Planning processes, policies and initiatives in ICTD education at institutions of higher learning in Asia and the Pacific:

India Country Paper

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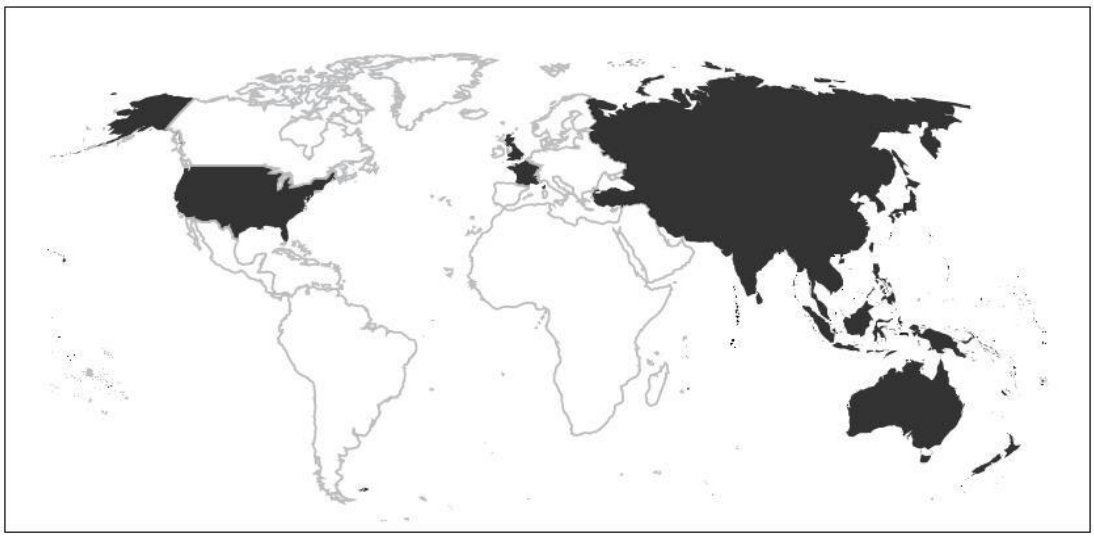

The shaded areas of the map indicate ESCAP members and associate members.

Acknowledgements

This paper was prepared by Sujata Gamage of LIRNEasia, with substantive contributions from Atsuko Okuda, Dongjong Lee, Siope Vakataki Ofa, Alexey Kravchenko, Shaina Hasan, Jonas Flake, Jeremy Marand and Momar Mbengue, and research assistance from Tarnkamon Chantarawat and Sakollerd Limkriangkrai of the Information and Communications Technology and Development Section, under the guidance of Tiziana Bonapace, Director, Information and Communications Technology and Disaster Risk Reduction Division (IDD) of ESCAP. The paper also benefited from comments received from Sayuri Cocco Okada of Gender Equality and Social Inclusion Section, Social Development Division, Nuankae Wongthawatchai of the United Nations Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT) and Jonghwi Park of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

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Abbreviations and Acronyms

ACSS	Administrative Computerization Support Services
ADSL	Asymmetric Digital Subscriber Line
AICTE	All India Council of Technical Education
AJEE	Advanced Joint Entrance Examination
APCICT	Asian and Pacific Training Centre for Information and Communication Technology for Development (United Nations)
CS	Computer Science
CS&E	Computer Science and Engineering
DEITy	Department of Electronics and Information Technology
ESCAP	Economic and Social Commission for Asia and the Pacific (United Nations)
Gbps	Gigabits per Second
GDP	Gross Domestic Product
ICT	Information and Communications Technology
ICTD	Information and Communications Technology for Development
IHL	Institution of Higher Learning
IIT	Indian Institute of Technology
ITU	International Telecommunication Union
JANET	Joint Academic Network
JISC	Joint Information Systems Committee (United Kingdom)
LAN	Local Area Network
MEITy	Ministry of Electronics and Information Technology
MHRD	Ministry of Human Resource Development
NGO	Non-Governmental Organization
NKN	National Knowledge Network
NMEICT	National Mission on Education through Information and Communication Technology
NPTEL	National Programme on Technology Enhanced Learning
NREN	National Research and Education Network
OER	Open Educational Resource
SARUA	South African Regional Universities Association
SC/ST	Scheduled Caste and Scheduled Tribe
STEM	Science, Technology, Engineering and Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organization

1. Introduction

This paper aims to provide a national-level gender-sensitive analysis of information and communications technology for development (ICTD) education in institutions of higher learning (IHLs) in India. The paper analyses the planning processes, policies and initiatives in IHLs to prepare future ICTD leaders in the country. It includes an examination of information and communications technology (ICT) connectivity issues, and exploration of the partnerships between IHLs, policymakers, regulators and the private sector.

ICT holds the promise of improving the lives of people, and of disadvantaged people in particular. IHLs in developing countries, especially the public institutions, are continually reminded that they should prepare future leaders with the advanced knowledge and skills needed for the next stage of development in their countries, with the specific aim to achieve the Sustainable Development Goals.

The need for an orientation towards ICTD in academic curricula, whether in ICT or other disciplines, is recognized by the United Nations Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT) in its Turning Today's Youth into Tomorrow's Leaders' Programme, as pointed out in the following:[1]

> Recent research has indicated that universities and other higher-learning institutions in the region responsible for training the next generation of leaders lack adequate coverage of ICTD in their curricula. Programmes and courses that are best suited to provide training and impart knowledge about the use of ICT for socioeconomic development either do not cover ICTD or [do not] address it in a manner that sufficiently identifies the potential of ICTD.

Does India have plans, policies and initiatives necessary to build tomorrow's ICT leaders with sensitivity to ICTD issues, at the national, institutional and programme levels? This country study attempts to answer this question through desk research, and a case study of a selected academic institution, which includes an in-depth study of its ICT programme. In India, the Computer Science and Engineering Department at the Indian Institute of Technology at Delhi (IIT Delhi) has been selected for the case study.

An ICTD leader must be able to leverage the potential of ICT for development purposes. For the most part, this requires ICT competencies, although in some cases, business, public policy or domain expertise may suffice. The ICTD practice also requires working in remote, peripheral locations and with vulnerable people. ICT connectivity is likely to be problematic in such areas and for such people. IHLs that prepare ICT or ICTD leaders will be hindered if they lack good ICT connectivity and awareness on the conditions and requirements to implement ICTD initiatives. Therefore, it is necessary to examine the state of ICT connectivity at national, institutional and programme levels. It is hoped that the findings will then feed into the process of policymaking and programming at the IHLs, as well as at the national level, to encourage students and researchers to develop, implement and innovate ICTD initiatives for inclusive and sustainable development.

Additionally, analysis with gender dimensions is important because the low participation of women in computing is a worldwide phenomenon. For women to become ICTD leaders, IHLs

[1] APCICT, "Turning Today's Youth into Tomorrow's Leaders Programme". Available from http://www.unapcict.org/partners/aboutus/programmes/advisory/future-ict-leaders-programme.

should have a sufficient number of female graduates in ICT to start with and encourage their active participation in ICTD initiatives.

The paper begins by defining ICTD in the context of this study.

1.1. Definitions of ICTD

There is no standard definition of ICTD, but three commonly-referenced sources—APCICT, Heeks and the World Bank[2]—provide sufficient guidance for compiling a definition. APCICT introduces ICTD broadly as the use of ICT to achieve socioeconomic development goals. Heeks who is reputed to have coined the term ICTD, uses ICT in the context of addressing pressing problems of the poor in developing countries. The 2012 World Bank Group Strategy includes the use of ICT to reduce poverty, increase productivity, boost economic growth, and improve accountability and governance. The following definition captures ICTD attributes highlighted in all three sources:

> ICTD is the use of ICT for inclusive and sustainable socioeconomic development.

Preliminary discussion with ICT educators at IHLs reveals that "ICTD" and "inclusive and sustainable socioeconomic development" are difficult concepts for educators and students to grasp, and it is necessary to elaborate on these concepts. Issue 1 of the APCICT Primer Series on ICTD for Youth[3] provides a set of case studies on ICT applications in different sectors and cross-cutting issues, including agriculture, climate change, cultural preservation, education, health, governance, poverty reduction, and the empowerment of marginalized groups. Based on these case studies, the following definition has been found to be useful in explaining ICTD to ICT faculty, students and alumni:

> ICTD is the use of ICT to address problems of a public interest nature that may not be addressed by the private sector without subsidies or other inducements. Examples include ICT applications that bring quality education to marginalized communities, the dissemination of agricultural information to rural communities, and the analysis of big data to better understand and manage public health issues, such as the spread of diseases.

1.2. ICT/ICTD in Higher Learning

Higher education policies and initiatives in a country are generally determined and implemented at three levels:

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[2] APCICT, *Primer Series on ICTD for Youth – Issue 1: An Introduction to ICT for Development* (Incheon, 2013). Available from http://www.unapcict.org/pr; Richard Heeks, "The ICTD 2.0 Manifesto: Where Next for ICTs and International Development?" Development Informatics Working Paper, No. 42 (Manchester: University of Manchester Global Development Institute, 2009). Available from http://www.gdi.manchester.ac.uk/research/publications/other-working-papers/di/di-wp42/; and World Bank, *ICT for Greater Development Impact: World Bank Group Strategy for Information and Communication Technology, 2012-2015* (Washington D.C.: World Bank, 2012). Available from https://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/WBG_ICT_Strategy-2012.pdf.

[3] APCICT, *Primer Series on ICTD for Youth – Issue 1: An Introduction to ICT for Development* (Incheon, 2013). Available from http://www.unapcict.org/pr.

1. The Ministry of Education or Ministry of Higher Education;
2. The agency that liaises between IHLs and the ministry (e.g., a University Grants Commission); and
3. The accreditation authority

Typically, national policies are set by the Ministry of Education. The formulation and implementation of national and sector-specific policies are carried out by the relevant agencies. A separate accreditation agency may be given the responsibility to maintain standards.

IHLs generally operate with greater autonomy than other educational institutions offering primary, secondary, technical and vocational education.[4] This may be because IHLs are at the top of the credentialing hierarchy in a country, and are therefore expected to self-regulate through peer review and related mechanisms. As a result, IHLs usually formulate and implement policies on their own within the broad guidelines set by the relevant ministry or the responsible agency.

As ICT policies are equally relevant to the objectives of this study, the policies for both higher education and ICT in India are examined.

1.3. ICT Connectivity

If IHLs are to produce future ICT or ICTD leaders, they need data and information on ICT connectivity and usage in teaching and learning processes, and related administration, for decision-making. While country data on general ICT connectivity are available from the International Telecommunication Union (ITU), there are no international surveys conducted on ICT issues in IHLs.

A study by the United Nations Educational, Scientific and Cultural Organization (UNESCO) identifies four critical issues related to the use of ICT in higher education as follows:[5]

1. Better access at lower costs
2. Access through mobile technology
3. Cloud computing
4. Open resources or digital content

However, country-level analyses are missing in the UNESCO study. Similarly, an Asian Development Bank study[6] discusses ICT strategies for universities, but national-level data are not provided in the report. Based on a literature review, only reports from the South African Regional Universities Association (SARUA) have been found to provide details on ICT connectivity at an institutional level. The 2006 SARUA study on ICT connectivity at IHLs

[4] Arthur L. Stinchcombe, *Information and Organizations* (Berkeley: University of California Press, 1990).
[5] UNESCO, *ICTs for Higher Education: Case Studies from Asia and the Pacific* (Bangkok, 2011). Available from http://unesdoc.unesco.org/images/0021/002141/214143E.pdf.
[6] Jouko Sarvi and Hitendra Pillay, *Integrated Information and Communication Technology Strategies for Competitive Higher Education in Asia and the Pacific* (Mandaluyong City: Asian Development Bank, 2015). Available from https://www.adb.org/publications/integrated-ict-strategies-competitive-higher-education.

reports on results from 54 institutions in 27 African countries.[7] SARUA summarizes the state of Internet connectivity at IHLs in Africa as too little, too expensive and poorly managed.

To provide an overview of ICT connectivity at IHLs in India, the study looks at the national ICT policies and initiatives, and the national-level indicators relevant to ICT connectivity. Since institutional-level data on ICT connectivity at IHLs are not available in India, the study examines in detail the ICT connectivity at IIT Delhi, the selected IHL. IIT Delhi is a premier public IHL in the country with possibly the best connectivity in a public IHL in India.

1.4. Gender Issues in ICT Education

This paper aims to integrate a gender perspective. The low participation of women in computer science and engineering programmes is a worldwide phenomenon.[8] Data on science, technology, engineering and mathematics (STEM) related fields are available only for Cambodia and the Republic of Korea from a survey of seven countries conducted on women in STEM.[9]

The participation of women in STEM degree programmes from Cambodia, Republic of Korea and United States of America (USA), is estimated at 11 per cent, 19.5 per cent and 20 per cent, respectively.[10] It may be inferred that women's participation in computer science is also in these ranges. The reason for the low participation of women in STEM and computer science across the world is not understood too well. Social conditioning is thought to play a large role.[11] When women's participation in ICT education is small, their participation in ICTD may be assumed to be minuscule. Yet, women could be more enthusiastic about development-oriented applications than men. For instance, it is found that women entrepreneurs are more socially committed, irrespective of their businesses in developed or developing economies. Women are 1.17 times more likely than men to create social ventures rather than economic ventures, and 1.23 times more likely to pursue environmental ventures than economic ventures.[12]

The present study will focus specifically on women's participation in ICT programmes in Indian IHLs.

2. Methodology

This country report is part of a five-country study of ICTD education at IHLs in Asia and the Pacific. The other countries that the study covers include Cambodia, Republic of Korea, Sri

[7] SARUA, "African Tertiary Institutions Connectivity Survey Report", 2006.
[8] Wachira Kigotho, "Women enrol in sciences but not STEM", *University World News*, 20 February 2015. Available from http://www.universityworldnews.com/article.php?story=20150218131443779; and UNESCO, *A Complex Formula: Girls and Women in Science, Technology, Engineering and Mathematics in Asia* (Bangkok, 2015). Available from http://unesdoc.unesco.org/images/0023/002315/231519e.pdf.
[9] National Science Foundation, "Women, Minorities and Persons with Disabilities in Science and Engineering". Available from https://www.nsf.gov/statistics/2015/nsf15311/digest/theme2.cfm.
[10] Ibid.
[11] Eric S. Roberts, Marina Kassianidou and Lilly Irani, "Encouraging Women in Computer Science", Department of Computer Science, Stanford University (no date). Available from http://www-cs.stanford.edu/people/eroberts/papers/SIGCSE-Inroads/EncouragingWomenInCS.pdf.
[12] APCICT, *Women and ICT Frontier Initiative: Enabling Role of ICT for Women Entrepreneurs (Core Content, Module 2)* (Incheon, 2016). Available from http://www.unapcict.org/wifi.

Lanka and Thailand. These countries have been selected based on the following criteria: (1) there must be at least one country from each of the major sub-regions—South Asia, South-East Asia and East Asia; and (2) there must be at least one country from each of the World Bank Lending Groups–high income, upper-middle income, lower-middle income and low income.

The focus of the country study is on "building ICTD leaders with higher skills", and emphasis is placed on analysing the academic programmes that provide graduates with advanced skills in ICT at the bachelor's level, with some information collected on master's and doctoral degree programmes. Given the paucity of data on ICT or ICTD education at IHLs in general, the focus is on uncovering as many good practices as possible from a well-established ICT degree programme in one selected institution in each country, as identified by the Times Higher Education Ranking Survey[13] or by local recognition. The five selected ICT degree programmes are the top programmes from each of the five surveyed countries. Together, they offer a set of observations on good practices that may be used as reference points, and a basis for ICT and education policymakers to enhance the quality and relevance of policies and programmes in the coming years.

The Times' ranking found the IITs in Bombay, Delhi and Kanpur falling within the 400-500th range in its ranking of best universities worldwide. With regard to computer science programmes, only IIT Bombay and the Indian Institute of Science are ranked among the top 100 programmes in the world. Despite this, IIT Delhi was selected over IIT Bombay because the former has been actively involved in an ICTD initiative to develop the capacity of smaller universities and colleges through the National Programme on Technology Enhanced Learning (NPTEL).

The data for the case study were collected by Dr. P. Vigneswara Ilavarasan, an Associate Professor of the Department of Management Studies at IIT Delhi, with inputs from a former head and current professor at the Computer Science and Engineering Department. Dr. Ilavarasan's observations were based on numerous interactions he had with computer science and engineering students and with faculty members in various capacities—as course coordinator, conference delegate, member of dissertation committees and participant at faculty meetings.

In this study, the national-level data on ICT connectivity at IHLs are limited to: (1) ICT policies, frameworks and initiatives; (2) ICT connectivity in general; (3) the national research and education networks (NRENs); (4) open educational resources (OERs) in the country; and (5) the situation and experience in the selected institution and ICT programme.

Related to ICTD education, information on national and institutional policies and initiatives, and general programme characteristics such as data on student enrolment, student-teacher ratios, uses of ICT in education, and innovations in ICT and ICTD education, have been documented.

Data on the percentage of women among the student body and the faculty have also been collected. Informants have been asked to report on any special initiatives to increase the participation of women, and provide country-specific reasons for low women's participation

[13] Times Higher Education, *The World University Rankings* (2016). Available from http://digital.timeshighereducation.com/THEREPRANKINGS2016/offline/download.pdf.

in ICT and ICTD. As a rule of thumb, participation is considered low if it is less than 33 per cent.

From an analysis of all the data and information, a set of challenges and opportunities to foster ICTD leaders in India is presented. It is hoped that the examples and experiences documented in this paper will be used by ICT and education policymakers to strengthen the linkage between the ICT academic programmes, faculty and graduates, and the society at large.

3. ICT Connectivity

In this section, national issues relevant to ICT connectivity at IHLs are examined. These include the: (1) national ICT policy framework; (2) national indicators of ICT connectivity; (3) NRENs; and (4) OERs. The ICT connectivity of IIT Delhi, the selected IHL, and its integration of ICT in education will also be examined.

3.1. National Policies

India elected a new government in May 2014 with Mr. Narendra Modi as Prime Minister. Digital India is an initiative of the new government to connect India digitally with emphasis on rural India. The three "vision areas" of Digital India are: (1) digital infrastructure as a core utility to every citizen; (2) governance and services on demand; and (3) digital empowerment of citizens.

When the Modi government came to power in 2014, there was a ministry known as the Ministry of Information and Communications Technology. As the result of a cabinet reshuffle in 2016, the functions were separated and assigned to new entities—the Ministry of Communications and the Ministry of Electronics and Information Technology (MEITy). [14]

The Department of Telecommunications, which is responsible for ensuring an adequate telecommunications infrastructure in the country, and the Department of Posts are the two major agencies under the purview of the Ministry of Communications.

Three of the key departments in MEITy are the Department of Electronics and Information Technology (DEITy), Media Lab Asia and National Informatics Centre. MEITy is more relevant to the present study because India's NREN—the National Knowledge Network (NKN)—is under the purview of the National Informatics Centre (see Section 3.3). The Department of Telecommunications is under a different ministry (the Ministry of Communications), and coordination between the two ministries is necessary for the effective functioning of the NKN.

3.2. ICT Connectivity Indicators

[14] Aman Sharma, "DeITY becomes a new ministry, leg-up for Ravi Shankar Prasad", *The Economic Times*, 19 July 2016. Available from http://economictimes.indiatimes.com/news/economy/policy/deity-becomes-a-new-ministry-leg-up-for-ravi-shankar-prasad/articleshow/53285683.cms.

India's Internet access indicators improved markedly from 2013 to 2015, according to ITU's ICT connectivity data:[15]

- The proportion of individuals using the Internet increased from 15 per cent in 2013 to 26 per cent in 2015.
- Fixed broadband subscriptions increased marginally from 1.2 to 1.3 per 100 inhabitants.
- While mobile broadband subscriptions nearly tripled from 3.2 to 9.4 per 100 inhabitants.
- Internet access at home also increased from 13 per cent to 14.1 per cent.
- Proportion of households with a computer increased from 11.9 per cent to 20 per cent.
- Mobile cellular subscriptions increased from 70.8 to 78.8 per 100 inhabitants.
- Fixed telephone subscriptions decreased from 2.3 per cent to 2.0 per cent.

Table 1: ICT and related indicators in the five surveyed countries, 2015

	Cambodia	India	Sri Lanka	Thailand	Republic of Korea
GDP per capita, 2015 (current USD)	1,159	1,582	3,926	5,816	27,222
Fixed-telephone subscriptions per 100 inhabitants	1.6	2.0	12.0	7.9	58.1
Fixed (wired)-broadband subscriptions per 100 inhabitants	0.5	1.3	3.1	9.2	40.2
Mobile-cellular subscriptions per 100 inhabitants	133.0	78.8	112.8	125.8	118.5
Mobile-broadband subscriptions per 100 inhabitants	42.8	9.4	15.8	75.3	109.7
Households with a computer (%)	16.0	20.0	24.2	29.5	77.1
Households with Internet access at home (%)	21.0	14.1	18.1	52.2	98.8
Individuals using the Internet (%)	19.0	26.0	30.0	39.3	89.9

Sources: ITU, "Statistics". Available from http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx; and World Bank, "GDP per capita (current US$)". Available from http://data.worldbank.org/indicator/NY.GDP.PCAP.CD?page=3.

[15] ITU, "Statistics". Available from http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.

A comparison of 2015 ICT connectivity data across all five surveyed countries is of interest here. Values of all indicators increase from Cambodia to India, Sri Lanka, Thailand and Republic of Korea in that order, except for mobile-cellular subscriptions, mobile-broadband subscriptions and households with Internet access. These three indicators are higher in Cambodia than in India, even though Cambodia has a lower gross domestic product (GDP) per capita. Nevertheless, the connectivity indicators at IIT Delhi are far above that of the parallel institution in Cambodia (see Section 3.5).

3.3. National Research and Education Network

The NREN is a specialized Internet service dedicated to supporting the needs of the research and education communities within a country. Building such networks for research and education seems to be priority in most countries.[16] The NREN in India is known as the NKN and is an integral part of the National Mission on Education through Information and Communication Technology (NMEICT) of India.

The NMEICT was launched on 3 February 2009 in Andhra Pradesh, as a centrally sponsored scheme to leverage the potential of ICT in teaching and learning by providing: (1) broadband connectivity to all colleges and universities; (2) low-cost Internet access and computing devices for students and teachers; and (3) high-quality e-content generation.

The first major initiative of the NMEICT is open access e-content generation. For example, the NPTEL is a joint initiative of the IITs and the Indian Institute of Science to provide e-learning through online video courses (see section 4.2). There are nearly 1,000 different courses on engineering, technology, science and humanities available online. Emphasis has been placed on accessibility and efficiency whereby existing resources under the Creative Commons license are used as lessons and translated into 15 local languages of India.

The availability of quality e-content is not sufficient unless there are devices to access the content. Hence, the NMEICT funded the development of ultra-low-cost computing devices. The devices, launched in 2012, include interactive lessons building, online quiz software, spoken tutorials, open source software for creating interactive animation, and the ability to write programming code. So far, a million of such low-cost devices have been distributed among various remote centres and colleges across the country.

Finally, to access the free e-content on low-cost devices, it is necessary to provide connectivity to the devices. The NKN is intended to provide the infrastructure for high-speed delivery of and access to online educational resources, as well as promote research collaboration among institutions. Sixty per cent of the entire policy budget has been earmarked for the NKN, with the aim to provide broadband connectivity to all IHLs, including over 26,000 colleges and 2,000 polytechnics in the country. The NKN is expected to support distance education in fields such as engineering, science and medicine in order to bridge existing knowledge gaps in the country, evolve as a knowledge society, and spur knowledge-intensive economic activities.

[16] See TERENA, "Research and Education Networking FAQ". Available from https://www.terena.org/activities/development-support/r+e-faq/.

The NKN is one of the important components of the NMEICT, which is administered by the National Informatics Centre of MEITy. The other component is the Sakshat web portal.[17] Sakshat is the repository for the OERs, and comes under the purview of the Ministry of Human Resource Development (MHRD).

To our knowledge there has not been any formal evaluation of the NKN or Sakshat. In a study, Jain and Singh[18] conducted a comparative analysis of the NKN and the United Kingdom's NREN—the Joint Academic Network (JANET). The analysis offers some insights on the approach and process of the NKN. For instance, the NKN is a top-down initiative, centrally administered and funded by the Government of India, while JANET is a bottom-up initiative, driven by British universities. As a result, NKN has to focus on outreach and awareness raising among Indian IHLs, while JANET already has buy-in from the universities and its emphasis is on improving the effectiveness and management of the network to support its member universities. The authors note that JANET has a mechanism to continually review and evaluate the network, while the lack of an evaluation mechanism in the NKN may limit the effectiveness of the NKN to support Indian IHLs and achieve its objectives.

3.4. Open Educational Resources

The Sakshat web portal is described by the MHRD as "a one-stop education portal launched on 30 October 2006 by His Excellency, the then President of India, to facilitate lifelong learning for students, teachers and those in employment or in pursuit of knowledge free of cost to them."[19] Its launch preceded that of the NKN. The Sakshat web portal has become a valuable online resource for students in colleges and universities across India. Some of the resources include: "Talk to a Teacher" portal that provides pre-recorded conversations with a teacher; "Spoken Tutorial" portal with audio or video tutorials; "e-PG Pathshala" portal, which is a gateway to postgraduate courses; and "NPTEL Engg" portal that provides video courses on engineering subjects.

NRENs, in some form or other, exist in all the five surveyed countries, but India is the only country that has made a concerted effort to deliver education and research content through NREN. However, evaluation of its success in connecting universities for better teaching and research is yet to be seen.

3.5. Connectivity at Institutional and Programme Levels

The ICT facilities at IIT Delhi are available to all the students. The department-specific infrastructure available to computer science and engineering students is more or less the same as for other students at IIT Delhi.

Internet access in the academic areas is provided to faculty, students and guests through wired or wireless connections to the campus local area network (LAN). The IIT Delhi campus is a residential campus. The residential part of the campus is also well connected. All faculty members and staff who are resident on campus are connected to the LAN through

[17] MHRD, "Sakshat". Available from http://www.sakshat.ac.in.
[18] Rekha Jain and Manjari Singh, "A Framework for Comparative Analysis of National Knowledge Networks in UK and India", Indian Institute of Management Ahmedabad, Working Paper No. 2015-03-29, March 2015.
[19] MHRD, "Distance Learning". Available from http://mhrd.gov.in/technology-enabled-learning-1.

asymmetric digital subscriber line (ADSL) connections provided to each home by the university computer services. The student residents in hostels connect through LAN cable connection in their rooms. They may also use the Wi-Fi connections in common areas.

The campus LAN is connected to the Internet through the NKN with a broadband capacity of 20 Gbps. Previously, IIT Delhi experimented with a private Internet service provider but reverted to the NKN.

As for devices, each faculty member at IIT is provided with personal computers and laptops. Students secure their own laptops.

The ICT connectivity at IIT Delhi compares well with connectivity at the Chulalongkorn University in Thailand, supporting the observation that the IITs are oases with upper-middle income facilities in a lower-middle income country.

3.6. Integration of ICT in Education

The real test of the ICT connectivity at an IHL is the extent to which ICT is integrated into student management systems, learning management systems and administrative management systems.

3.6.1. Student Management System

At IIT Delhi, the student management system has been built in-house by the Administrative Computerization Support Services (ACSS) using open source tools. It is currently used for all administrative tasks, including the selection and registration of courses, and the access to student records and grades. But it took close to 10 years for the faculties' acceptance and use of this system. According to a former Dean, the institute started off with PeopleSoft enterprise resource planning solutions, but it was discontinued after two years due to difficulties in maintaining the commercial product. Dr. Ilavarasan commented that the current student management system is functioning fairly well.

The ACSS has also developed a Faculty Information System to manage faculty appraisals and various data and information, such as the number of doctoral students supervised by a faculty member. In addition, through a student-led project,[20] a room booking service has been developed as part of the system.

3.6.2. Learning Management System

IIT Delhi uses Moodle for its learning management system. It has been designed to help educators create effective online courses with a focus on interaction and collaborative construction of content. The learning management system also serves as a knowledge management repository that could be shared with teams or individuals. The learning management system is separate from Sakshat, which serves all academic institution in India.

[20] Faculty members encourage students to carry out service projects as part of their coursework. Service projects can be on any topic, not just ICT-related, and can be targeted at the university community or the general public (see Section 4.3.2).

According to a former Senior Professor of Computer Science and Engineering who was also the Dean of Student Affairs until recently, Moodle is used in only about 25 per cent of the 400 courses being taught at IIT Delhi in a given semester. The uptake and use of the learning management system throughout IIT Delhi, including the Department of Computer Science and Engineering, has been slow due to teething problems. Faculty members prefer to communicate with students through announcements in class, Google group e-mail lists, class representatives or notices posted outside their offices.

Another service offered to faculty members is the creation of course pages that students can access through IIT Delhi's intranet. However, such course pages are used by less than 20 faculty members (or five per cent of the total). The lack of programming skills, time and interest are some of the reasons for its low uptake.

3.6.3. Technology Use in Classrooms

Each classroom at IIT Delhi is equipped with a multimedia projector. Three years ago, each classroom was given a computer, but this has been discontinued. The Educational Technology Services Centre maintains all the projectors in the classrooms. It also manages a facility for two virtual classrooms or videoconferencing, with a seating capacity for 25 people.

3.6.4. Other ICT Resources

In addition to these resources in classrooms, computer facilities are available in labs and at the central library at IIT Delhi. The central library provides access to e-resources, e-journals and bibliographic databases of professional society publications, including journals, conference proceedings, newsletters and multimedia titles. The bibliographic databases include: (1) journals and conference proceedings from the American Institute of Physics, American Society of Civil Engineers and American Society of Mechanical Engineers; (2) the IEEE/IET Electronic Library; (3) Optics InfoBase; and (4) EBSCO Business Source Complete.[21]

4. ICTD Education Planning, Policies and Initiatives

4.1. National Level

The higher education sector in India is overseen by a ministry, regulatory agency and a separate accreditation body. The Department of Higher Education is the higher education policy arm of the MHRD. The University Grants Commission is a statutory organization established by an Act of Parliament for the coordination, determination and maintenance of standards of university education. The National Assessment and Accreditation Council is an autonomous body established by the University Grants Commission to assess and accredit institutions of higher education.

A fourth body relevant to the present discussion is the All India Council for Technical Education (AICTE).[22] The mission of the AICTE gives prominence to the: (1) promotion of

[21] In contrast, the University of Moratuwa in Sri Lanka, another lower-middle income country, does not have access to this range of bibliographic resources.

[22] AICTE, "About AICTE". Available from http://www.aicte-india.org/aboutaicte.php.

innovations, research and development in established and new technologies; (2) generation, adoption and adaptation of new technologies to meet development requirements; and (3) overall improvement of educational processes. The AICTE also aims to promote the technical education of women, persons with disabilities and other marginalized groups.

4.2. Institutional Level

The IITs in India have been leaders in curriculum planning, laboratory development, establishment of examination systems for engineering education, and faculty development for themselves and for the teachers of other engineering colleges.[23] The IITs' endeavour to serve the educational community, particularly in engineering education, is carried out through their participation in the NPTEL component of the NMEICT. The NPTEL serves smaller universities outside of the IITs, while the learning management system serves the IITs community.

The NPTEL[24] is an initiative to offer online video courses on various computer science and engineering disciplines—including civil engineering, computer science, electrical engineering, electronics and mechanical engineering, as well as core science courses that are mandatory for all engineering students in India. The online video courses are based on a model curriculum recommended by the AICTE and the syllabi of major universities in India. Seven IITs in Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee, and the Indian Institute of Science are involved in content development. The copyrights are jointly owned by the MHRD, IITs, Indian Institute of Science and the faculty in the institutes. As explained by the NPTEL, their service is similar to the OpenCourseWare initiative of the Massachusetts Institute of Technology in USA. But while OpenCourseWare is aimed at self-learners worldwide, the NPTEL has been developed specifically for smaller universities and colleges in India.

4.3. Programme Level

IIT Delhi offers ICT programmes through four of its academic units:

1. Department of Computer Science and Engineering
2. Amar Nath and Shashi Khosla School of Information Technology
3. Bharti School of Telecommunication Technology and Management
4. Department of Mathematics.

Stand-alone undergraduate programmes in ICT are offered only by the Department of Computer Science and Engineering. The other units offer either bachelor's and master's degree combinations and/or postgraduate programmes in ICT. This case study focuses specifically on the computer science and engineering programme at IIT Delhi.

4.3.1. Programme Description

The Department of Computer Science and Engineering at IIT Delhi[25] was established in 1982. The department currently has 30 full-time faculty members (all doctoral degree holders

[23] IIT Delhi, "History of the Institute". Available from http://www.iitd.ac.in/content/history-institute.
[24] NPTEL, "Frequently Asked Questions". Available from http://nptel.ac.in/faq.php.
[25] IIT Delhi, "Department of Computer Science and Engineering". Available from http://www.cse.iitd.ernet.in/.

from leading institutions). This number is expected to grow in the coming years. In addition to the full-time faculty, the department has several visiting and adjunct faculty members from leading academic and research institutions and labs.

For all undergraduate programmes, students are admitted on the basis of the Advanced Joint Entrance Examination (AJEE). The AJEE is conducted by the IITs for candidates who qualify from the Main Joint Entrance Examination, which is conducted by the Central Board of Secondary Education in India. The AJEE is thought to be one of the toughest exams in the world, given the ratio of number admitted to number sitting for the examination.[26]

The student population in the Department of Computer Science and Engineering is distributed as follows: 250 in undergraduate programmes, 150 in dual degree programmes, and 100 in master's and doctoral degree programmes. The total number of undergraduate students is 400, of which 15 per cent are female.

Table 2: Student enrolment and full-time faculty headcount across five surveyed countries

	Cambodia	**Sri Lanka**	**India**	**Thailand**	**Republic of Korea**
	CS (Yr. 2-4)	**CS&E**	**CS&E**	**CS&E**	**CS&E**
No. of students	2000	500	400	304	400
% Female	~7-8%	20%	15%	-	~30%
No. of faculty members	45	20*	30	36	32
% Female	4%	35%	10%	28%	3%
Student-teacher ratio	44	25	13	9	13
No. of master's degree students	60	200	50	200	~140
No. of doctoral degree students	-	2-3[#]	50	36	~100

Notes: CS = Computer Science; and CS&E = Computer Science and Engineering.
* 28 if visiting faculty members and those on study leave are included.
[#] None graduated yet.
Sources: Desk research and interviews, July-August 2016.

	Cambodia	**Sri Lanka**	**India**	**Thailand**	**Republic of Korea**
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[26] For further details see http://jeemain.nic.in/webinfo/Public/Home.aspx, http://www.jeeadv.ac.in/ and https://en.wikipedia.org/wiki/Joint_Entrance_Examination.

No. of doctoral degree students	-	2-3[#]	50	36	~100

Notes: CS = Computer Science; and CS&E = Computer Science and Engineering.
* 28 if visiting faculty members and those on study leave are included.
[#] None graduated yet.
Sources: Desk research and interviews, July-August 2016.

In order to enrol in the Master of Technology and Master of Science programmes at the Department of Computer Science and Engineering, qualifying scores from the Graduate Aptitude Test in Engineering (GATE) are needed for admission. The GATE exam is conducted by the IITs. The requirement to sit for the GATE exam is either a four-year undergraduate degree in engineering or a five-year Master of Science degree.[27]

The student-teacher ratio for undergraduate programmes at IIT Delhi is 13. It is in the range of case study programmes in the Republic of Korea and Thailand—both of which are in higher income groups than India, and are known for their advanced computer science and engineering education. This is a further indication that through the IITs, the Government of India has created a set of elite institutions endowed with resources above and beyond the levels expected of a lower-middle income country.

4.3.2. Curriculum

The focus of this paper is on any aspect of the curriculum that might promote ICT applications for development. Although there are no courses in the computer science and engineering curriculum of IIT Delhi that are specifically devoted to ICTD issues,[28] there is evidence of ICTD activities in co-curricular and extra-curricular activities, such as student projects, the use of ICT to address various issues in the IIT community, the organization of guest lectures on ICTD topics, and faculty participation in public outreach activities.

An interviewed faculty member estimated that one in ten student projects may be development oriented at the Department of Computer Science and Engineering in IIT Delhi. Out of the 12 student projects listed on the faculty website, three may be identified as ICT related.[29]

At IIT Delhi, students are encouraged to contribute solutions to issues faced by the university community, which give students exposure and experience in applying ICT solutions to real-life problems. A successful example is Eckovation, a mobile-based social learning platform created by IIT Delhi students, Ritesh Singh and Akshat Goel, who graduated in 2012. The Eckovation application allows collaboration between students, peers, teachers and parents on a single platform. The two former IIT Delhi students that created the platform have continued to develop and manage Eckovation as a private initiative.[30]

[27] Graduate Aptitude Test in Engineering. Available from http://www.gate.iisc.ernet.in.
[28] IIT Delhi, "Courses of Study 2016-2017". Available from http://www.iitd.ac.in/sites/default/files/semsch/CouStudy_201617.pdf.
[29] The titles of these three projects are: (1) Monitoring the state of cellular data connectivity in India; (2) Building citizen engagement into the implementation of welfare schemes in rural India; and (3) The rich and middle classes on Twitter. IIT Delhi, "Student projects". Available from http://www.cse.iitd.ernet.in/index.php/2011-12-29-23-15-14/student-projects.
[30] See http://eckovation.com.

The organization of guest lectures is another way of introducing students to ICTD and other ICT-related issues not covered in the curriculum. The Department of Computer Science and Engineering arranges one or two guest lectures per month, some of which are relevant to ICTD.[31] For example, a lecture delivered in November 2016 by Nobel Laureate Kailash Satyarthi was on "youth leadership for change". Other relevant lectures conducted in early 2017 included, "urban sustainability, preserving privacy," and "pervasive computing and communication techniques for smart healthcare".

4.3.3. Faculty Research, Development and Outreach Activities

Faculty members at IIT Delhi have engaged in ICTD through their research—smart canes for the blind is an example of such research.[32] The SmartCane™ device is an electronic travel aid that fits on the top fold of the white cane. It serves as an enhancement to white canes by detecting knee above and hanging obstacles. With simple orientation and training, any visually-impaired person who is a regular user of the white cane for mobility can benefit from this device.

This smart cane research project and other similar projects are typically implemented in partnership with non-governmental organizations (NGOs). In addition, almost all faculty members at the professor level serve on government committees in different capacities, and are regularly invited to meetings and consultation workshops conducted by MEITy, MHRD and other ministries. Faculty members at IIT Delhi also contribute video lectures to the NPTEL as part of their outreach activities. The video lectures are used by smaller universities and colleges, as discussed in section 4.2.

Although direct links between these activities and faculty and students' initiation of ICTD activities are difficult to establish, it is conceivable that some faculty members, through their involvement in ICTD activities, would inspire some students to expand their knowledge, skills and experience in ICTD.

4.4. Gender Issues

In contrast with the other four surveyed countries in the study, gender disparities in higher education in India are recognized at the national level. For example, one of AICTE's priorities is the promotion of technical education for women, persons with disabilities and other marginalized groups by awarding them grants to pursue their technical education. In practice, however, gender issues are "muted" along with other socioeconomic and cultural considerations, including caste disparities, as elaborated in a report by the Ministry of Women and Child Development.[33]

The report demonstrates the contradiction between AICTE's intention to "formulate schemes for promoting technical education for women, handicapped and weaker sections of

[31] IIT Delhi Department of Computer Science and Engineering, "Talks by visitors to the Department". Available from http://www.cse.iitd.ernet.in/index.php/2011-12-29-23-14-40/talks-by-visitors.
[32] Assistech, "SmartCane". Available from http://assistech.iitd.ernet.in/smartcane.php.
[33] Ministry of Women and Child Development, Government of India, "Report of the Working Group on Empowerment of Women for the XI Plan", 2006, p. 77. Available from http://www.aicte-india.org/downloads/woman_empowerment.pdf.

the society",[34] and the actual practice of awarding educational grants to these marginalized groups:

> There is no special consideration for "being female" in these grants, though the poor educational status of scheduled caste and scheduled tribe (SC/ST) girls, vis-à-vis that of boys in these communities is borne out in each set of Government data on levels of SC/ST enrolment, drop out and attainment. Other such gender-muted instances of affirmative action include reservation of seats for SC/ST candidates in the IITs, Indian Institutes of Management, Regional Engineering Colleges, and Central Universities.

Similarly, at the institutional or programme level, gender issues do not receive due attention. Only 15 per cent of those enrolled in the computer science and engineering undergraduate programme at IIT Delhi are females, and correspondingly, for the computer science and engineering programmes at master's and doctoral levels, 13-15 per cent of the students are female. Female enrolment in computer science and engineering programmes in the other four surveyed countries range from 7-8 per cent in Cambodia to 30 per cent in the Republic of Korea, which means that India is more or less in the mid-range by comparison (see Table 2).

As a faculty member explained, admission to the undergraduate programme in computer science and engineering at IIT Delhi is only open to the top rankers in the entrance examination, which is perhaps the most difficult examination in the country. Very few women have been reported to achieve high marks,[35] resulting in low female enrolment.

As noted in Section 1.4, the low participation of women in computer science and engineering programmes in universities is a global phenomenon. However, recent news from Stanford University suggests that premier institutions can increase female enrolment in computer science and engineering programmes, if there is commitment from the university and the relevant faculties, and a coordinated strategy is in place. In October 2015, Stanford University reported that for the first time the computer science major became most popular among women, overtaking biological science, the previously favoured major.[36]

4.5. ICTD Alumni Perspectives

In addition to interviewing selected faculty members at IIT Delhi, this study also obtained the perspectives of two alumni. Unfortunately, the institutional contact could identify male graduates only.

- **Mr. Movin Jain**, Founder of Galleri5, a sharing and discovery platform for user-generated content
  - Educational background – Bachelor of Technology, 2009
- **Mr. Chirag Bansal**, Software Engineer at Rivigo Services Private Limited

[34] AICTE, "About AICTE". Available from http://www.aicte-india.org/aboutaicte.php.

[35] Sreeradha Basu, "More girls qualify for IITs, but fail to make it to top 100", *The Economic Times*, 13 June 2016. Available from http://economictimes.indiatimes.com/industry/services/education/more-girls-qualify-for-iits-but-fail-to-make-it-to-top-100/articleshow/52719850.cms.

[36] Jonna Louvrier "For Stanford's computer science department, the future won't be like 1984", *Stanford University*, 16 November 2015. Available from http://gender.stanford.edu/news/2015/stanford%E2%80%99s-computer-science-department-future-won%E2%80%99t-be-1984.

- Educational background – Graduated in 2015

Movin Jain pointed out that they faced slow Internet connectivity at the hostel and used to have only a LAN connection when he was a student. Laboratory facilities at the department were good enough to support their learning needs. The infrastructure and the interface for the student management system were not really developed and were managed by a third party rather than by students at IIT Delhi. Some of the features he felt useful allowed students to: (1) engage in the development of the learning management system and student management system, under the guidance of faculty members; and (2) enrol in elective subjects from other departments along with their major specialization. Citing an example from his own experience, Jain mentioned that he along with three other students developed IIT Delhi's training and placement cell's website, which was earlier the responsibility of a third party. The new website was a major improvement. Jain suggested that IIT Delhi should include subjects such as Artificial Intelligence, Machine Learning, Image Recognition and Virtual Reality since these are emerging topics.

Chirag Bansal, whose experience is more recent, was satisfied with the Internet connectivity at IIT Delhi, although there were usage limits and time restrictions at the hostels. As a result, students accessed the Internet from the library and other common areas. His experience with the learning management system and the student management system was positive, and recommends the greater involvement of students in the university's ICT development activities.

5. Summary of Observations and Conclusion

ICTs have the potential to enhance economic and social development, and this study aimed to identify planning processes, policies and initiatives in ICTD education at IHLs in Asia and the Pacific. Based on desk research and faculty and student interviews in India, in conjunction with the analyses from the other four country studies, a number of observations and recommendations can be made. These are categorized as initiatives at the: (1) country level, implemented by central/regional government authorities; (2) institutional level, conducted by individual IHLs; and (3) programme level, by computer science and engineering programmes in the IHLs. A particular emphasis was made on examining the issue of gender imbalance prevalent among computer science and engineering programmes.

Country-Level Initiatives

The government authorities in India are well aware of the advantages ICTs in education hold for socioeconomic development, and are actively promoting the use of ICTs in IHLs and education in general. The most notable policy is the NMEICT, which provides broadband connectivity to all colleges and universities, low-cost Internet access and computing devices for students and teachers, and high-quality e-content generation.

Institutional-Level Initiatives

To examine initiatives at IHL level, IIT Delhi was selected as a case study for analysis. In addition to desktop research, interviews were conducted with IIT Delhi staff, faculty members, students and alumni.

The IITs in India have been established to provide a leading role in engineering education. Like other IITs, IIT Delhi is involved in the NPTEL initiative as one of the e-content generators. The developed courses are similar to the OpenCourseWare initiative by the Massachusetts Institute of Technology in USA, but the NPTEL is targeted specifically at smaller universities and colleges in India.

By design, IIT Delhi appears to be an oasis in a country that is home to some of the poorest people in the world, and as a result, the university is able to play a leadership role in computer science and engineering education in India. IIT Delhi offers ICT undergraduates excellent student-teacher ratio, superior connectivity, and opportunities to work in research teams consisting of faculty members, doctoral students and/or post-doctoral fellows. The student management system and learning management system are more developed than the surveyed university in Sri Lanka, a country with a higher GDP per capita than India. Creating such oases with mandates for leadership in higher education is a model worthy of emulation by other developing countries.

Programme-Level Initiatives

At the programme level, ICTD education is encouraged in a number of ways. Firstly, although it is ultimately based on the preferences of students and faculty members, about 10 per cent of computer science and engineering student projects are estimated to be ICTD-related. Secondly, students are encouraged to contribute solutions to issues faced by the university community, which give students exposure and experience in applying ICT solutions to real-life problems. Students' participation in addressing institutional needs may contribute to their course credits. Thirdly, guest lecturers that give talks on ICTD can encourage computer science and engineering students to consider channelling their efforts to ICTD initiatives. Fourthly, the faculty's own research agenda and outreach activities with NGOs influence its course delivery and engagement with students, and may have inspired students to explore ICTD initiatives.

Gender Imbalance

The study found significant gender imbalance in enrolment. The origin of this imbalance seems to be rooted in high entrance requirements. The national policy has specific provisions for equal female opportunities in India's constitution, specific legislature and acts, yet the gap remains. To address the gender imbalance, the AICTE purports that a holistic approach is required, covering all levels of education.[37]

Fewer specific policies can be found at the institutional level. One recent attempt to address this gap institutionally by the IITs has been to reduce the entrance test fee to half for women.[38] No other gender policies, other than indirectly through targeting those belonging to underprivileged castes/tribes, are specifically addressing this gap at an institutional level.

[37] Ministry of Women and Child Development, Government of India, "Report of the Working Group on Empowerment of Women for the XI Plan", 2006. Available from http://www.aicte-india.org/downloads/woman_empowerment.pdf.

[38] Fairy Dharawat, "Girls admission in engineering colleges increase by 1 %", 20 August 2015. Available from http://www.embibe.com/100marks/girls-admission-in-engineering-colleges-increase-by-1.

The concerted effort made by Stanford University is an insightful reminder that female students are interested to enrol in computer science and engineering programmes, and institutional-level strategies have been successful in increasing female participation in computer science and engineering education.

Concluding Remarks

An outstanding feature of IIT Delhi, and other IITs, is the generation of educational content for other IHLs in the country. While no ICTD content was found in the computer science and engineering curricula, the application of ICT for socioeconomic development has been experimented in the form of student projects as well as within the campus. It is expected that efforts in this direction will be expanded, and more innovative ICTD initiatives will be systematically integrated into IIT Delhi's activities in the future.

Additionally, it will be helpful to strengthen the linkage between the IHLs and policymaking, as many professors were cited as serving various government committees and consultation groups. These occasions present excellent opportunities to reinforce and communicate the importance of ICTD and ICTD education.