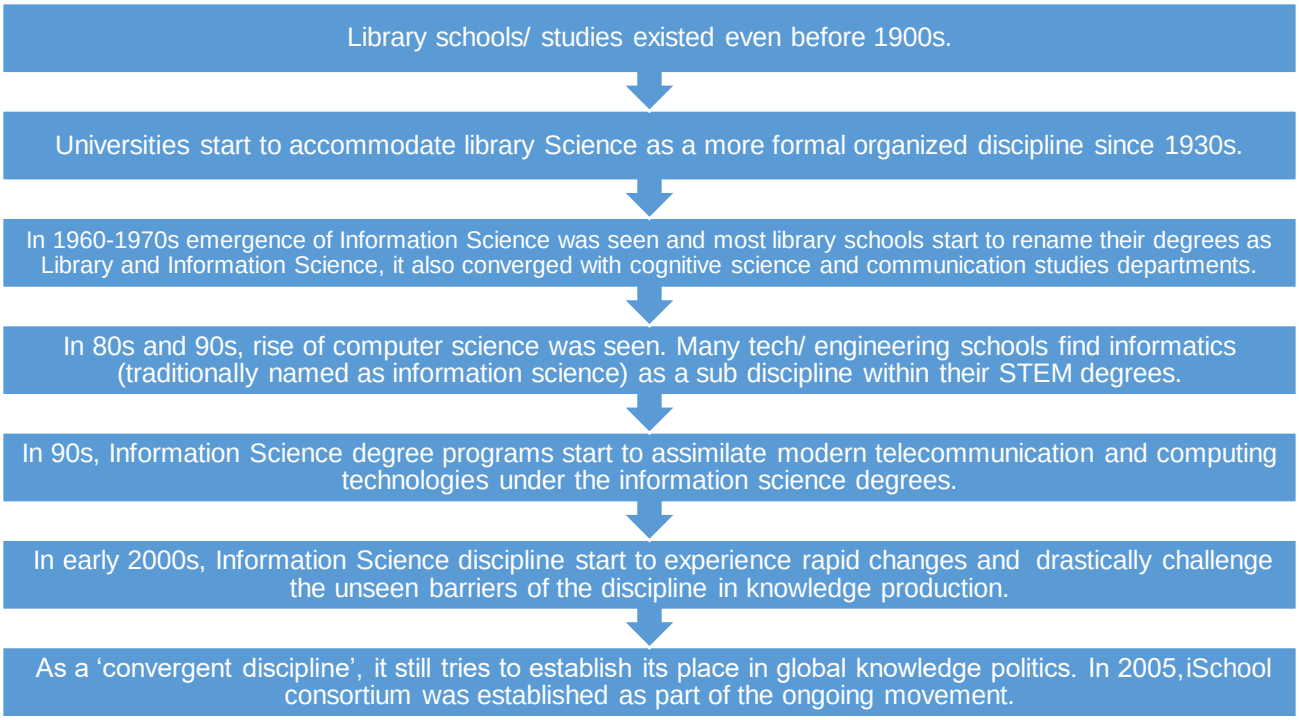

Figure 1: Historical Evolution of Information Science

A Brief History of the Development of ICTs

Usage of ICT can be traced back when humans started to use objects to communicate to exchange information. However, the world has been experiencing a rapid advancement in terms of development of ICTs since 1800s. We try to capture this chronological development of ICTs across the world in four historical periods: a) pre-mechanical period, b) mechanical period, c) electro-mechanical period, and d) electronic period. The following table summarizes the prevalent technologies, their impacts and relevant examples in these periods.

Table 1: Historical development of ICTs

Period	Prevalent Technologies	Impacts	Relevant Examples	References
Pre-mechanical period Approx. 1450 BCE to 1450 CE	Pictograms in rocks paper, books numerical system, abacus, cataloging	Origin of libraries as first data center in the history.	Nalanda University which functioned between the 5th and 13th centuries. The Library of Alexandria, sources claim that it was established in c. 323–c. 283 BC). It may have included over 500,000 papyrus scrolls containing works of literature	David C. Lindberg (15 March 1980). *Science in the Middle Ages*. University of Chicago Press. p. 5. ISBN 978-0-226-48233-0. https://www.history.com/news/8-

			and texts on history, law, mathematics and science.	impressive-ancient-libraries
Mechanical period Approx. Year 1450-1840	The mechanical calculator, "Pascaline" invented by the Blaise Pascal and Wilhelm Schickard	Numerical calculations started to be automated.	Pascaline was invented in Europe following the ongoing technology boom. Initially it was used for tax collection.	https://www.britannica.com/technology/Pascaline
	Analytical Engine, first programmable mechanical computer, invented by Charles Babbage (Father of Computers)	Numerical calculations continued being automated and speed up.	It influenced origin of first algorithm and later give birth to Computer Science in Europe.	https://www.computerhistory.org/babbage/adalovelace/
Electro-mechanical period Approx. year 1840-1940	Telegraph invented by William Cooke and Sir Charles Wheatstone Samuel Morse introduced the first single-circuit telegraph which give rise to the Morse code	The use of electricity hugely impacted information processing and transfer.	Railway signal telegraphy was developed in Britain from the 1840s onward. It was used to manage railway traffic and to prevent accidents as part of the railway signaling system. This technology has been used in World War II by many forces including the Australians.	David L. Woods, "Heliograph and mirrors", pp. 208-211 in, Christopher H. Sterling (ed), Military Communications: From Ancient Times to the 21st Century, ABC-CLIO, 2008
	Telephone patented for Alexander Graham Bell in 1876	Information processing and transfer became faster than ever.	Telephone was used for business purposes in North America with the first transcontinental phone call from New York in January 1915.	https://www.biography.com/inventor/alexander-graham-bell
Electronic period *Approx. year* 1940- present	Automatic Sequence Controlled Calculator (It could perform the 4 basic Arithmetic operations	Electronic devices have become more usable and popular among mass people. Games, natural and neural language	Inventions were simultaneously coming from Europe and America. First generation computers has large	A.Wilkinson (1968). Computer Models, Edward Arnold, UK,

	ENIAC (Electronic Numerical Integrator And Calculator) (1st large-scale vacuum-tube computer) EDVAC (Electronic Discrete Variable Automatic Computer) (employed binary arithmetic) EDSAC (Electronic Delay Storage Automatic Calculator) (one of the first stored-program machine computers) UNIVAC (Universal Automatic Computer) (commercially available first generation computer) IBM (International Business Machines) (1st commercial Business computer) (1960s) Second generation computers (Used transistors) (1959-1965) Third generation computers (Used integrated circuits) (1965-1971) Fourth generation computers (VLSI	processing, robotics, IoT are the latest addition.	number of vacuum tubes required and the fourth generation (VLSI) was also largely out of reach, too, due to most of the design work being inside the integrated circuit package. Second and third generation computer designs (transistors and SSI) were perhaps the best suited to being undertaken by schools and hobbyists.	SBN 7131 1515 X C.Mead and L.Conway (1980). Introduction to VLSI Systems, Addison-Wesley, Reading, USA

	circuits enabled microcomputers) (1971-1980) Fifth generation computers (rise of artificial intelligence) (present and beyond)			
	Mobile Phones (1G in 1973, 2G in 1980s, 3G in 2001, 4G in 2009, 5G in current period)	Instead of relying on multiple base stations with separate cells, the first mobile phone networks involved one very powerful base station covering a much wider area.	Public Mobile Phone calls were first introduced in UK, Europe. Soon it started to become popular. Motorola communications system had an influential business.	https://www.uswitch.com/mobiles/guides/history-of-mobile-phones/
	Internet (1960s, commercialized in 1990s)	World Wide Web is currently the primary tool billions use to interact on the Internet, and it has changed people's lives immeasurably.	The World Wide Web (sometimes abbreviated "www" or "W3") is an information space where documents and other web resources are identified by URIs, interlinked by hypertext links, and can be accessed via the Internet using a web browser and (more recently) web-based applications.	Dewey, Caitlin (March 12, 2014). "36 Ways The Web Has Changed Us". The Washington Post. Retrieved August 1, 2015

Does the change in Information Science curriculum coincide with the change of ICTs?

In majority cases, technological innovations began from Europe. It gradually spread across the globe having North America on the driving seat. This technological development contributed to the emergence of Library and Information Science and then Information Science as an organized independent discipline in Europe and North America. The field which was previously concerned about physical spaces such as libraries, museums, collections, and other repositories, soon started to respond to the digital and virtual spaces such as online communities, social networking, the World Wide Web, and databases in coherence with the dramatic change in the technological world. Many schools, colleges, and

departments was created or evolved from programs formerly focused on specific tracks to respond to the change of technologies. However, the changes within the discipline were not homogenous in Asia, Europe and America, they evolved differently following the trends of technological advancements in those regions. The next section captures the current trends of this evolution.

Section 2: Current Trends of Information Science Discipline

Our observations around the current trends of this discipline are based on these questions: a) which type of faculties offer Information Science programs? b) Is there any regional trends in faculty orientations? c) What trending streams currently exist in global Information Science Curriculum? d) Do the faculties prioritize these streams differently? And, e) Is there any regional trends while prioritizing these streams?

Orientations of faculties offering Information Science degree programs

In our analysis, we have found seven types of orientations of the faculties that offer Information Science degree programs. Globally, 60 Information science schools are situated at Library and Information Science oriented faculties, 18 schools in Computer Science oriented faculties, 15 schools in Management/ Business oriented faculties, and 13 schools are situated at Media and Communication Studies oriented faculties. Engineering/ Information Technology oriented faculties hold 8 schools and Cognitive Science and Education based faculties hold 6 schools. Only one school in the USA is located in a Disaster Preparation focused faculty.

Regional Trends in Faculty Orientations

The following figure shows the number of schools and their faculty orientations in North American, Asian and European regions.

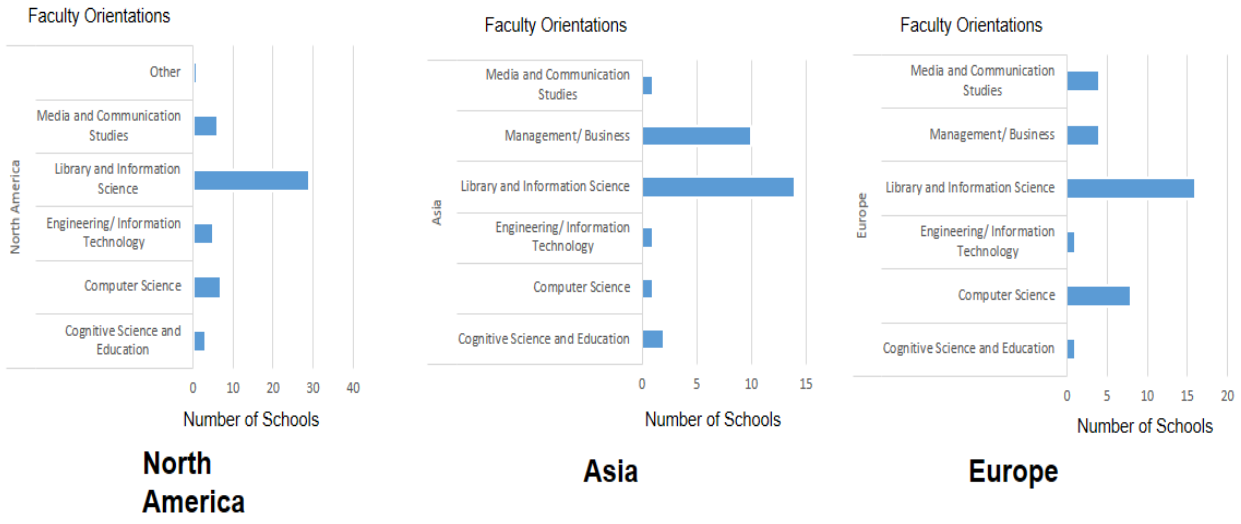

Figure 2: Regional trends in faculty orientations

It is evident from the figure that faculties across the world are in majority of cases Library Science oriented till date. Apart from this, in North America, many Information Science Schools are situated in Computer Science or Engineering focused faculties. In Asia, many Business Schools offer Information

Science related degrees. While in Europe, we find a balance among business and STEM oriented faculties in terms of offering Information Science related degrees.

Global Current Streams of Information Science Curriculum

From our analysis, we have identified 10 emerging streams within the Information Science degree programs across the world. Table 3 shows the number of iSchools and their prioritized streams within their curriculums. Globally, the current major streams of Information Science discipline are: Library and Archival Studies, Information Management, Intelligent Systems and Cyber Security, Human Computer Interaction (HCI), Applied Data Science, and Media and Communication Studies.

Table 2: iSchools and their currently prioritized streams of curriculum

Currently prioritized streams	Number of schools
Applied Data Science	9
Education	4
Health/ Bio Informatics	1
Human Computer Interaction	10
ICTD	3
Information Management	25
Intelligent Systems and Cyber Security	22
Library and Archival Studies	32
Linguistics and Psychology	6
Media and Communication Studies	9
Total	121

Faculty orientations and priority of different streams within degree programs

We have observed that the stream that any particular iSchool prioritize within its curriculum depends on its faculty-orientation in majority of the cases. For example, 15 iSchools are located in Business oriented faculties across the world, and 13 of those schools prioritize Information Management stream in their curriculum. Similarly, iSchools which are located in Cognitive Science oriented faculties prefer Linguistics and Psychology stream in their curriculum. However, Intelligent Systems and Cyber Security stream is prioritized across different faculties having varied orientations such as Media and Communication Studies, Computer Science and Engineering/STEM. Figure 3 shows these findings.

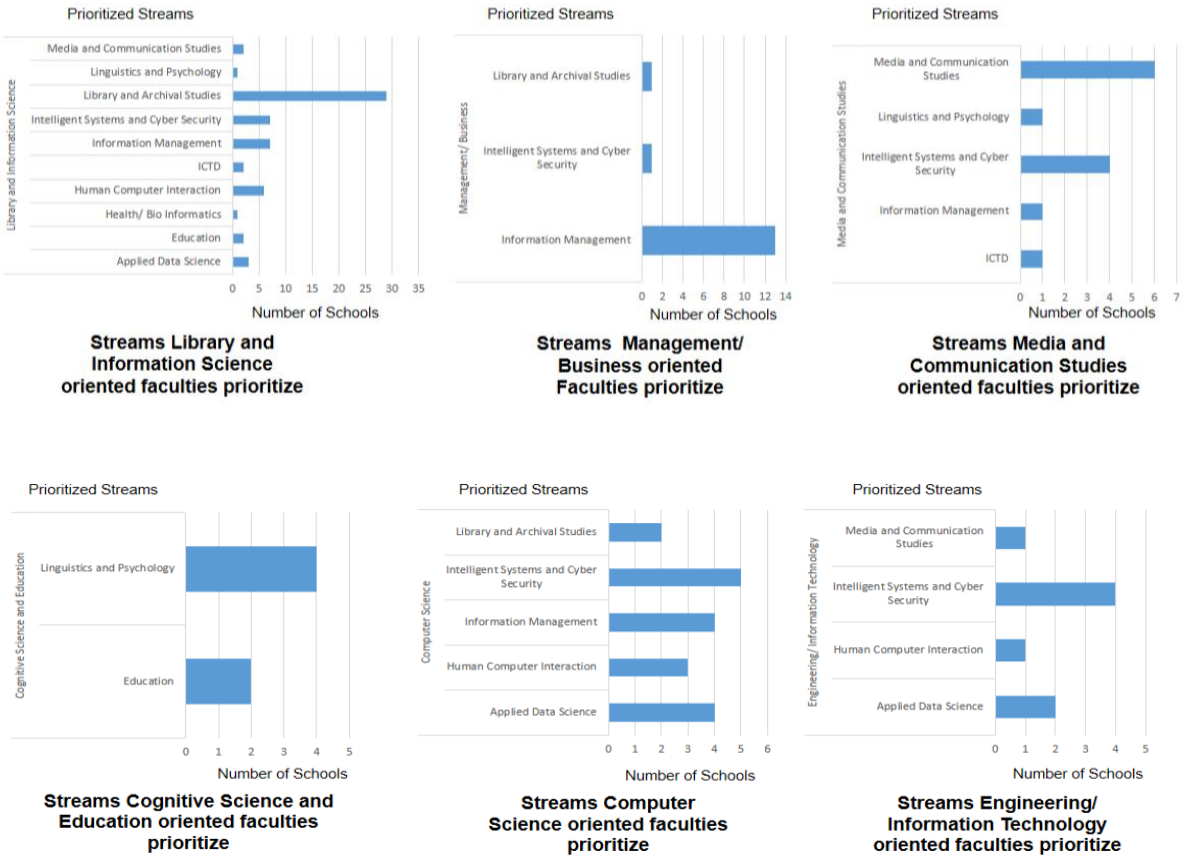

Figure 3: Faculty orientations and priority of different streams within degree programs

Regional trends in prioritizing streams within the curriculum

We have found that after the Library and Archival Studies stream, North American iSchools mostly prioritize Intelligent Systems and Cyber security, HCI and Applied Data Science streams of Information Science. While in Asia, the second most prominent stream is Information Management.

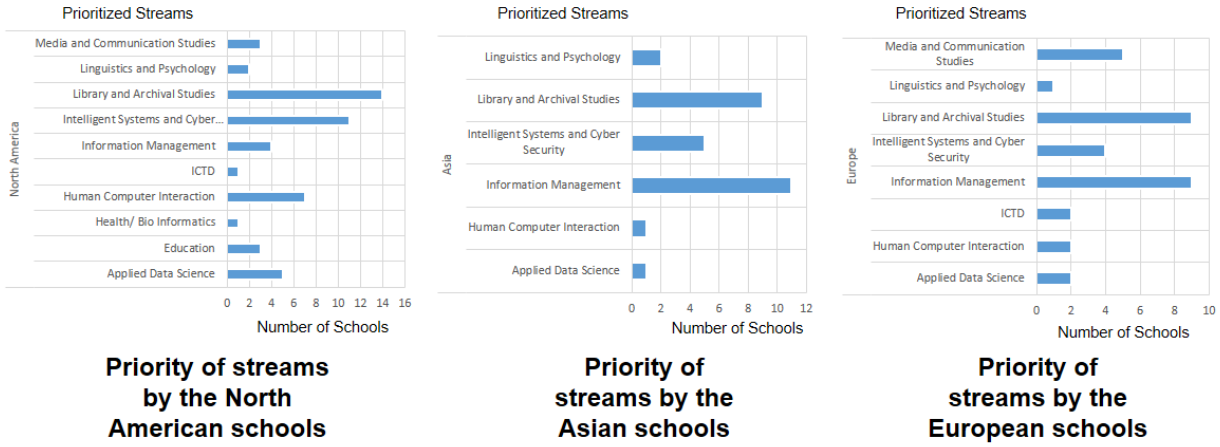

Figure 4: Regional trends in prioritizing streams within the curriculum

In European iSchools, we find a mix in their priorities within the curriculums with a high frequency for Media and Communication studies stream. Figure 4 shows these findings.

Regional Differences in Universities' Responses

The Information Science discipline is continuously changing its trajectory. However, there are regional differences in universities' responses to this change. Table 3 presents three representative cases of the gradual advancement of the pedagogy practiced in those schools. At Pittsburgh, the school began with a Library Science focus, but it has continuously introduced newer tech-based courses and updated itself with the technological disruptions. University of Philippines was established much later after the American one, however it has prioritized the high-tech streams from the beginning. On the contrary, the Chinese school has prioritized the local market needs and has made e-commerce management its primary focus.

Table 3: Cases: Regional Differences in Universities' Responses

Case 1: University of Pittsburg (North America)	Case 2: University of the Philippines (Asia)	Case 3: Central China Normal University, Hubei, China (Asia)
1901: The School of Library Science is established 1964: The school is renamed the Graduate School of Library and Information Science 1966: Pitt's Department of Computer Science is established 1974: The Master of Science in Information Science degree is introduced 1979: The Bachelor of Science in Information Science degree is introduced 1986: The Intelligent Systems Program is introduced 1987: The Master of Science in Telecommunications degree program is introduced 1996: The school's name is changed to the School of Information Sciences After 2000: The School of Information Sciences, the Department of Computer Science, and the Intelligent Systems Program came together to found and create a new entity, the School of Computing and Information (SCI)	The Institute of Library Science was founded in 1961 The institute reinvented itself to be more attuned to the demands of the times by upgrading its programs and curriculum to be information technology-oriented starting school-year (SY) 1995-96 Later it became the Institute of Library and Information Science on August 2002. The change in name reflected the change in curriculum when the Institute shifted from the purely traditional forms of librarianship to information technology assisted librarianship On March 2007, the Board of Regents approved its second change of name to School of Library and Information Studies in recognition of its dynamic growth	In 1920, Library Science degree was first offered In 1983, the school started to offer specialization in Library and Information Science, and established the Department of Library and Information Science. In 2012, the school was renamed as School of Information Management. Information Science is a key discipline in Hubei Province. Besides, E-Commerce is a brand specialty in the province. The school's popular course is e-commerce management.

Our overall observations show that the Library or archival studies stream is prioritized by the schools which were established earlier, and the curriculum of this stream is still theoretical. Media and Communication Studies and Linguistics and Psychology streams currently involve applied Information Science theories. The Intelligent System and Cyber security stream is rapidly growing and has potential to be a separate subject/ discipline. Few Schools are focusing on Health and Bio-informatics, but this is comparatively a new and powerful merger. Many schools in North America are offering separate degrees on HCI; this stream also has potential be a separate subject/ discipline. Applied Data Science stream is rapidly growing, it involves interdisciplinary application of statistics. Information Management is developed to respond the market needs, and Asian schools are prioritizing them. This is to be noted, when we saw the emergence of information schools in the twentieth century, in most cases, it had started with just a degree program in an existing school. Globally, we observe similar trends in current days' iSchools.

Moreover, American iSchools position them in two ways: a) by prioritizing rigorous humanities and critical research while responding to the Academia, and simultaneously, b) promoting the Intelligent Systems stream (Game Development/ AI/ other frontier technology studies) while responding to the industry. In Asia Pacific Region, most schools respond to the industry needs and offer courses like Business Analytics, e-commerce, and information Management. In Europe, we find universities making a balance while responding to both the academia and the industry.

Section 3: Emergence of ICTD

Although ICTD sometimes identifies itself under Information Science curriculum as 'Development Informatics', there are already separate ICTD degree programs in Undergrad/ Graduate levels across the world, and these degrees are offered from six differently oriented faculties. Table 4 shows examples of universities and their different faculty orientations where ICTD degrees are offered.

Table 4: ICTD degree programs and faculty orientations

Development Studies Ex: University of Sussex	International Affairs Ex: University of Georgetown	Geography Ex: University of London – Royal Holloway
Information Studies Ex: University of Michigan	Computer Science Ex: University of Berkeley	Media and Communication Ex: University of West Indies

Emergence of ICTD as separate degree programs from variety of faculties is a response to the global and regional development agenda. Our observations say that the rise of Development Studies and International Affairs disciplines accelerated this process 1950 onwards. In majority cases, these degrees are taught in developed countries although the curriculum involves developing ICT tools and methods to better capacitate the developing ones.

Section 4: Bangladesh Situation

Broadly, we find three components in global Information Science curriculum: Computation component, Social Science (Archival, Media and Communication Studies) component and Information Management component. In Bangladeshi universities we find these components in the curriculums of different degree programs in heterogeneous proportions. 79% degree programs have computation component in their

curriculums with or without combining other components, 21% have a mix of computation and management component, and 15% degrees combine computation with social science component. However, these degrees are offered from differently oriented faculties: Computer Science/ IT (60%), Mass Communication and Journalism (18%), Business (15%) and others (6%). Figure 5 shows our findings.

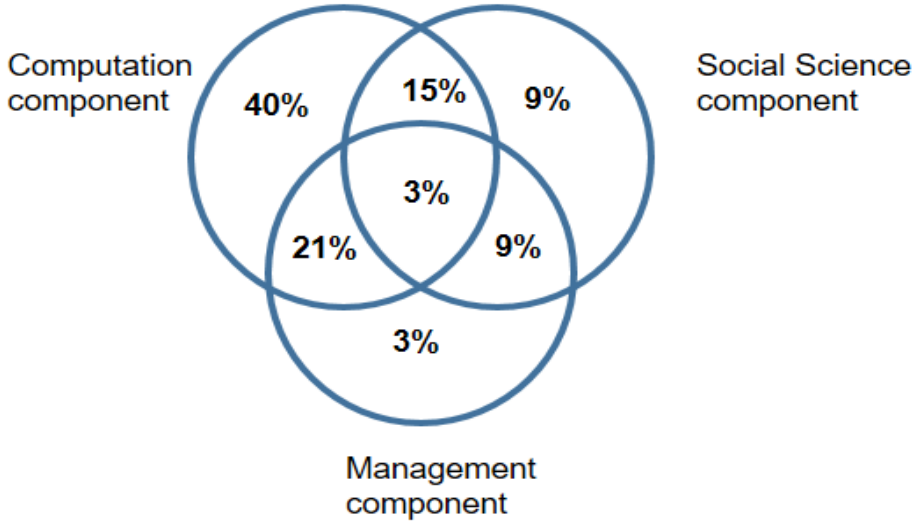

Figure 5: Presence of different components of Information Science in degrees offered by Bangladeshi Universities

We have found that Bangladeshi Universities, on majority basis, are focusing on the Intelligent Systems and Cyber Security stream of Information Science in response to the global trends. Public engineering universities have kept AI, ML and many other intelligent system related courses as core courses of their CS program and in most cases kept HCI as an optional subject. Among the general public universities, we see a in some cases Faculty of Arts and Humanities (specially Mass Communication and Journalism Department) and Faculty of Business Administration are offering a few relevant courses. Rajshahi University is the only university that has an Information Science and Library Management department. However, it only offers a Post Graduate Diploma degree. The Private Universities (Specially IUB and Daffodil) have an emerging trend to merge IT, Information Systems, and Business and Management in their degree programs. BRAC University has a unique program of Masters of Development Studies MDS that offers Development Informatics/ ICTD course within its curriculum.

Concluding Remarks

Degrees of advancement of ICTs in different regions of the world have historically influenced universities of those regions to design and offer Information Science degree programs. With variations in their faculty orientations, iSchools are currently prioritizing different streams of Information Science curriculum by responding to the technology and market dynamics of the regions they are located. Information Science continues to interact and exchange with other disciplines, the emergence of ICTD degree programs within and outside iSchools is an indicator. To better design useful and relevant degree programs or courses, Bangladeshi universities should carefully prioritize or make a balance between their mandates of global knowledge generation and local workforce creation.

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