

SKILL DEVELOPMENT FOR SCALING UP IT/ITES IN BANGLADESH

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November 1, 2022



Economic Research Group

Human Resource Development for Scaling up IT/ITES Firms, and Leveraging Digital Entrepreneurship and Innovations

An Assessment of Training Needs

November 1, 2022

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Executive Summary

The overarching objective of this study is to recommend BHTPA ways to scale up IT/ITES firms and leverage digital entrepreneurship and startups through skill development. In this regard, BHTPA would like to know what kind of skill development programs BHTPA should embark on to upskill whom and how. To address this overarching issue, the study reviewed growth models of IT/ITES firms to highlight the role of skill development to scale up those firms. The report draws lessons from several IT/ITES success stories from Asia Pacific regions and discusses the opportunities and challenges to scaling up Bangladesh's IT/ITES sector through skill development.

Historically, Bangladesh attempted to replicate India's remarkable success in the IT service export market. For leveraging wage differential, Bangladesh focused on skill development and infrastructure advancement. Despite the progress of skill development through training, Bangladesh's success to transfer that advancement to scale up the IT/ITES industry has been very limited. For example, in addition to 150+ public and private universities, two training institutions alone trained more than 100,000 youths with IT/ITES skills. Several of these training programs were funded by loans provided by Asian Development Bank and the World Bank. Furthermore, reputed foreign institutions were engaged to deliver some of the training programs that were funded from the loans. The present report notes that several outlets of foreign training institutions provided numerous trainings in Bangladesh over last two decades. While linear model of service export had successes in scaling up the IT/ITES industry in some countries like India and the Philippines, the report argues that Bangladesh is unlikely to realize similar success by following the same route.

In the early 1980s, Indian IT firms struggled to find a scalable growth path as they were focusing on customized application delivery in serving the domestic market. Fortunately, scalability showed up due to the opportunity of supplying skilled IT/ITES human resources to the global clients, as opposed to developing software for the clients. Due to growing demand, Indian firms concentrated on training fresh graduates with certified IT/ITES skills and offering them to foreign clients to lease, establishing the prospect of the 'linear model' to succeed. For being an early entrant, India had rapidly harnessed economies of scale, scope, and network externality effects, creating barriers to followers to replicate the success. Historically, Bangladesh followed India and attempted to replicate the linear model success. Hence, such attempts, with similar skill development activities, by a late entrant Bangladesh proved unsuccessful in spite of favorable wage differentials. Therefore, for scaling up Bangladesh's IT/ITES industry through skill development, there is a need for BHTPA to have deeper insights.

Upskilling for scaling up existing IT/ITES industry's linear and customized application delivery models: Despite the focus on skill development through training, the study finds that professionals working in the IT/ITES industry of Bangladesh find conventional certificate-based training far less effective than other channels. Furthermore, employers are after university graduates of computer science and engineering (CSE) programs as opposed to recruiting certified professionals of any disciplines. Despite rapid growth of university level CSE programs and enrollments, skill gap exists. The Study finds that as high as 39 emerging IT/ITES skills are not covered by existing academic programs and there are options to integrate some of those within the existing programs. The remaining ones could be addressed through offering new courses and trainings. Furthermore, internship could be strengthened to reduce the gap substantially.

In addition to entry level skill gaps, skill requirement in the IT/ITES industry has been rapidly changing. Interestingly, more than 90 percent respondent professionals reported self and on-job learnings as the most effective means for upskilling. Despite the prevailing dissatisfaction with the gap between industry and academia, professionals reported that academic courses, projects, thesis and internship have been playing very important role in addressing the upskilling requirement. Among the potential channels, conventional training has the least traction. Furthermore, efficacy of self-learning depends on academic foundation, and on prior management and soft skills. Particularly, for soft skills, long conducive association is needed, which cannot be addressed through short training. Besides, the study finds that universities have a large pool of qualified faculty members. Though not exhaustive, the list is submitted for BHTPA's future pursuits.

With the given skill gaps, as well as with the challenges and feasibility to address those, the study recommends linking university programs with the industry. Due to the industry's preference of recruiting university graduates from CSE and other technical disciplines/programs, recipients of upskilling should ideally be undergraduate and graduate students of Computer Science and Engineering, Electrical and Computer Engineering and other related disciplines. However, for digital entrepreneurship, innovation, and business process reengineering, graduates of other disciplines having functional background could also be target recipients.

Recommended delivery channels include (i) linking existing academic programs with industry demanded skills, (ii) focusing on developing management and soft skills through academic activities and Internships, and (iii) patronizing industry-university joint R&D programs. In certain cases, trainings may also be arranged. In pursuing the latter, the 31 laboratories, which were set up by the BHTPA at various universities, should be leveraged. Due to growing female student population at universities, there will be little or no barrier to their entry into the proposed upskilling programs. Such university-industry linkage-based upskilling is highly recommended for improving self-learning ability and creating sustainable channel of upskilling. Due to the rapid change of skill requirement and high efficacy of self-learning, it is recommended that BHTPA makes gradual transition from offering standalone certificate-based training activities to a facilitator in developing a robust ecosystem for sustained learning. BHTPA may serve the upskilling purpose better by facilitating stronger academic foundation, better linkage, and higher self-learning abilities. In the transition period, both training and linking academic institutions with the industry could be pursued.

Skills for creating digital entrepreneurship success and entering exponential growth path through intellectual asset development and trading: Although the current IT/ITES industry in Bangladesh is mostly busy in offering services out of technical skills remaining stranded in linear growth path while some of the leading countries avail higher scale and scope advantages, higher growth path may be achieved by developing and trading intellectual assets (IA). For example, India and Malaysia's high-tech industry are following the linear model. Due to scale, scope and externality effect, Bangladesh has been facing high barrier to replicate their successes. Hence, Bangladesh should consider focusing on IA for finding exponential growth path, which could be leveraged for scaling up customized application delivery and linear models. Particularly, in the IT/ITES sector, the prospect is very high due to the zero cost of copying software and content. Furthermore, progress in developing and trading IA will increase the valuation of startups and increase the capacity of digital entrepreneurs and startups to leverage private equity and venture capital funds. Despite high possibility, there are significant weaknesses in current knowledge, skills and in the functioning of the market. Hence, this study recommends that BHTPA can focus on developing skills and creating market for leveraging the scope of intellectual assets—with the intent to avail exponential scale advantage.

Skills and Policies for leveraging Semiconductor industry: For expanding the footprint of IT/ITES industry, Bangladesh must exploit the emerging opportunities. One of them is the Semiconductor industry,

which is a 70-year-old industry and by no means, a newly emerging sector. Countries like Malaysia and South Korea got into it in the late 1960s and early 1970s. Upon entering in the semiconductor value chain in the 1980s, Taiwan has created a large high-paying industry in the areas of foundries, fables, and OSAT segments. In the contrary, Bangladesh has made a tiny footprint in the sector with only two chip design firms, employing 300+ professionals and one LED bonding and testing FDI. With the size of the global industry estimated to reach \$600 billion in 2022, and having high prospects for future growth, Bangladesh needs to go much beyond. Fortunately, a large number of universities have been offering courses and programs in the area of chip design. Clearly, an intervention is needed to kick start and scale up, and BHTPA needs to pursue both upskilling and policy reform. In contrast to the services generated out of labor and knowledge along a linear path, BHTPA may consider pursuing the exponential growth path by sowing seeds for creating intellectual asset-based success. One of the prominent examples has been Taiwan. From the very beginning, Taiwan has been learning, assimilating, and advancing by themselves for creating ideas and trading those as features of foundries and chips—an exponential growth model that Bangladesh may find worth pursuing.

Developing and leveraging 4IR skills through sectoral transformation: In the Asia Pacific (APAC), there has been a growing demand for 4IR skills—(i) Artificial intelligence, (ii) Big Data and (iii) Cloud Computing (ABC). But Bangladesh’s IT/ITES industry has been showing a tepid demand. Besides, LinkedIn analytics of skill demands show a growing global demand of ABC skills. Hence, down the road, Bangladesh’s IT/ITES industry will likely be demanding such skills. Fortunately, Bangladeshi universities have a strong faculty pool having relevant academic background. Many of the local universities have been offering courses in relevant areas. Besides, ICT division has been patronizing many post-graduate fellowships and innovation grants for undertaking academic research and R&D works on 4IR technologies and innovation. On the other hand, many of the economic and public sectors are poised to benefit from the transformation out of 4IR technologies. Hence, BHTPA has much to gain from Singapore’s experience in creating footprint to develop transformational map and facilitate the reinvention with 4IR innovation through the collaborative participation of local industry and universities. As a result, local economy and public service will improve, and both demand and supply of industry ready 4IR skills will show up—creating a market. Subsequently, industry will tap into it for exploiting the opportunity of the export market.

Recommendation for training as a transition strategy: Although, strengthening academic institutions and establishing linkage with the industry offers the pathway to develop sustainable skill capacity of the industry, there appears to be a need for intervention through training to address immediate skill gaps. One of the underlying reasons for the need of the training is due to long procedural delay in updating academic programs. Furthermore, academic policy and regulatory institutions such as University Grant Commission (UGC) and BHTPA are not within the same line ministry. Hence, this study has recommended training programs as a transition strategy for addressing the skill base to scale up IT/ITES industry, foster the digital entrepreneurship and leverage unfolding 4IR. In this regard, in section 6.5, skill development in 15 occupations have been recommended. Skills in those occupations are in line with global trend, shaping the future demand in the local industry. It’s recommended that online delivery model should complement the classroom-based approach. However, online channel should not replace classroom-based approach as there is a need for developing soft and management skills, which is vital for developing self-learning ability. Furthermore, special needs of recipients may be addressed by adopting suitable technology assistance.

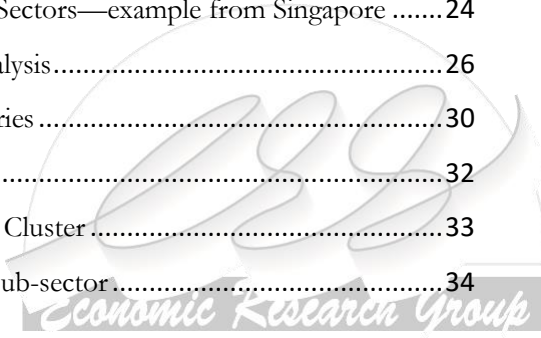
BHTPA would like to scale up IT industry through skill development, which is essential for meeting Bangladesh’s economic aspiration. As explained, standalone certified training has low efficacy, and such a path faces high barrier to scale up IT/ITES industry by replicating the success of early entrants following a linear model. In addition to scaling up linear and customized application delivery models pursued by existing IT/ITES industry, BHTPA has also other options. Three notable ones are skills for (i) developing

and trading intellectual assets, (ii) expanding footprint in the global semiconductor value chain, and (iii) transforming economic and public sectors through 4IR technology possibilities. Furthermore, for efficacy and sustainability, university-industry partnership appears to be the most effective channel. Hence, upon considering all these realities, possibilities and urgency, this study has recommended industry-university centric skill development programs, with the objective of scaling up existing industry, entering new areas, and opening exponential growth path out of intellectual assets. Within this framework training is considered a transition activity.



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List of Acronyms

4IR	Fourth Industrial Revolution
8FYP	8 th Five Year Plan
ABC	Artificial intelligence, Big Data, and Cloud Computing
APAC	Asia Pacific
BACCO	Bangladesh Association of Contact Center and Outsourcing
BASIS	Bangladesh Association for Software and Information Services
BEZA	Bangladesh Economic Zones Authority
BHTPA	Bangladesh Hi-Tech Park Authority
BITM	BASIS Institute of Technology & Management
BTEB	Bangladesh Technical Education Board
DEIEDP	Digital Entrepreneurship and Innovation Eco-system Development Project
e-CAB	E-Commerce Association of Bangladesh
ESCO	European Skills, Competences, Qualifications and Occupations
HR	Human Resource
HTPs	Hi-Tech Parks
IA	Intellectual Assets
ISCO	International Standard Classification of Occupations
IT	Information Technology
ITES	Information Technology Enabled Services
LDC	Least Developed Country
LICT	Leveraging ICT (for Growth Employment and Governance)
OSAT	Outsourced Semiconductor Assembling and Testing
STPs	Software Technology Parks
UGC	University Grant Commission
WB	World Bank



1. Introduction

1.1 Preamble

Bangladesh's rise from the least developed country (LDC) status to lower-middle income level is remarkable indeed. So far, Bangladesh's economic uprising has been rooted in the commercialization of low-end value addition out of labor. To scale-up this success, Bangladesh set targets to achieve upper and high-income country status by 2030 and 2041 respectively. Accordingly, broad vision and strategy have been spelled out in the Perspective Plan 2041 (PP2041, 2020) and in the 8th five-year plan (8FYP, 2021). In those planning documents, it has been clearly stated that the continuation of labor-based low-level value addition is not going to empower Bangladesh to attain the said objectives in the stipulated time frame. Hence, to augment labor-based productive activities, the focus should be on creating economic value out of knowledge and ideas.

To create the capacity of producing economic value out of knowledge and ideas, Bangladesh has made tremendous progress in expanding education system. The current student population appears to be around 50 million. Notably, the expansion of the tertiary education system has been notable. According to a UGC report (UGC2020, 2020), as of 2020, there were 50 public universities. In 2020, these universities, including the national university, had an enrollment of 43,62,187 students. 44% of whom were female students, and female enrollment has been growing ever since. Among the student population of public universities, 3,24,193 students are in natural science, and 69,008 are in engineering and technology. Besides, 50 public universities in 2020 had 15,426 faculty members.

Over a period of last 30 years, there has been tremendous growth of private universities in Bangladesh as well. In 2020, there were 107 private universities with a total enrollment of 3,28,689 students, more than 30% of whom were females. It's quite encouraging to note that private universities in 2020 had 1,38,312 students in Engineering and Technology, the proportion being higher than that of public universities. Furthermore, under Bangladesh Technical Education Board, 617 Polytechnic institutions had enrollment of 1,21,080 students in Diploma in Engineering programs (BTEB, 2019).

For uplifting to higher income level, Bangladesh's opportunity has been to engage this large student population of the tertiary education system into knowledge and innovation workforce. Fortunately, IT/ITES sector has been showing a bright prospect of engaging the growing number of graduates of tertiary education system to produce economic value out of knowledge and ideas. Reportedly, there are more than 1000 startups in Bangladesh (StartupBD, 2020), and 600,000 (or more) freelancers are working as independent contractors in the global marketplace (OLI, 2022). IT-ITESStat (2021) reported 1755 registered IT/ITES companies in Bangladesh, which may have exceeded 1800 by now.¹

So far, taking the advantage of this opportunity has been in the demonstration and low-value addition segment. The challenge is to scale up and migrate to higher value addition. Among the registered companies, some of them are active in serving the export market. According to media report, in reference to BASIS, more than 225 companies from Bangladesh exported software to over 80 countries, generating more than \$300 million in revenue (Hasan, 2021). Furthermore, there has been a steady growth in export.

¹ BASIS membership figure in 2022 exceeded 1800.



Besides, a few foreign companies have captive development centers in Bangladesh in sourcing engineering services. It appears that the availability of quality human resources with right set of skills is a major barrier to the growth of the IT/ITES companies serving the global market. Furthermore, so far IT/ITES companies are mostly busy in exporting services—based on billing hours (referred to as the linear model). Unfortunately, despite the importance, business model of developing and trading intellectual asset is largely absent.

Bangladesh's aspiration to succeed in the global technology trade is often influenced by their neighbor's success. There are however caveats. The Indian success has largely been rooted in wage-differential edge she enjoys in trading technology services in the global market. While neighboring countries, including Bangladesh, may have a larger wage differential, India enjoys economies of scale and scope advantage that her neighbors do not have. Such advantages outweigh the extra wage differential the neighbors may have. In addition, given the huge population in India, the supply never outstrips the global demand. Hence, it will be absurdity to think that the neighboring countries will succeed by following the regional leader.

The above realization led the research team to look inward and reflect on the country's deficiencies, and untapped opportunities. Customized application development model of Bangladesh's IT and ITES firms is not scalable, as they suffer from diseconomy of scale at a very early stage. The latter also explains why Bangladeshi IT/ITES firms are small, and why their gross margin is very low though they offer far lower wages than many other competing countries. As a result, the skill development agenda as demanded by the existing firms do not offer scalable growth path for Bangladesh to achieve its vision. Since BHTPA intends to bring about noteworthy changes in the IT/ITES ecosystem, aligned with the visions stated in the country's policy documents, there is a strong need to look for alternatives to existing local model significantly tied to customized application, startups' subsidy, and to often-prescribed path of following the linear model. Clearly, Bangladesh's policymakers need to outsmart their competitors in rest of the world, and the present report tries to search for such alternatives for developing human resources (HR) in the country.

1.2 Background of the Study

For realizing the goals of Digital Entrepreneurship and Innovation Eco-system Development Project (DEIEDP), BHTPA would like to enhance the skill base. The aims of the skill development programs are to support (i) development of a pipeline of IT and ITES SMEs capable of leveraging private equity and venture capital, (ii) agglomeration of IT and ITES SMEs in Dhaka's Vision 2021 Tower Software Technology Park, and (iii) promotion of digital entrepreneurship more broadly among young professionals and women. Target groups of this skill development are (i) young professionals, (ii) employees, entrepreneurs, and (iii) firms who are in the IT/ITES and Hi-Tech industry supply chain.

Furthermore, for developing a world Class HR in upcoming emerging technologies, BHTPA would like to scale up the skills of target recipients to face the challenges and innovations of the 4th industrial revolution, such as IoT, Data Analytics, Robotic and Cyber Security sector of Bangladesh. Hence, BHTPA would like to find out the gaps in skills available to the IT/ ITES and Hi-Tech Sector in the context of the latest technological innovations and unfolding dynamics.

In this context, BHTPA would like to know (i) the sector trends in skills demand in the upcoming 5 years, (ii) the existing expertise level of the industry, (iii) the skill gaps, (iv) the segments of beneficiaries, (v) feasibility of closing the relevant skills gaps in the market, (vi) involvement of people in the training, (vii) means to fix the performance challenges, and (viii) channels for making training available.

1.3 Objective and Scope of the Study

Objectives

The overall objective of this study is (i) to determine the training needs for the IT and ITES sector and (ii) to obtain recommendations on the training programs so that the sector can scale up. The detailed objectives are (i) to conduct sector/market analysis through studying the short, medium, and long-term demand of skills both at the national and the international level, (ii) to conduct a feasibility analysis (FA) and identify the topics to be prioritized for further analysis, (iii) to conduct a target population analysis (TPA) for determining recipients of skill development services (whom), (iv) to figure out training programs (what), and (v) to determine how the training will be delivered (how).

Scope

The overall scope of this exercise is to determine training need, based on (i) Sector-wise demand analysis, (ii) Available expertise analysis in local industry in present days, (iii) The set of skills to meet the market demand and skill gaps, and (iv) Segments of beneficiaries.

Upon realizing the above, one needs to assess (i) Skill proficiency of those in or entering the labor market, (ii) Extent (frequency) of skill usage and therefore the scale of skills in demand, compared to numbers available in the labor market, and (iii) Level of skills crucial to running business/job performance.

Within this context, the scope of the study are (i) to perform sector/market analysis of skills need and skills gap in the IS and ITES sectors in the short-term (1 year), medium-term (2-3 years) and long-term (4-5 years), (ii) to conduct feasibility analysis regarding a high-level assessment of the capabilities of the providers in skills development currently supporting HTPs and STPs, (iii) to propose a taxonomy for describing skills which is meaningful to employers, described in the context of occupations using a taxonomy such as ISCO or ESCO, (iv) to recommend processes, training programs and qualifications, and propose prioritization, (v) to perform a target population analysis (TPA) to describe the potential recipients of training, (vi) to analyze context to examine the training and the needs of the target population and recommend how training should be delivered, and (vii) to assess the barriers to accessing training and employment which training recipients might experience.

To address the scope, the study will include activities of (i) conducting individual interviews, (ii) having focus group discussions, (iii) meetings with targeted groups/beneficiaries, and (iv) discussing with World Bank, BHTPA, and any other stakeholders if required. Upon analysis, the study will recommend actions for BHTPA to implement.



1.4 Approach, Methodology and Study Design

Based on the situation and context analysis, the study attempted to figure out skill demand, assess trend, profile skill supply capacity, assess efficacies of different channels of skill development, determine skill gaps, figure out feasibility and recommend options to address skill gap for scaling up service and products sub-sectors of the IT and ITES sector of Bangladesh. Skill development areas, target participants, skill development processes and delivery channels, and program design with mapping to ESCO/ISCO taxonomies have also been identified. Besides, the study explores emerging sectors which are at infant stage in Bangladesh.

Based on literature review, KIIs, FGDs, consultations with relevant BHTPA and WB officials/consultants, and prospective tenants of HTPs and STPs, the report rationalizes the selection of sub-sectors and skill development areas, target recipients, process and channels, and subsequently, recommends program activities.

Study methodology comprises of (i) assessing local and global situation, (ii) identifying analytical need, (iii) gathering data, (iv) analyzing data, (v) drawing insights, (vi) deriving recommendations, and (vii) preparing the report. For gathering data, the study used tools like (i) key informant interviews, (ii) focused group discussion, (iii) field visits, (iv) analysis of job postings, and (v) survey. Three different survey tools have been administered for this purpose.

An overview of the study design and execution of plans to collect data and data analysis is shown in the following Table 1.

Table 1: Summary of study tools and their executions

Sl.	Study Tools	Overview of Execution, Data Collection and Analysis
1	Literature review	For gathering necessary data, the Study undertook systematic review of literature pertaining to skill development programs of Bangladesh, India, Indonesia, Malaysia, Taiwan, and Singapore. Study also reviews skill development frameworks of a few countries (India, Singapore, and Taiwan) and development programs of World Bank and ADB.
2	Review of global trend of IT/ITES skills	Country report of emerging IT/ITES skills produced by LinkedIn on countries like India, Indonesia, Malaysia, Thailand, Australia, the USA and Canada were reviewed.
3	Dissection of job postings	Recent job postings in the area of information technology at BDJobs (https://www.bdjobs.com/) were analyzed, skills were identified, and frequency analysis was performed. Furthermore, job postings on chip design at https://www.naukri.com/ were reviewed.
4	Key informant interviews	Information was gathered from directors of BASIS, e-CAB, and BACCO, and CEO/COO/Director of prominent firms like Spectrum, CSL-resources, BJIT, Viser, Dream71, Brainstation, Bondstein, Enosis, Cefalo, BiTM, Kotha and Selise, and faculty members of universities.

Sl.	Study Tools	Overview of Execution, Data Collection and Analysis
5	Getting feedback from Stakeholders	At the very beginning, a consultation meeting took place with the representatives of World Bank and BHTPA
6	Review of ICT fellowships and innovation grants	82 ICT fellowships and 89 innovation grants offered by ICT division in the fields of emerging technologies and IT/ITES were reviewed, and relevance to supply of emerging skills (pertaining to 4IR) was mapped.
7	Review of BHTPA training programs	Mapping of BHTPA-conducted training programs was done.
8	Profiling of faculty members of universities	Profiles of 1400+ faculty members of 30 public and private universities having credentials in the broad of area of emerging technologies, and IT/ITES were reviewed, and frequency map was developed.
9	Profiling of BHTPA setup labs	Review of BHTPA setup 31 specialized labs in universities was done and mapping to study objective and scope was prepared
10	Profiling of 4IR, IT/ITES courses	Academic programs of 30 universities offering courses in AI, Machine Learning, Robotics, and IT/ITES related areas were profiled
11	Profiling of IT/ITES professionals	A survey instrument using Google Form was developed and used administered over 10+ firms, and 120+ professionals responded.
12	Profiling of HTP and STP tenants	A survey instruments was developed and sent to all HTP and STP tenants and follow-up was maintained to receive firm level inputs
13	Mapping of emerging IT/ITES skills with academic programs	An editable pdf file for gathering inputs from 89 university faculty members from 25+ public and private universities for gathering inputs on how to establish linkage with 39 skills to academic programs was sent and followed up over the telephone.
14	FGD with tenants of STP/HTP and at CUET	An FGD was conducted with the tenants of Vision Tower and representatives of BASIS, BACCIO and eCab was conducted to figure out skill gap for scale up. Two FGDs were conducted at CUET— first one with faculty members and the other one was with startups. Another FGD was conducted with the tenants of HTP at Kaliakore.
15	Getting feedback from BHTPA	Study progress was reported to BHTPA representatives and feedback was received
16	Profiling of academic programs of Polytechnic	The review of courses of selected Polytechnic Institutions as shown in Appendix H indicates that Diploma level programs have been developing IT/ITES skills, at the low end though.
17	Profiling of training institutions	Profiling of 06 training institutions has been done.
18	Interviewing female professionals	Female professionals were interviewed. As the recommended upskilling program is based on industry-academia collaboration and there has been high

Sl.	Study Tools	Overview of Execution, Data Collection and Analysis
		enrollment of female, female participation will be ensured.
19	Data analysis and insights gathering	Both qualitative and quantitative analysis on gathered data were performed to find insights within sound theoretical framework, and skill mapping was done with ISCO
20	Recommendations	Recommendations about process, framework, channels and programs (with applicable ISCO) mapping has developed and documented as part of this report.

1.5 Outline of the Report

Section 1 laid out the background, objective, scope, approach, and methodology of the study. The previous sub-sections had also described the design and execution of different study tools. In addition, the preamble at the beginning of this section explicitly noted the need for widening the focus. It was argued that the prospects for Bangladesh's IT/ITES industry lie in exploiting the possibilities of knowledge and ideas.

Since IT/ITES firms often commence their journeys as startups, and survey information is more readily available on startups, Section 2 presents an overview of the IT/ITES sector. It also reviews the startup landscape in Bangladesh and what it takes to increase capacity of startups for making better usage of private equity and venture capital fund. Untapped growth potential of Bangladesh's IT/ITES sector is introduced in Section 3 in two segments. The first outlines different growth models and argues why, given the regional experiences, Bangladesh has little to gain by following the path underlying linear growth model of the industry. The chapter also discusses at length an alternative pathway to follow by exploiting intellectual assets and engaging in feasible activities within the semiconductor industry. The chapter reviews unfolding prospects of semiconductor industry, Bangladesh's entry, capacity and possibility of scaling by exploiting possibilities. Since the experiences of Malaysia, India and Taiwan in exploiting potentials in semiconductor industry through skill development are relevant for Bangladesh's learning, those have been reviewed as well. The global skill trend analysis, elucidated in that Section, is based on emerging skills in selected countries of APAC, and LinkedIn's insights.

Section 4 sheds light on global trend of IT/ITES skills and skill framework, and local demand as well as supply capacity of skills. Upon drawing lesson from global trend, the report proceeds to share insights about the skill demand in local industry. Dissections of recent job posting at BdJobs, profiling of IT/ITES professionals, and survey result of HTP/STP tenant firms provide insights about skill demand, target recipient groups, and efficacies of different channels for skill development. Based on profiling of universities, BHTPA's labs, ICT fellowship and innovation grants, polytechnic institutions and training centers, this section also provide insights of potential skill supply capacity. Section 4 also outlines the skill development frameworks of Taiwan and India

Based on the analysis of the data and findings of previous chapters, Section 5 proceeds to detect skill gaps, feasibility of addressing it, identify target skill recipient groups, and highlight efficacy of different delivery channels. The concluding section (Section 6) begins with the summary of findings, followed by observations on how study objectives have been addressed. The section provides remarks on different skill development

approaches within the context of BHTPA's objective. Towards the end, summary answers to several vital questions are provided for quick reference. The concluding section also provides indicative time frame and tentative cost elements involved in the proposed program for skill development.



2. Overview of IT/ITES Sector of Bangladesh and Leveraging Digital Entrepreneurship through Skill Development

2.1 Overview of the IT/ITES Sector of Bangladesh

Over the last decade, Bangladesh has made significant progress in laying the foundation for underpinning the growth of the IT/ITES sector. Along with the progress of purpose build infrastructure like 39 high-tech and software technology parks, enrolment in tertiary education reaching 3.8 million, vibrant start-up ecosystem, internet penetration crossing 100 million, industry need focused training and management capacity uplifting, offering of science and technology education by more than 150 universities and 50+ Polytechnic institutions, growing consumption of mobile handsets, computers, and household technology appliances reaching over \$2 billion, rolling out of critical services over digital channels, unfolding of reasonably-cost global connectivity through multiple fiber optics links and Bangladesh’s own satellite, and investment-friendly public policies and incentives are among the major growth drivers of Bangladesh’s IT sector. Locations of a few high-tech parks and their benefits are shown in Fig. 1. Success stories in the space of digital services like digital financial services leading to a cashless society, e-Commerce, software innovations, start-ups, high-tech assembling, and global outsourcing at the online marketplace have already started to emerge.

28 Hi-tech parks planned with ample land availability

Significant supporting infrastructure and ICT infrastructure coverage

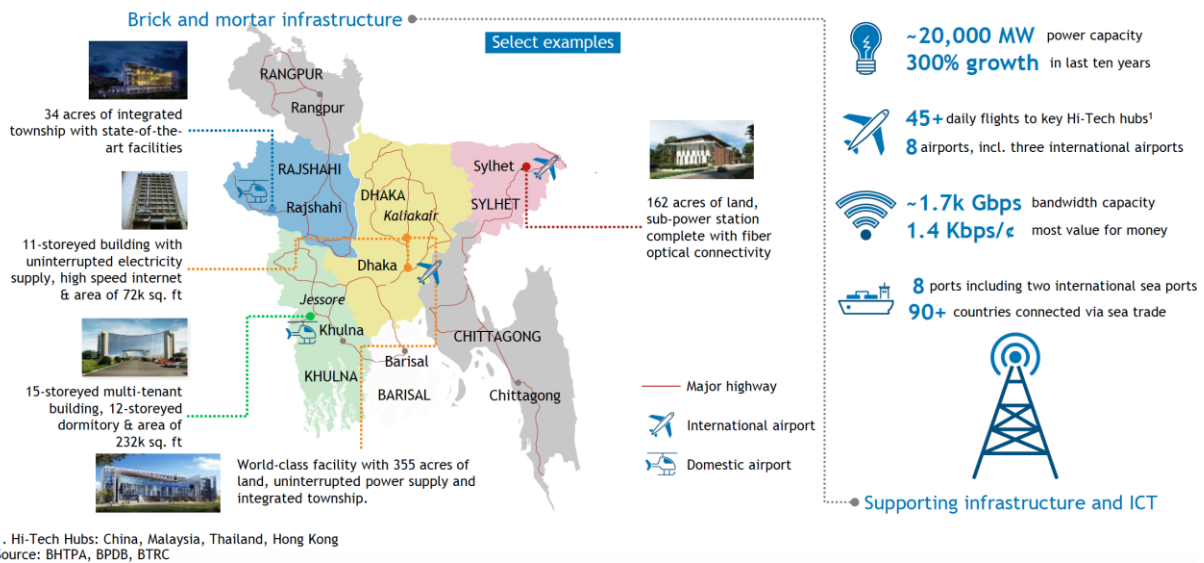
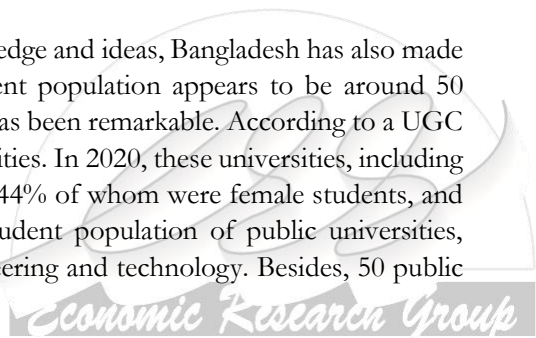


Figure 1: Selected high-tech parks are being developed in Bangladesh

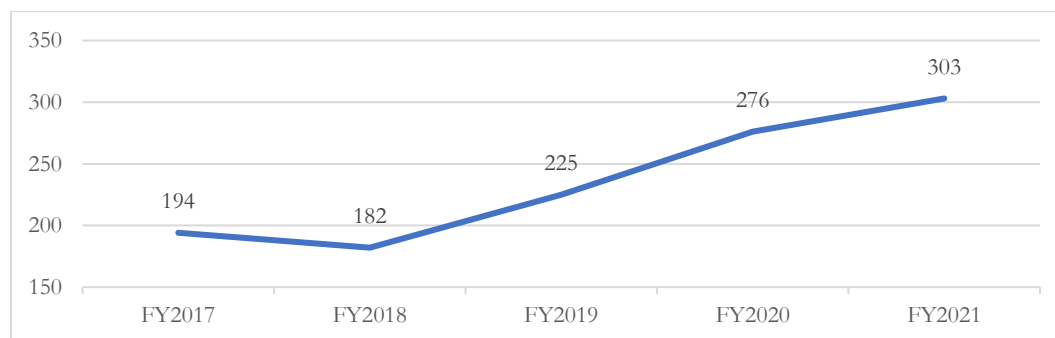
To create the capacity of producing economic value out of knowledge and ideas, Bangladesh has also made progress in expanding the education system. The current student population appears to be around 50 million. Notably, the expansion of the tertiary education system has been remarkable. According to a UGC report (UGC2020, 2020), as of 2020, there were 50 public universities. In 2020, these universities, including the national university, had an enrolment of 43,62,187 students. 44% of whom were female students, and female enrolment has been constantly growing. Among the student population of public universities, 3,24,193 students are in natural science, and 69,008 are in engineering and technology. Besides, 50 public universities in 2020 had 15,426 faculty members.



Over a period of last 30 years, there has been tremendous growth in the number of private universities in Bangladesh. In 2020, there were 107 private universities with a total enrolment of 3,28,689 students, more than 30% of whom were females. It's quite encouraging to note that private universities in 2020 had 1,38,312 students in Engineering and technology, the proportion being higher than what public universities had. Furthermore, under Bangladesh Technical Education Board, 617 Polytechnic institutions had an enrolment of 1,21,080 students in Diploma in Engineering programs (BTEB, 2019).

For moving ahead to a higher income level, Bangladesh's opportunity lies in engaging this large student population of the tertiary education system into the knowledge and innovation workforce. Fortunately, the IT/ITES sector has been showing a bright prospect of engaging the growing number of graduates of the tertiary education system to produce economic value. So far, taking the advantage of this opportunity has been in the demonstration and low-value addition segment. The challenge is to scale up and migrate to higher value addition. Among the registered companies, some of them are active in serving the export market. According to a media report, in reference to BASIS, more than 225 companies from Bangladesh exported software to over 80 countries, generating more than \$300 million in revenue (Hasan, 2021). Furthermore, there has been a growing trend in export, as shown in Figure 2.

Figure 2: Export Trend in Bangladesh's IT/ITES Service (million USD)

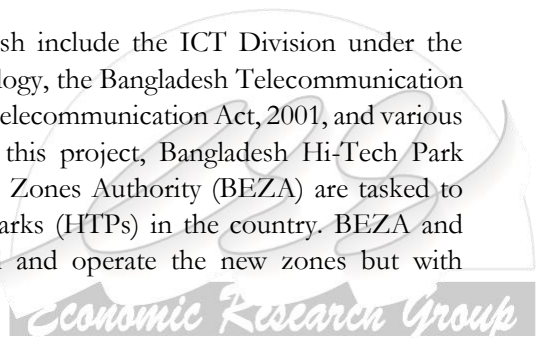


Source: EPB

Reportedly, there are more than 1000 startups in Bangladesh (StartupBD, 2020), and 600,000 (or more) freelancers are reportedly working as independent contractors in the global marketplace (OLI, 2022). IT-ITESStat (2021) reported 1755 registered IT/ITES companies in Bangladesh, which may have exceeded 1800 by now.

Furthermore, a few foreign companies have captive development centers in Bangladesh for sourcing engineering services. It appears that the availability of quality human resources with the right set of skills is a major barrier to the growth of the IT/ITES companies serving the global market. Furthermore, so far, the IT/ITES companies are mostly busy exporting services—based on billing hours (referred to as the linear model). However, a business model of developing and trading intellectual assets is largely absent. Literature on the demand side of the IT/ITES Sector of Bangladesh is scarce and it has been primarily covered in the analysis portion of this study.

The regulatory bodies within the IT/ITES sector of Bangladesh include the ICT Division under the Ministry of Posts, Telecommunications and Information Technology, the Bangladesh Telecommunication Regulatory Commission (BRTC) founded under the Bangladesh Telecommunication Act, 2001, and various Government agencies under the ICT Division. The client of this project, Bangladesh Hi-Tech Park Authority (BHTPA), and another agency Bangladesh Economic Zones Authority (BEZA) are tasked to oversee the expansion of economic zones (EZs) and hi-tech parks (HTPs) in the country. BEZA and BHTPA rely mainly on private capital and expertise to build and operate the new zones but with government oversight



2.2 Leveraging Digital Entrepreneurship through Skill Development

Part of the HTPA's skill development program has been to support (i) the development of a pipeline of ITS and ITES SMEs capable of leveraging private equity and venture capital, (ii) agglomeration of ITS and ITES SMEs in Dhaka's Vision 2021 Tower Software Technology Park, and (iii) promotion of digital entrepreneurship more broadly among young professionals and women. Target groups for this skill development are stated to be (i) young professionals, (ii) employees, entrepreneurs, and (iii) firms who are in the IT/ITES and Hi-Tech industry supply chain. Given such mandates, it is important to get an overview of the startup landscape in Bangladesh.

2.2.1 Overview of Bangladesh's Startup Landscape

Growing adoption of smartphone and internet density has been opening up digital transformation of major sectors. According to the media report in 2022 (Hasan, 2022), as high as "48% mobile phone customers in Bangladesh have a smartphone." Hence, like many other countries, there has been a growing startups population in Bangladesh. A study (StartupBD, 2020) estimates that there is approximately 1000+ startups in Bangladesh. These startups are distributed in 17 categories, as shown in Table 2. Among these 1196 startups, more than 900 are in Dhaka, and almost 100 are in Chittagong. It appears that most of the startups are led by university graduates as shown in Fig. 3, and nurturing startups has been their full-time jobs (Fig. 4). Unlike the advanced countries, only 1 percent of the startups in Bangladesh operate from university owned facilities. This study finds that 82 percent of the startups in Bangladesh referred to "Financing" as the topmost barrier. Such a finding appears to be in line with the observation that startups in Bangladesh are after subsidies in developing the customer base of their offering in the digital space. The market has been referred to as the most difficult barrier. Perhaps this is due to the fact that customers are not finding enough value in the offerings, leading to inadequate willingness to pay. It appears that as high as 70 percent of the startups are driven by entrepreneurs in a full-time manner.

Table 2: Estimated number of startups by sector of economic activity (N=1196)

Sl.	Target Sector	No. of Start-ups	%
1	E-commerce/Marketplace	272	21%
2	Digital Service	171	13%
3	Health, Food Processing, Medicine, Medical Treatment	165	13%
4	Education	150	12%
5	Transportation	60	5%
6	Agriculture	59	5%
7	Media & Entertainment	56	4%
8	Manufacturing	47	4%
9	Tourism	43	3%
10	Financial Service	38	3%
11	Infrastructure	41	3%
12	Environment/Weather	31	2%
13	E-Governance	19	1%
14	Social Media	27	2%
15	Power/Energy	11	1%
16	RMG Sector	9	1%
17	Legal	2	1%
	Others	74	6%

Source: StartupBD, 2020

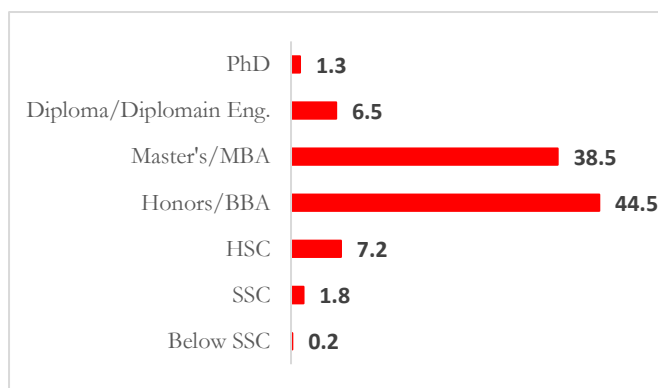
It's worth noting that although there have been recent developments in startups in Bangladesh, the study could not find additional recent secondary sources in providing added clarity about skills for startups. For example, the following two websites track recent news on fund raising, merger and acquisition, but not on skill needs or number of firms:

<https://www.lightcastlebd.com/startup-dashboard/> and
<https://www.crunchbase.com/hub/bangladesh-startups>.

2.2.2 Skill Requirements for developing Digital Entrepreneurships

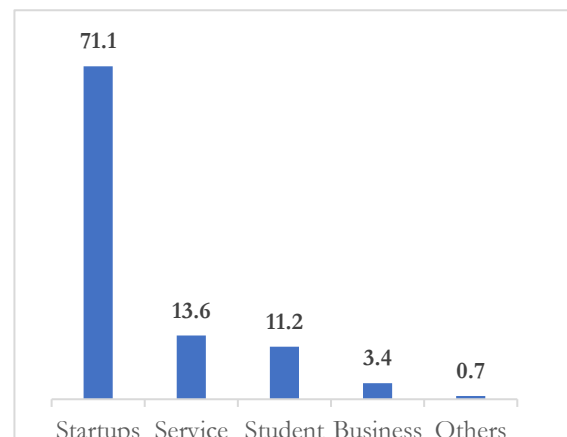
The focus has been on the integration of available technologies for transferring services to the digital space. The underlying thesis has been that the sheer benefit of facilitating service consumption over the digital platform has been good enough to make them better substitutes to existing approaches. Hence there has been a very weak focus on R&D and the development of patentable ideas. As a result, despite huge growth in startup number and equity funding, there has not been proportionate growth in patent filling in the local office. Hence, there is a need for uplifting **skills in the area of R&D management, intellectual assets, innovation, and technology**. Further clarity has been derived from an FGD with startups held at the incubator premises at CUET campus, as shown in Box 1.

Figure 3: Academic background of entrepreneurs



Source: StartupBD, 2020

Figure 4: Occupation of founders

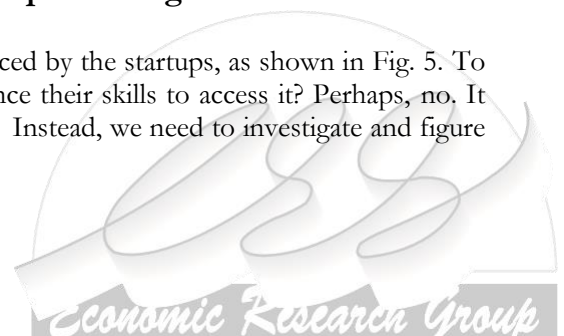


Source: StartupBD, 2020

Although, for certain services like money transfer, the sheer benefit of digitization may sound good enough to create a profitable willingness to pay among a large group of customers that has not been the case in many other applications. For example, app-based food ordering and delivery add substantial costs over dine in options. But, the sheer benefit of placing orders and monitoring the status of the delivery is not sufficient enough for encouraging an additional amount to offset delivery cost. Similarly, app-based ridesharing or e-commerce is failing to make it a cheaper alternative to conventional taxi services. It seems that local startups have substantial weakness in *leveraging technology innovation to keep increasing quality and reducing cost*.

2.2.3 Financing and Systematic Weakness in Startups of Bangladesh

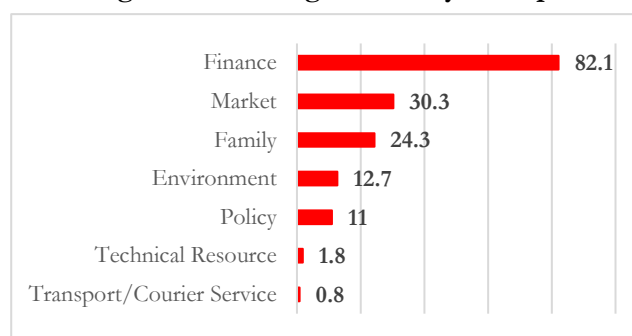
A recent study finds that access to finance is a major barrier faced by the startups, as shown in Fig. 5. To address it, should we increase the source of finance and enhance their skills to access it? Perhaps, no. It runs the risk of increased liability with the growing failure rate. Instead, we need to investigate and figure



out the purposes for which they need financing and whether there are solutions to their journey of developing profitable business innovation. Hence, questions like what could be a better alternative and what is the skill base needed for taking advantage of it? deserve investigation.

For creating a customer base for their products in the digital space, local startups are offering subsidies. So far, as shown in Table 3, personal savings is the major source. The thesis has been that once experience and information gap of service consumption over the digital platforms is addressed, customers will be willing to pay a premium for turning their loss-making revenue into profit. Hence, from startups, argument in favor of giving subsidies is very strong.

Figure 5: Challenges faced by startups



Source: StartupBD, 2020

This thesis of subsidy driven customer base development appears to be unsustainable. There is no denying that such an approach contributes to reduce customers' experience and information gap. But, in many cases, the value proposition is not strong enough to reach a profit, even once the gap is addressed. For this reason, perhaps, loss in global flagship startups has been increasing (AsiaTech, 2021) -- Gojek wrote off a \$17m loan to Pathao. Hence, there has been a strong focus on profit in India's startup space (EconomicTimes, 2020). In absence of profit, even upon listing on the stock market, late-stage investors are failing to find a profitable exit path. Profitless revenue growth is no longer sufficient for creating a startup success story (ForbesCasper, 2020).

Although startups are after expanding the customer base through subsidies and increasing valuation for drawing further investment to sustain loss making operations, however, investors are losing interest in providing additional funds. Investors are increasingly getting impatient to see the clear path to profitability. It appears that most of the startups pursuing digitalization of services are not in any position to meet such an expectation. Hence, there is a strong possibility that the startup rush in Bangladesh is running the risk of high mortality. Therefore, focus should be on finding means for increasing the value proposition and reducing the cost.

Table 3: Sources of Finance

Sources of Funds	All	Sources of Funds	All
Personal savings (Cash)	88.5	Bank loans	3.8
Cash from friends	14.6	Informal loans	2.7
Government funds	9.8	Venture capital funding	1.3
Cash from parents	9.2	By selling land/property	1.1
Partner	7.2	No investment	0.5
Non-government support/grant	6.9	Angel funding	0.4
Cash from relatives	4.3	Base - All Respondents	553

Source: StartupBD, 2020; note: role of venture capital financing from has substantially gone up from 1.3% in 2020 due to recent surge—particularly, due to the success of bKash to raise \$250 million and ShopUp to rise \$75 million.



2.2.4 Profiling of Selected Digital Entrepreneurs

A section of startups in Bangladesh has been profiled in Appendix B. Among the 13 prominent digital startups, bKash, ShopUp and Pathao have been at the top in fund raising. But none of them are running at profit. It's quite surprising that the loss of bKash has been rising constantly (bKashGrowingLoss, 2020). More or less, all these startups are after imported technology integration base roll-out of innovations out of subsidies. Hence, patent office data do not reflect their progress in making their offering better and cheaper and increasing valuation out of additional flow of ideas. There should be a growing focus producing new ideas and keep improving them through a flow of ideas. Despite it, some of these startups have become target of foreign investments. For example, recently, bKash succeeded to raise \$250 million from Japanese Softbank. Another notable success is ShopUp's \$75 million in Series B and \$22.5 million in Series A (FEShopUp, 2021). In general, there has been a growing trend in funding in startups in Bangladesh. For example, in 2021, Pathao, Paperfly, Praava, Chaldal and Shohoz raised \$35 million, \$11.8 million, \$10 million, \$10 million and \$25 million respectively (DTstartup, 2022).

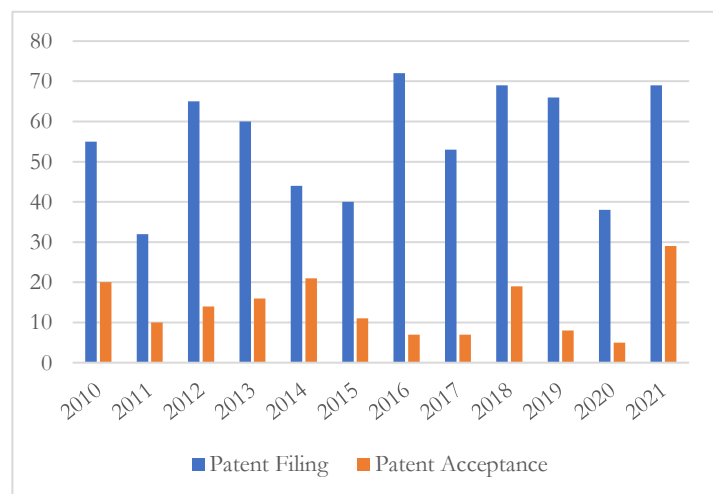
2.2.5 Skill Gaps for Venture Capital and Private Equity for Growth

Venture capital and private equity funds are after profiting from the exploitation of untapped digital innovation opportunities. However, irrespective of the greatness, all innovations begin the journey at a loss. Furthermore, as shown in Appendix B, some of the digital startups appear to be late-stage local adaptations of foreign ideas. For example, ride sharing ones seem to be adaptation of Uber in serving local unique requirement. Similarly, many of the e-commerce startups appear to be adaptation of Amazon by taking into consideration of local situation and customer preferences. To roll out their ideas and keep expanding the market base, they have been after subsidies. Although the need for subsidy in the early days appears to be indispensable, there is a scope to keep reducing it and turning the loss into profit by addressing unique local requirements with a flow of ideas. The challenge is to reduce the loss through quality improvement and cost reduction. Hence, there has been a growing realization that the focus should be on innovation, instead of subsidies, for creating startups success stories out of venture funds and equity capital.

Although startups in Bangladesh have become successful to raise private equity and venture capital funds through subsidy-based customer acquisition or gaining markets model (as shown in Appendix B), there has been a growing concern about the sustainability and the wealth creation. Some reported unethical practices in the e-Commerce startups space appear to be attributed to the non-sustainability of this model. However, measures could be taken to help the sector to overcome such barriers.

Fortunately, there have been a better alternative to leverage private equity and venture capital fund. That is about managing the growth of innovation out of R&D, intellectual capital development, and innovation management. For example, Amazon has converted the losses relating to e-trading of paper books by turning conventional books into eBooks. To make it happen, Amazon had to manage a long journey of R&D management and intellectual asset development. Furthermore, focusing on R&D in producing intellectual assets in the form of patents also increases the valuation. But it seems that the startups in Bangladesh are not after R&D for patents. As a result, there has been no noticeable progress in patent filing in Bangladesh (Fig. 6). Hence, for leveraging private equity and venture capital fund for leveraging digital

Figure 6: Patent filing and acceptance at the patent office of Bangladesh by local entities



Source: developed by the study, based on data available at <http://www.dpdt.gov.bd/site/page/cda6b625-2ebd-4354-bc48-46e40c14656d/->

entrepreneurship, SME, and startup opportunities, the skill development focus should be on R&D, R&D management, and management of innovation and technology. In the absence of it, increasing the flow of funds or enhancing the skill of raising more fund to finance the subsidy driven model run the risk of increased liability and failure stories. It's worth noting that the lack of success among the Indian startups has been attributed to a lack of innovation, not finance (IndiaStartupsFail, 2017). In Bangladesh, despite the emergence of as high as 1000 startups, there has been no progress in filling of patents, as shown in Fig. 6.

Box 1: Feasibility of fostering and Scaling-up Digital Entrepreneurship through Training

As part of the study, BHTPA organized a focused group discussion with startups at the ICT business incubator premises of Chittagong University of Engineering and Technology (CUET). These startups are now housed at the BHTPA's software technology park at Agrabad, Chittagong. The discussion revealed that these startups are mostly after imitating well-known startup ideas like e-commerce, technology training tool kits, digital content sharing platforms, etc. They are currently facing difficulty to ensure profit and expand revenue due to intense competition and lack of effective demand for their offerings. In an ideal setting, they would have to create differentiation through flow of new ideas, backed up by systematic R&D capacity for creating intellectual asset base and integrating those into commercially viable products and processes. Such capability cannot be developed through short-term training. It was also found that participating startups are unaware of the necessity of systematic idea generation, gathering, screening, and selecting, let alone feeling the requirement of skills. Furthermore, there is a lack of awareness about the necessity of attaining economies of scale, scope, and network externality effects--let alone having the skill sets. The research team concluded that the participating startups do not have a basic understanding of core issues for selecting ideas and scaling those into viable businesses. Although these startups may have gained technical competence in technology integration and demonstration, they do not have the competence in R&D for managing and nurturing innovations. In the absence of it, these startups run a high risk of failure once BHTPA's supports dry out.

Hence, it's recommended that the skill base for fostering and scaling up digital entrepreneurship should be done in close association with academic programs (see, Box 2). Clearly, it is not feasible to foster and scale up Digital Entrepreneurship through short-term training with inadequately developed intakes.



3. Untapped Growth Opportunities: Scaling up through Skill Development

Bangladesh has the prospect to scale up the growth trend and increase value addition for establishing itself as a strong delivery node in respective global value chains. In order to realize this, Bangladesh needs to capitalize the mental capacity of growing number of graduates to generate and trade ideas. BHTPA’s skill development program is very much in line with the scaling up agenda of Bangladesh’s IT/ITES sector. Fortunately, unlike many other industries, IT industry offers the opportunity of starting the journey with low-cost labor advantage, while giving the option of moving up the value chain through idea trade. The study took this prospect into cognizance. The present section introduces three business models for scaling up (in 3.1) IT/ITES firms, discusses selected challenges of developing digital entrepreneurship (in 3.2) and discusses the prospects associated with the growth of semiconductor industry (in 3.3).

3.1 Business Models and Scalability in the IT/ITES Sector

There are three predominant business models in the area of software, IT and ITES sectors. Those are: (i) offering services based on hourly basis, termed here as linear model, (ii) producing and trading intellectual assets, and (iii) customer specific customized application development. The production functions of these models are shown in Fig. 7, Fig. 8 and Fig. 9 respectively.

Work for hire—linear model:

Per-person billing—India’s success story out of linear model is remarkable indeed (as shown in Fig. 7). Growth is only limited by the demand and supply of programmers—leading to a huge scale advantage. Due to India’s early lead and huge supply capacity, Bangladesh could not benefit from following this model. But fortunately, a few firms started showing the possibility. They are after offering software development professionals to startups of the advanced countries.

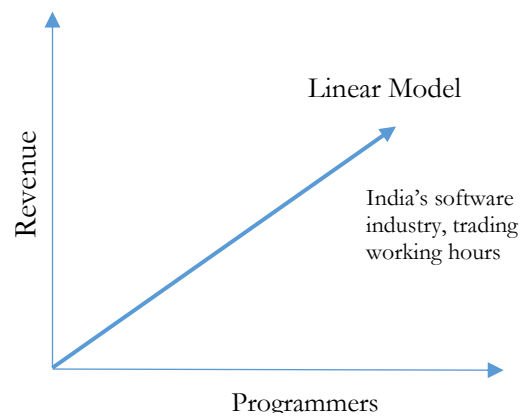


Figure 7: Revenue linearly grows with the number of programmers leased to clients

Trading software asset: leverage scale opportunities from zero cost of copying software

To be on an exponentially growing revenue path, focus should be on reusability for selling the same software assets to a growing number of customers. Due to zero cost of copying, this model offers exponential advantage (as shown in Fig. 8). However, it demands R&D investment for creating willingness to pay among growing number of customers.

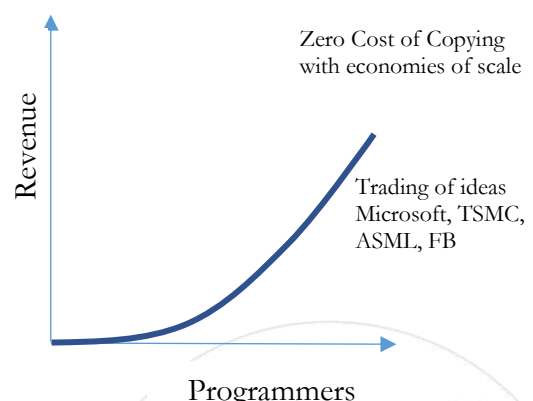


Figure 8: Exponentially growing Revenue with Intellectual asset trading

Customized software production:

Often, software firms begin the journey for delivering customized applications. The production function of this business model takes S-curve like shape, as shown in Fig. 9. Due to the complementary role—there is a bit of signature of exponential growth at the beginning. As a firm keeps adding more professionals for performing same task, such as, coding or requirement capturing, and pursuing strict policy of job division and specialization, total revenue stops growing linearly. Here are few causes: (i) waiting time due to interdependence, (ii) rework due to introduction of errors for

miscommunication, (iii) weaker reusability due to knowledge gap. To overcome it, focus should be on creating optimum workload, standardization, process maturity and so on. This is the underlying cause of slow growth and small size of software firms in Bangladesh.

There is a high degree of variation in skill requirements in each of these business models. For example, companies operating in customized application development demands business process analysis, requirements capturing, bid document preparation, and project management. On the other hand, programmers engaged in linear business model demands excellence in a specific set of technical skills. But exponential growth model through intellectual asset trading demands a strong base in technology and innovation management, and strategy. Hence, careful analyses of prevailing and target business models should precede adaptation of upskilling programs.

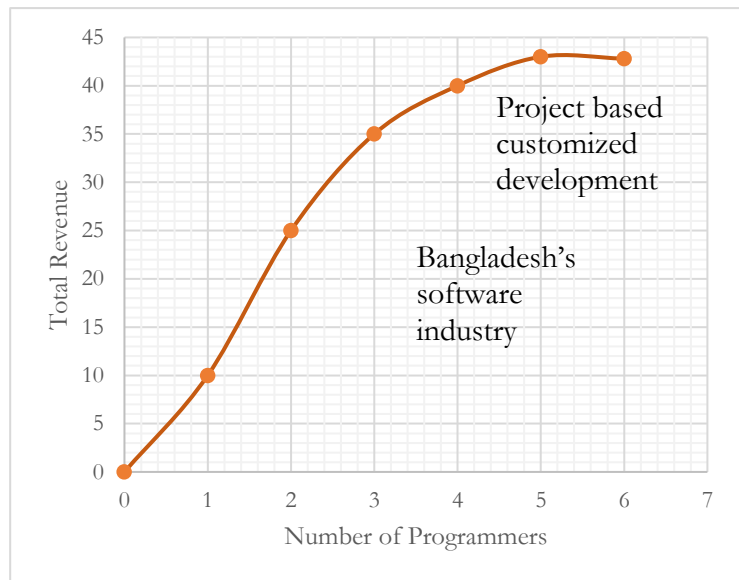
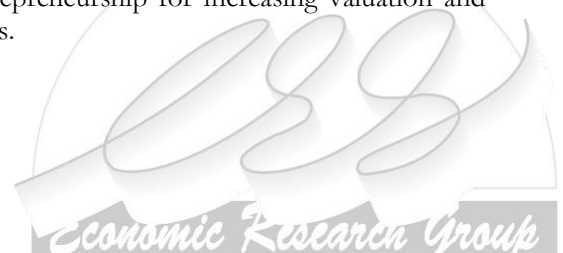


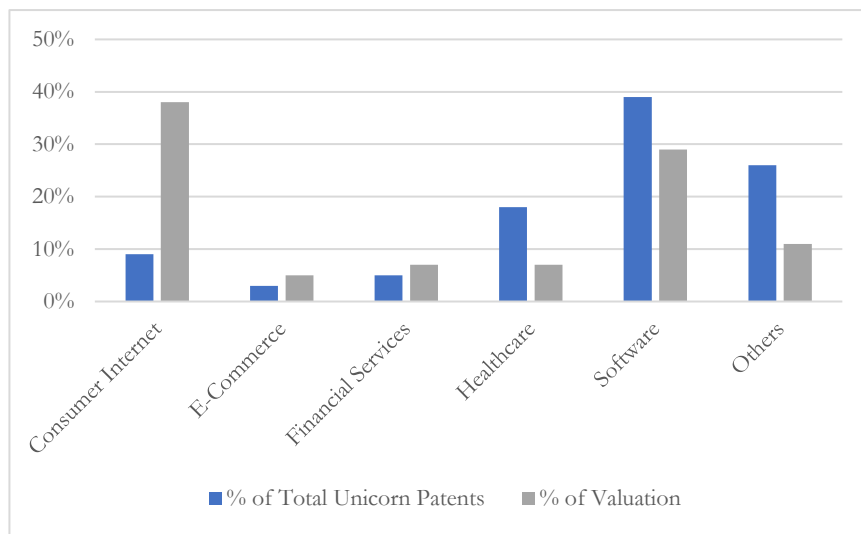
Figure 9: Production function of customized application delivery

3.2 Challenges in Developing Digital Entrepreneurship Cluster

The development of a pipeline of ITS and ITES SMEs capable of leveraging private equity and venture capital for realizing agglomeration of ITS and ITES SMEs in Dhaka's Vision 2021 Tower Software Technology Park, and promoting digital entrepreneurship is required to face the challenges of a subsidy-based model or thesis of digital innovation. The predominant model of digital startups has been to increase the customer base through subsidies and inflate the valuation based on such performance so that they can raise more funds from the investors. But such a model is neither sustainable nor conducive to wealth creation out of digital innovation.

But there has been an alternative to this subsidy-based valuation model. This is about undertaking R&D and developing intellectual assets for increasing the quality and reducing the cost so that loss making emergence turns into profit. Therefore, BHTPA may like to focus on advancing the R&D capacity of the ecosystem for creating pipeline digital SMEs to create the envisioned agglomeration of ITS and ITES SMEs in Dhaka's Vision 2021 Tower Software Technology Park. Hence, the skill development focus for leveraging digital entrepreneurship should not be on raising more funds through subsidy-based inflated valuation. Instead, the focus needs to be on developing intellectual assets for increasing the valuation of ideas. For example, in the US unicorn space, intellectual assets contribute as high as 40 percent in the valuation of consumer Internet and software startups, as shown in Fig. 10 (StartupValuationPatent, 2020). On the contrary, there has been no noticeable progress in Bangladesh, as far as the patent office data are concerned. Hence, skill development programs should focus on building partnerships between industry and academia for developing intellectual assets of digital entrepreneurship for increasing valuation and accessing equity and venture capital funds to scale up their ideas.





Source: Exhibit 2: U.S Unicorns: IP valuation Distribution by Industry

Figure 10: Role of patent in valuation of startups

3.3 Emerging Opportunities: Semiconductor

The semiconductor industry, with USD600 billion in global sales in 2022, is distinguished by a highly specialized, globally dispersed, and interconnected value chain. With the establishment of 28 high-tech parks, Bangladesh has been targeting to participate in this global value chain for reaping countless benefits, including increased employment and export opportunities. In addition to heavy investment in research and development (R&D) and design, this industry also demands a low-cost skilled labor force for manufacturing, testing, assembling and packaging. Review of experiences with semiconductors in other countries is done in Section 4, under global setting.

3.3.1 Globally Distributed Semiconductor Value Chain

The semiconductor industry dominates the global high-tech sector. High-tech components and products have been driving the information technology and unfolding the fourth industrial revolution. The demand for a wide spectrum of competencies, starting from high-end R&D to skilled labor centric workforce, offers job creation opportunities for a wide group of workforces. Moreover, the competition pressures have led semiconductor companies to develop business models that look beyond national borders to achieve efficiencies to compete in the marketplace. Hence, expanding demand and globally distributed value chain as shown in Fig.11 offers highly attractive opportunity for Bangladesh to enter and create jobs for growing number of graduates. However, to figure out the entry and growth opportunity, we need to very carefully analyze the value chains and its transformation. This existing value chain has a strong footprint in Asia Specific region. However, Bangladesh is yet to establish her presence in this highly distributed value chain. Moreover, this distributed value chain spanning across the globe is highly optimized.

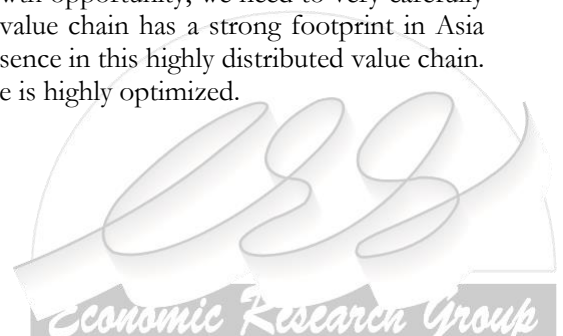
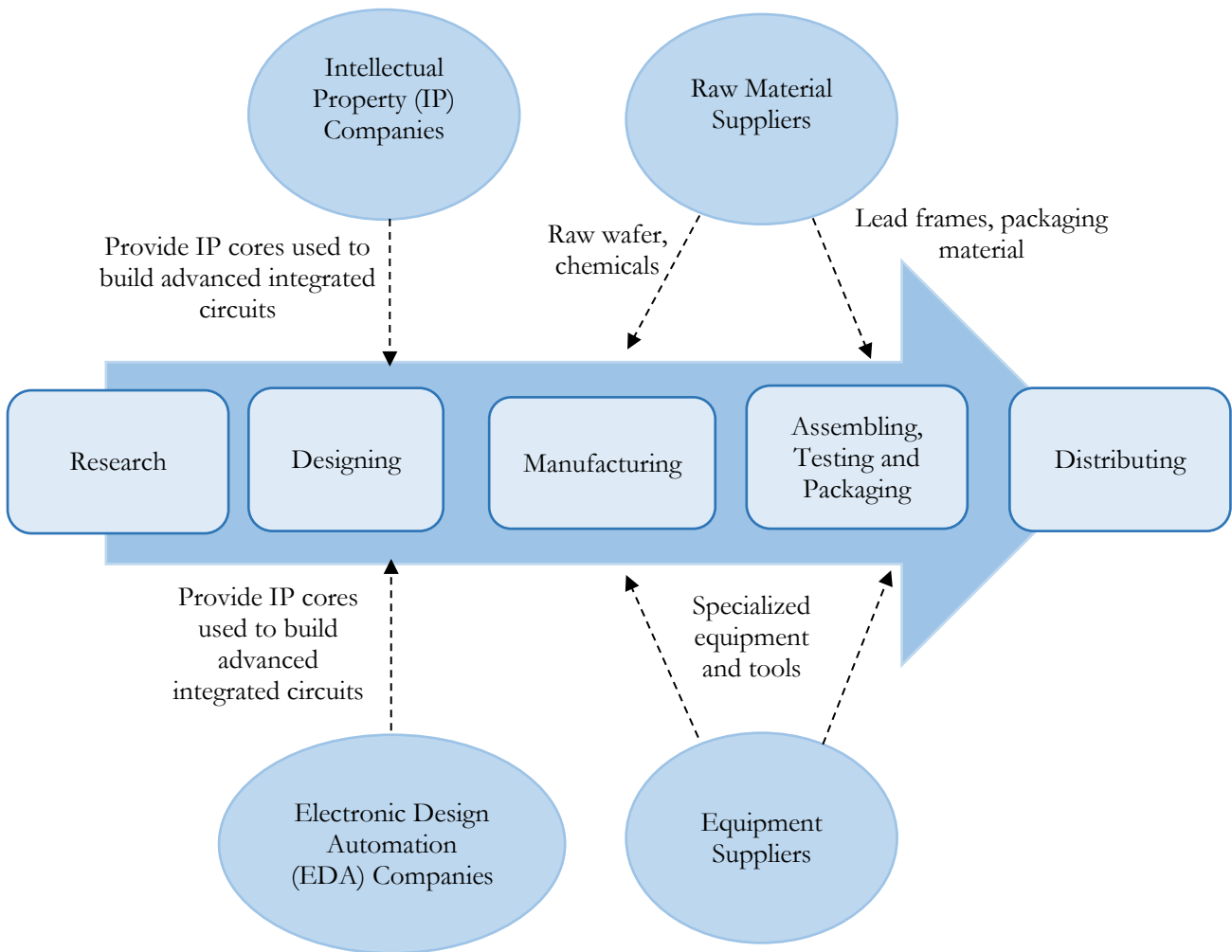


Figure 11: Semiconductor value chain—distributed ecosystem



Source: Semiconductor ecosystem, Nathan Associates

3.3.2 Disintegration and Functional Evolution of the Semiconductor Value Chain

Like many other industries, the semiconductor industry started its journey as Integrated Device Manufacturer (IDM). A single firm used to perform R&D, component design, manufacturing, testing, packaging, and distribution. In the beginning, the role of software used to be also very low. However, over the years, the scope job division and specialization started to unfold. Instead of a single firm performing all the tasks, individual firms with specialization started to evolve. As shown, in Fig. 12, as opposed to IDM, there are eighty different types of specialization for firms in 2010s. This disintegration has been played vital role in sourcing diverse types of materials, equipment, and human competencies from different firms, often located in different parts in the world. For example, Intel, OSRAM and many other high-tech firms came to Malaysia to source labor for ATP services. Similarly, fabless companies are offering design services. Along with QUALCOMM or Broadcom, even small companies from Bangladesh are also active in this segment. Such segmentation offers both opportunities and challenges. The challenges include having highly optimized logistics services to remain in sync with both up-stream and downstream nodes of the GVC.

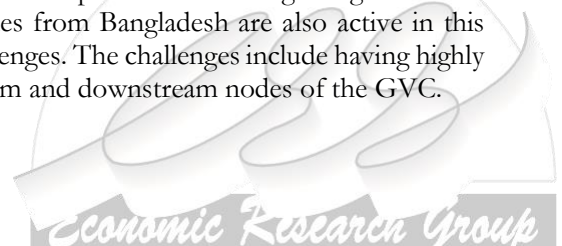


Figure 12: Progression of disintegration of semiconductor value chain over 60 years

1950s	1960s	1970s	1980s	1990s	2000s	2010s
						Software
				IP Provider	IP Provider	IP Provider
			Fabless Companies	Fabless Companies	Fabless Companies	Fabless Companies
	Manufacturing Tools	Manufacturing Tools	Manufacturing Tools	Manufacturing Tools	Manufacturing Tools	Manufacturing Tools
IDM	IDM	IDM	IDM	IDM	IDM	IDM
		EDA Tools	EDA Tools	EDA Tools	EDA Tools	EDA Tools
			Foundries	Foundries	Foundries	Foundries
					Packaging	Packaging

Note: *Functional Evolution of the Semiconductor Ecosystem (1950s-2010s)*; The individual-colored blocks are only a representation of the participants present in the semiconductor value chain at various points in time. They are not indicative of their relative market size

Source: Heide, Mercel, et. al., Study on the changing role of Intellectual Property in the semiconductor industry— including non-practicing entities, (European Commission DG Communication Networks, Content & Technology,

Research and Development (R&D) AMD, Broadcom, MediaTek, Spreadtrum, Qualcomm CEA-Leti, IMEC, ITRI, SEMATECH, Semiconductor Research Corporation	Fabless-Foundry Model			Distribution (to OEMs/ODMs) * Allied Electronics, Arrow Electronics, Avnet, Digi-key, Mouser Electronics
	Design (Fabless) AMD, Broadcom, MediaTek, Spreadtrum, Qualcomm	Manufacturing (Foundries) Global Foundries, HH Grace, SMIC, Tower Jazz, TSMC, UMC	Outsourced Assembly and Test (OSAT) Amkore, ASE, ChipPac, JCET, J-Devices, Power-tech, SPIL	
	IDM Model			
Integrated Device Manufacturer (IDM) Infineon, Intel, Micron, Renesas, Samsung, Texas Instruments				

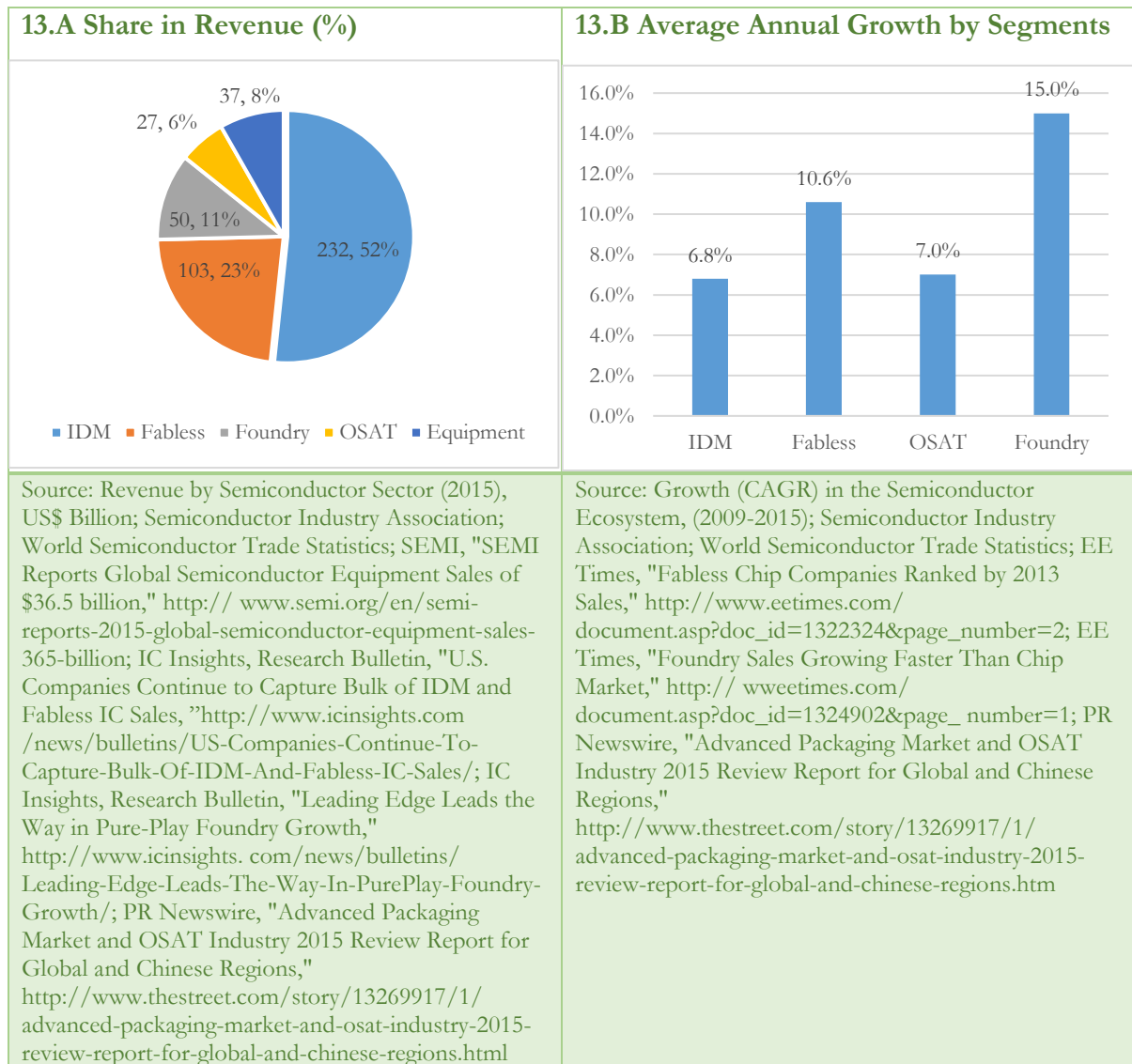
Note: * Original Equipment Manufacturers (OEMs)/ Original Design Manufacturers (ODMs) buy semiconductors to integrate into consumer end-products

Although IDMs like Intel or Samsung are dominating the high-tech business, there are thousands of small firms in other categories. For example, as reported by Nathan to SEMA, one U.S. semiconductor company has over 16,000 suppliers worldwide. Among them, more than 7,300 of its suppliers are based in 46 different American states. Remaining more than 8,500 of its suppliers are located outside of the United States, and many of them are in Asia.

As shown in Fig. 13, IDMs generated more than half of industry’s revenue in 2015. However, revenue in Fabless and OSAT (outsourced semiconductor assembling and testing) segments contributed to \$103 billion and \$27 billion respectively. Moreover, both of these two segments are experiencing growth. For Bangladesh, these two segments are highly attractive.

However, it may not be appropriate for Bangladesh to target the funder segment now. In addition to high capital and demand need, the job creation scope in this segment is very low. For example, recent OSRAM’s \$1.1 investment over 48 acres in Kulim high-tech park in Malaysia created the opportunity for only 1500 local jobs (source: Google Search). Moreover, such investment needed cluster advantage. Particularly, OSRAM’s Penang’s operation on ATP played complementary role. Basically, Chips produced at Kulim are destined for ATP operation at Penang. Over the years, 3rd party foundry services have grown in Taiwan and Singapore.

Figure 13: Revenue distribution and growth trend in the semiconductor value Chain, by segments



3.3.3 Uprising of OSAT Segment of Semiconductor GVC

Outsourced Semiconductor Assembly and Test (OSAT) firms provide third-party IC-packaging and test services. The OSATs are merchant vendors. Particularly, fabless firms outsource ATP services to OSAT vendors. However, IDMs and foundries with internal packaging operations also outsource a certain percentage of their IC-packaging production to the OSATs. The global OSAT market growth is primarily driven by increased demand for consumer electronics like TV, mobile phones, tablets, and others. This segment of the GVC of the semiconductor industry is expected to grow at a rate between 5% to 10% in the foreseeable future. It's anticipated that by 2023, the revenue from the OSAT segment will likely reach \$40 billion. It appears that there is a fierce competition in this segment. Competitors are looking for low-cost labor base to remain competitive.



3.3.4 Bangladesh's Entry, Capacity and Possibility for Leveraging Semiconductor

As early as 1989, Bangladesh entered the global semiconductor value chain—with the establishment of LED chip bonding and testing facility at Export Processing Zone, Chittagong. For taking the low-cost labor advantage, a Japanese company made this investment for serving the Japanese market. However, neither did it scale up, nor did any follow up investment take place.

In the recent past, Bangladesh has made an entry into the chip design segment. So far, there are only two home grown companies offering chip design services to the global market. More or less 300 graduates have been employed by these two firms. It has been learned that short of supply of skilled resources has been limiting the growth. However, the global chip design service market is dominated by MNCs having strong footprint in the design itself due to intellectual property issues. For example, India's most of 20,000 chip designers work in design centers of multinational corporations (MNC) like Intel, IBM, and Texas Instruments. So far, no MNC has set up chip design center in Bangladesh. As explained, as India has a lead, Bangladesh's low-cost labor advantage alone would not be sufficient to scale up the humble success. Hence, we should draw lesson from other countries, particularly, into experiences of skill development of Malaysia, India, and Taiwan. This is done in the following section for comprehending the options to add value in three distinct segments of the value chain.

4. Overview of Global IT/ITES Industry

The discussion in this section is based on the secondary literature review and the analysis of collected data by the study team. The focus is kept on the underlying forces of new job creation and changes in existing jobs contents, global skill demand, global skill supply, and skill development framework of selected countries.

4.1 Global Trend Analysis

The underlying forces that shape job creation and skill demand in advanced economies are often categorized into three, (i) Digital, (ii) Green, and (iii) Care (see, Fig. 14). These forces have been transforming all major industries resulting in changes in the content and skills profile of existing jobs, while creating new jobs. For taking advantage of it, employers and citizens of developing countries need to prioritize the acquisition of relevant skills in new and emerging areas.

For leveraging transformational possibilities of digital technologies, both Tech-Lite and Tech-Heavy roles are needed. Tech-Lite roles involve the use of foundational digital solutions at work, while Tech-Heavy roles refer to specialized roles responsible for the development, implementation and maintenance of more complex technological solutions and applications. More specifically, Tech-Heavy roles include software engineers, data scientists and AI engineers. On the other hand, data analysts, digital marketing analysts and customer insights specialists belong to Tech-Lite roles.

Although Tech-lite roles dominate the digital skill development in developing countries, Bangladesh's lead public sector agencies, including Hi-tech Park Authority (BHTPA), may consider playing Tech-Heavy roles.

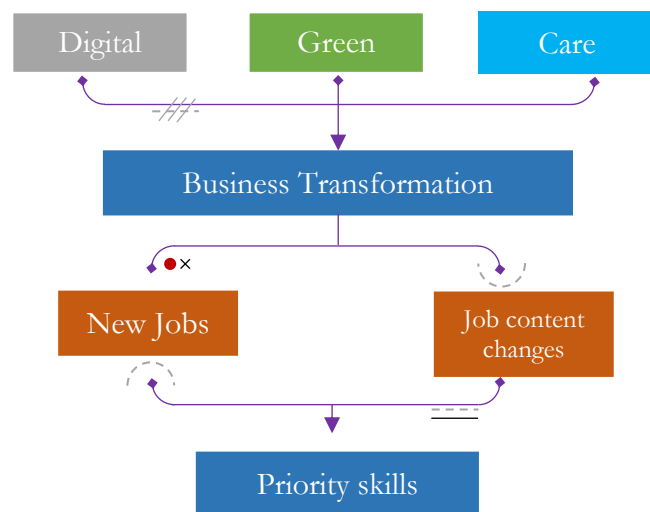


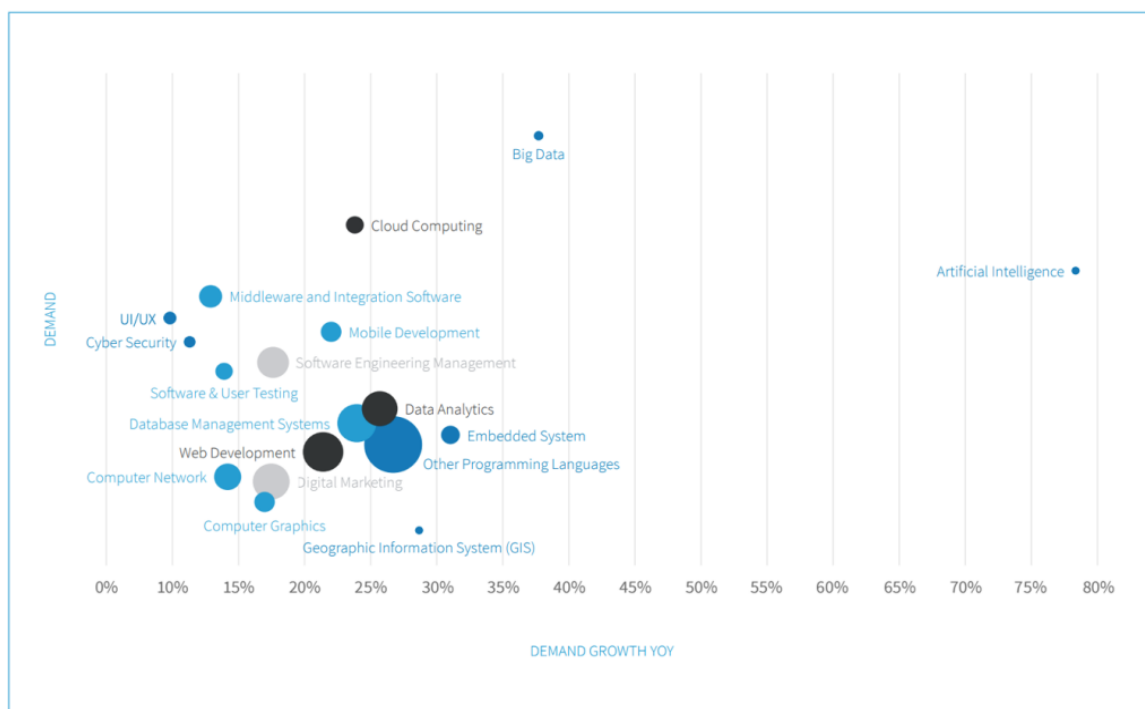
Figure 14: Technology driven new job creation and changes of existing job content

To illustrate the importance of such roles in a few major industries within the context of Singapore (SkillsFutureSG, 2021), few examples are mentioned in 4.1.2, Fig. 18.

4.1.1 Emerging Skill Demand

Artificial intelligence, Big Data and Cloud Computing (ABC) are at the core of emerging technologies. Skills pertaining to ABC also form the core of 4IR skill sets. Based on the analysis of members' data published by LinkedIn, supply is falling behind the rapid growth in demand for ABC skills as shown in Fig. 15 (DigitalWorkForce, 2017). As shown, in addition to technical skills, Software Engineering Management is an important skill. In addition to project management, it includes technology assessment, motioning and forecasting. It also includes innovation, product and intellectual asset management. This is a vital skill area for creating and extracting increasing value from technology skills. For example, cost of copying of software and digital content is zero. Hence, creating the scope of trading the same software and digital assets to increasing number of customers offers the technological scale advantage. For leveraging it, one needs to focus on Engineering Management Skills, which is usually overlooked. Even if attention is given, Engineering Management skill mixes up with the project and general management capability that are generally delivered by the business schools. It is worth noting that Taiwan has taken deliberate institutional attempt to address this vital skill for scaling up value creation out of technology skills (TMTaiwan, 2020).

Figure 15: Demand for ABC skills and its growth rate based on data of 2016/2017



Note: Demand for ABC talent is growing fast, but is comparatively low is supply; Horizontal axis shows YOY growth in demand from Aug '16 to Aug '17. Vertical axis shows demand from Aug '16 to Aug '17. Circle size indicates relative number of LinkedIn members. Source: LinkedIn

Based on LinkedIn data, skill in Big Data is tops the skill-demand list among emerging technologies (see, Fig. 15 and Table 4). Other top in-demand skills are cloud computing and artificial intelligence. On the other hand, the fastest growing in-demand skills are artificial intelligence, big data, and embedded systems. This graph provides indication about the global trend of skills of emerging and 4IR technologies, and other IT/ITES skill areas.

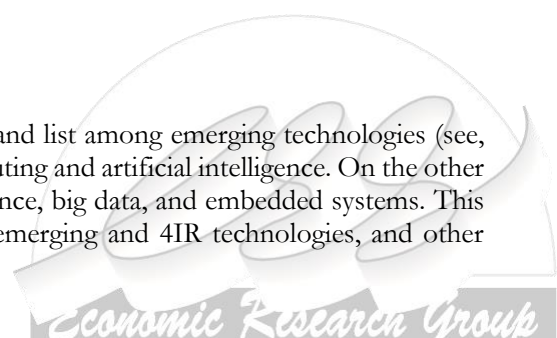


Table 4: Top and fastest growing in-demand skills

SL	Top in-demand skills	Fastest growing in demand
1	Big Data	Artificial Intelligence
2	Cloud Computing	Big Data
3	Artificial Intelligence	Embedded Systems

Source: LinkedIn

There are variations in the concentration of emerging skill demand in Asia-Pacific countries. Concentration of emerging skill demand in selected countries of Asia-Pacific is shown in Fig. 16. However, LinkedIn study finds that APAC region is losing ABC skilled work force, primarily to the USA, as shown in Fig. 17.

Figure 16: Demand for specific ABC skills in Asia-Pacific (APAC) countries



Source: LinkedIn

Figure 17: ABC skill migration from APAC



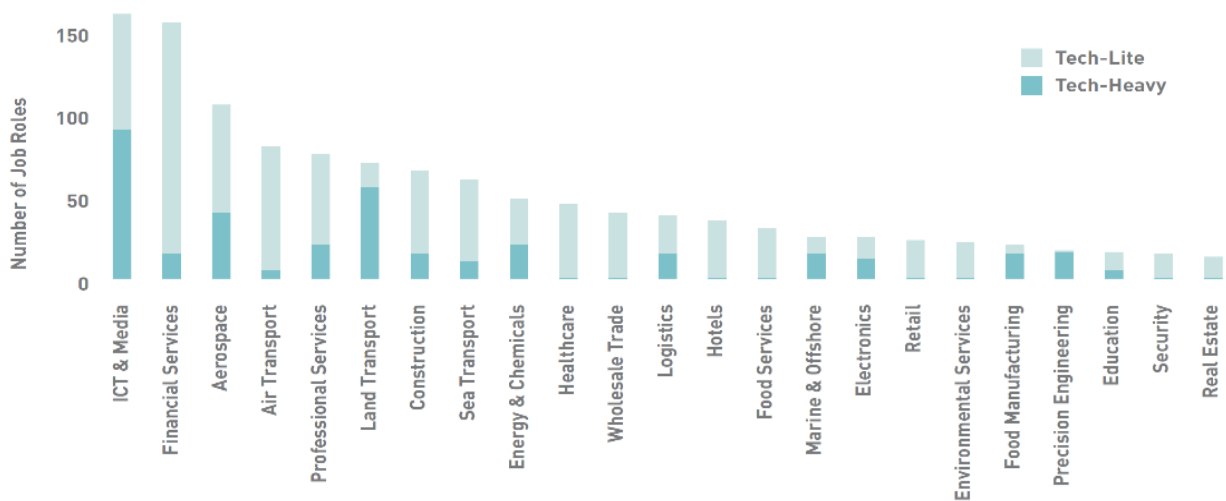
Source: Outflow of ABC talent from APAC, LinkedIn

4.1.2 Emerging Skills Due to Transformation in Different Sectors—example from Singapore

Singapore’s high-tech economy is dominated by multinationals. Only a small segment of the value chain of them operates in Singapore. For assessing skill requirements in the digital economy, Singapore has dissected 23 sectors, producing Industry Transformation Maps (ITMs), as shown in Fig. 18. In this mapping exercise, skills have been placed in two broad categories: Tech-lite and Tech-heavy roles. Tech-lite roles refer to usages of digital technologies in those segments, whereas Tech-heavy includes the role of software engineers, data scientists and AI engineers to innovate solutions to transform those industry segments through digital possibilities.

It appears that Singapore’s digital skills requirement substantially vary from that required by India and Taiwan. Instead of leasing digitally skilled workforce to foreign firms, Singapore’s digital skill demand is highly influenced by the transformation of the domestic sectors with digital technologies. On the other hand, Taiwan focuses on the development of intellectual assets pertaining to digital technologies and trades them in the global market. As BHTPA’s mission has strong export component, and Bangladesh is likely to face entry barrier if it follows the linear model, BHTPA will gain a lot by learning from Taiwan’s approach for skill development.

Figure 18: Breakdown of tech roles in different industries

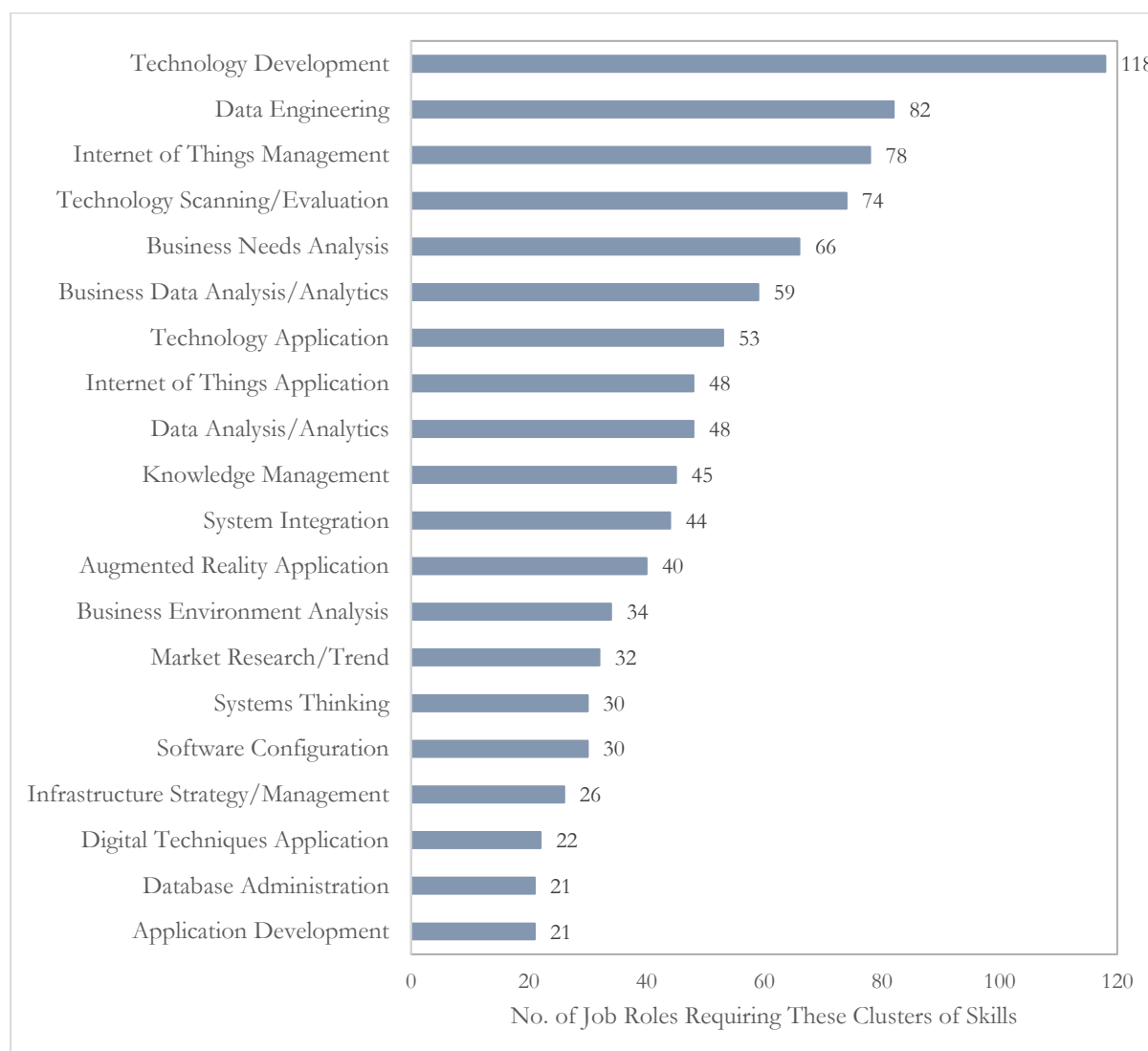


Source: Infocomm Media Development Authority (IMDA) and SkillsFuture Singapore



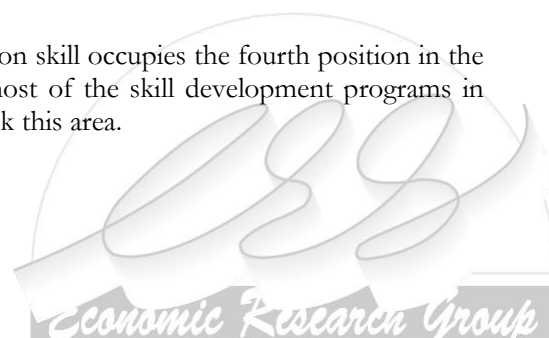
For increasing the performance of 23 sectors, Singapore has been transforming them by leveraging emerging technologies, including the ones driving the 4IR. Transformation of these sectors has been creating 4IR related emerging skill base as shown in Fig. 19. Priority skills for Tech-heavy roles in Singapore’s digital economy is also shown in Fig. 19. Certainly, this priority level depends on the economy and it keeps changing with respect to time. Nevertheless, it provides a glimpse about the likely demand of digital skills in major economies of the world

Figure 19: Clusters of skills required for tech-heavy job roles



Source: SkillsFuture Singapore

It is interesting to note that Technology Scanning and Evaluation skill occupies the fourth position in the skill cluster priority. Ironically, despite its high importance, most of the skill development programs in pursuing high-tech possibilities in developing countries overlook this area.



4.1.3 Emerging Skill Demand based on LinkedIn Data Analysis

Mapping of occupations and Skills in emerging technologies and their relative ranking in selected countries is shown in Table 5.

Table 5: Emerging skills pertaining to IT/ITES occupations

Sl	Occupations	Skills	Country specific situation						
			USA		Canada	Malaysia	India	Philippine	Australia
			Rank	AGR	Rank	Rank	Rank	Rank	Rank
1	Artificial Intelligence Specialists	Machine learning, Deep learning, TensorFlow, Python, Computer Vision, Natural language processing, Pytorch, Neural net, Image processing	1	74	1		2		1
2	Cyber Security Specialist	Information security, Network security, Splunk, Penetration testing, Security Information and Event Management (SIEM)	10	30	5	6	11	2	2
3	Marketing Automation Specialist	Marketo, Salesforce marketing cloud, e-mail marketing, Digital marketing, CRM marketing							3
4	Robotics Engineering (Software)	Robotic process automation, UiPath, Automation anywhere, Python and C programming language, SQL, Robotics	2	40	10		10	1	4
5	Site Reliability Engineer	Amazon Web Services (AWS), Linux, Go programming, DevOps, Docker Products, Terraform, Jenkins, Ansible, Kubernetes	5	34	2		7		5
6	Data Specialist/ Scientist	Machine learning, R, Python, Data mining, Data Science, Apache	3	37	3	1		4	7



Sl	Occupations	Skills	Country specific situation						
			USA		Canada	Malaysia	India	Philippine	Australia
			Rank	AGR	Rank	Rank	Rank	Rank	Rank
		Spark, Big Data, Data modeling							
7	Automation Consultant	RPA, UiPath, JIRA, Test Automation, Automation, Blue Prism, SQL					4		15
8	Service Designer or Experience Designer	Design Thinking, UX Research, User Centered Design, User experience, Customer experience design			9				13
9	Product Owner	Agile methodologies, Stakeholder management, Scrum, Product management, Business and Requirements Analysis, JIRA, Product development and management	15	24	13				12
10	Chief Strategy Officer, Growth Manager	Strategic partnerships, Merger and Acquisition (M&A), Digital Strategy, Business strategy, Management consulting, Digital Marketing							11
11	Cloud Engineer	Amazon Web Services, Cloud Computing, Microsoft Azure, DevOps, Docker products	13	27	15			10	
12	Block Chain Developer	Hyperledger, Solidity, Node.js, Smart Contract					1		
13	Software Engineering Management	Product, process and project management, technology monitoring and evaluation, productivity management, software marketing, innovation and intellectual asset management,							

Sl	Occupations	Skills	Country specific situation						
			USA		Canada	Malaysia	India	Philippine	Australia
			Rank	AGR	Rank	Rank	Rank	Rank	Rank
14	Full Stack Engineer	React.js, jQuery, Laravel, JavaScript, AngularJS, MySQL, MongoDB, Node.js, Git, AWS				4	9	6	14
15	Chip Designers	Skills for Chip design verification, logic design, design for testability, analog design, RTL design, SoC design, physical design and verification, ASIC design, EDA tools, building IPs, FPGA design, ASIC synthesis, Analysis and Simulation,					*		

*Note: India has targeted to develop 85,000 high-skilled engineers in chip designing for startups (The Economic Times). At Naukri.com (on March 29, 2022), there were 838 chip design job postings. Example of employers are Intel, IBM, TI, and Infineon. At present, 20,000+ Indian chip designers are working for various global semiconductor firms, which have set up chip design facilities in India. According to some reports, average chip designers' salary in India is ₹12,15,421 per year (USD16,000 PA, in ref to glass door). Hence, 20,000 chip designers working for MNCs in India are earning more or less USD 320 million.

Note: India's value addition in chip design may be lower than widely stated. How much 20,000 chip designers earn by working for MNCs' facilities in India is about India's value addition. That number stands roughly at \$320m (\$16k x 20k) -- not billions stated by the media.

Empty cells indicate that data are not available. Use of NA in too many cells reduce readability; hence, they been kept empty.

Source: LinkedIn, among 15 top ranking emerging occupations. AGR: Annual growth rate in %. Notes in next page as well.

4.1.3.1 Mapping of Emerging Occupations with ISCO

As per the study requirements, emerging occupations in IT/ITES sector have been mapped with ISCO classification, as shown in Table 6. Unfortunately, very close mapping was not feasible as ISCO has low breakdown in Level 4. The framework for mapping digital skills and occupations is presented in Appendix K.

Table 6: Mapping of IT/ITES occupations with ISCO classification

Sl.	Occupations	Relevant Concepts, Tools and Skills	Related ISCO occupation classification codes	ISCO Skill Level
1	Artificial Intelligence Specialists	Machine learning, Deep learning, TensorFlow, Python, Computer Vision, Natural language processing, Pytorch	2512, 2514	Level 4

Sl.	Occupations	Relevant Concepts, Tools and Skills	Related ISCO occupation classification codes	ISCO Skill Level
2	Cyber Security Specialist	Information security, Network security, Splunk, Penetration testing, Security Information and Event Management (SIEM)	2529,	Level 4
3	Marketing Automation Specialist	Marketo, Salesforce marketing cloud, e-mail marketing, Digital marketing, CRM marketing	2512,	Level 4
4	Robotics Engineering (Software)	Robotic process automation, UiPath, Automation anywhere, Python and C programming language, SQL, Robotics	2514,	Level 4
5	Site Reliability Engineer	Amazon Web Services (AWS), Linux, Go programming, DevOps, Docker Products, Terraform, Jenkins, Ansible, Kubernetes	2513, 2523	Level 4
6	Data Specialist/ Scientist	Machine learning, R, Python, Data mining, Data Science, Apache Spark, Big Data, Data modeling	2529,	Level 4
7	Automation Consultant	RPA, UiPath, JIRA, Test Automation, Automation, Blue Prism, SQL	2521,	Level 4
8	Service Designer or Experience Designer	Design Thinking, UX Research, User Centered Design, User experience, Customer experience design	2513, 2512,	Level 4
9	Product Owner	Agile methodologies, Stakeholder management, Scrum, Product management, Business and Requirements Analysis, JIRA, Product development and management	2512	Level 4
10	Chief Strategy Officer, Growth Manager	Strategic partnerships, Merger and Acquisition (M&A), Digital Strategy, Business strategy, Management consulting, Digital Marketing		Level 4
11	Cloud Engineer	Amazon Web Services, Cloud Computing, Microsoft Azure, Devops, Docker products	2523	Level 4
12	Block Chain Developer	Hyperledger, Solidity, Node.js, Smart Contract		Level 4
13	Software Engineering Manager	Product, process and project management, technology monitoring and evaluation, productivity management, software marketing, innovation and intellectual asset management, communication, motivation, problem solving		Level 4
14	Full Stack Engineer	React.js, jQuery, Laravel, JavaScript, AngularJS, MySQL, MongoDB, Node.js, Git, AWS		Level 4
15	Chip Designers	Skills for Chip design verification, logic design, design for testability, analog design, RTL design, SoC design, physical design and verification, ASIC design, EDA tools, building IPs, FPGA design, ASIC synthesis, Analysis and Simulation,		Level 4

Note: Occupational categories were obtained from LinkedIn source.
Source: Compiled by the ERG team

4.1.3.2 Relevance of ISCO Occupational Categories to Emerging Skills

An overview of ISCO occupations pertaining IT/ITES is shown in Table VII. As it has been shown, there is no close mapping between ISCO occupation classifications and IT/ITES occupations as outlined in Table 7.

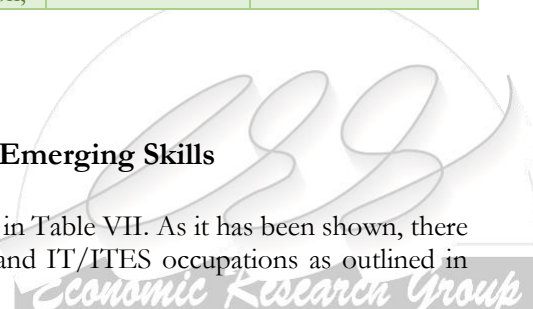


Table 7: Overview of ISCO occupation classification pertaining to IT/ITES industry

25	Information and Communications Technology Professionals	251	Software and Applications Developers and Analysts	2511	Systems Analysts
				2512	Software Developers
				2513	Web and Multimedia Developers
				2514	Applications Programmers
				2519	Software and Applications Developers and Analysts, not elsewhere classified
		252	Database and Network Professionals	2521	Database Designers and Administrators
				2522	Systems Administrators
				2523	Computer Network Professionals
				2529	Database and Network Professionals, not elsewhere classified
				1223	Research and Development Managers
				2152	Electronics Engineers
				2166	Graphic and Multimedia Designers
				2434	Information and Communications Technology Sales Professionals
				2120	Mathematicians, Actuaries, and Statisticians
				2149	Engineering Professions not elsewhere classified

Source: compiled by the ERG team

4.2 Emergence of Semiconductor Industry in Selected Countries

The semiconductor industry dominates the global high-tech sector. In-demand skills to work in this industry are very high and hence the industry requires special attention. This sub-section sheds light on the emergence of the semiconductor industry in selected countries.

Malaysia: Before the establishment of Intel’s semiconductor bonding and testing facility in the paddy field of Penang in 1972, Malaysia had no background in this industry (IntelMalasia, 2012). Intel brought the equipment, plant layout and operating procedures. In order to let the Malaysians, perform the testing and bonding task, Intel gave a short skill development training.

Down the road, more than 300 multinational corporations followed the Intel route of making Malaysia a home of semiconductor testing and bonding facilities. For facilitating them, Malaysia focused on infrastructure development, giving names to high-tech parks. Furthermore, those parks also set up training centers for supplying skills on how to operate imported machines as per the imported procedure. Hence, unlike Taiwan, Malaysia could not improve its value addition capacity. Through the infrastructure and skill development, incentives, and facilitating trade liberalization, Malaysia has been still adding value through labor to semiconductor high-tech.

The underlying driver of Intel coming into Malaysia was that Intel was looking for low-cost labor for the bonding and testing jobs, which caused eyesight hazards. Subsequently, all other MNCs followed Intel’s steps. Over the years, it has created an ecosystem that resulted in an economy of scale as well as scope advantage. Hence, despite the eroding wage differential, Malaysia is still home to the bonding and testing of global semiconductor companies.

India: Over the last few decades, India has succeeded to create jobs for approximately 20,000 chip designers. Most of these chip designers work for multinational corporations such as Intel, IBM and Texas Instruments. To make India attractive to these multinationals for setting up chip design centers, India took special measures to address their skill supply.

In 2014, India launched an umbrella program: Special Manpower Development Program for Chips to System Design (SMDP-C2SD) through the participation of 61 Academic and Research & Development

Institutions spread across the country including IITs, NITs, IISc, and IIITs. The program focused on developing 50,000 Specialized Manpower in the area of VLSI/System Design at BTech, MTech & PhD levels. In addition to teaching how to design chips, the program supported the design and development of proof-of-concept Working Prototypes of 15 SoCs/ 70 ASICs/30 FPGA based designs. Hence, the program focused on moving up the value chain by bringing in the culture of SoC/ Chip Design in the Country. However, this program had a root in the project initiated at nineteen institutions in 1998 with a total outlay of Rs. 14.99 Crores and was completed in March 2005.

The overall objective of the chip design skill development program in India has been:

- To bring in a culture of System on Chip/ System designing by developing working prototypes with societal applications.
- Capacity building in the area of VLSI/ Microelectronics and Chips for System Development.
- Broaden the base of ASIC/ IC designing in the country.
- Broaden the R&D base of Microelectronics/ Chips to System Design through a networked PhD program.
- Promote 'Knowledge Exchange Program'.
- Protection of Intellectual Property generated.

For developing the semiconductor skill foundation in India, the SMDP-C2SD has produced 26 Patents, in addition to trained manpower. A snapshot of the human resource development of this program in India is shown in the following Table 8:

Table 8: India's progress in developing human resources of the semiconductor industry

Sl.	Year	PhD	MTech (Microelectronics /VLSI)	MTech (Others) with courses/projects in Microelectronics/VLSI	BTech with courses/projects in Microelectronics/VLSI
1	2015-2016	129	881	1371	5634
2	2016-2017	69	913	1293	6694
3	2017-2018	292	1191	1624	7787
4	2018-2019	164	1070	1470	8485
5	2019-2020	332	1364	1798	9484
6	2020-2021	555	1305	1532	8018

Source: <http://smdpc2sd.gov.in/manpowertrained>

Based on EDA tools like Cadence, Mentor Graphics, and Synopsys, and Xilinx, India has developed various VLSI design labs for developing human resources. In this human resource development exercise, SMDP-C2SD supported the design of 15 System of Chips (SoCs) such as (i) FPGA/ASIC based Sensor Platform for Monitoring Air Pollutants, (ii) Integrated microchip module for wireless capsule endoscopy, and (iii) Collision Detection in Automobiles using CMOS Imagers. This program also sponsored the fabrication of 162 chips, using 180nm, 130nm and 65nm processing technologies.

Taiwan: For uplifting Taiwan from a labor-intensive economy into an innovation-driven economy, the Industrial Technology Research Institute was founded in 1973. Soon after its formation, in 1974, Taiwan embarked on a \$10 million four-year project to enter the semiconductor industry. The journey began with the signing of ITRI's contract for the "CMOS IC Technology Transfer Licensing Agreement" with RCA

on March 5, 1976, under which RCA would transfer its know-how in complementary metal-oxide semiconductor technology to Taiwan. Just before the signing of this deal, a Princeton University graduate with a doctorate in electrical engineering, Chintay Shih participated in the creation of Taiwan's IC industry from scratch.

As part of this deal, in April 1976 ITRI sent 19 young engineers to RCA's facilities for training in IC design, process technology, IC testing and semiconductor equipment (TaiwanToday, 2010). As a follow-up, more engineers went on the same pilgrimage to become Taiwan's industry pioneers. These trainee engineers focused on the mission to absorb as much of RCA's technology as they could. Subsequently, they tried to convert RCA's manufacturing processes into a set of standard operating procedures that would work for Taiwan.

While Engineers were undergoing technology absorption exercises in RCAs facilities in the USA, the ITRI was building Taiwan's first 3-inch wafer fabrication plant, which began its pilot run at the end of 1977. Mr. Shih became the first plant manager forming "the origin of the country's semiconductor industry." In addition to learning how to operate the RCA transferred technology, a team under the leadership of Mr. Shih focused on how to learn and transfer that learning into plants for better operating performance. Hence, within a few years, Taiwan's fab was running at a higher yield than RCA's plants. This ability of Taiwanese engineers of systematic learning and transferring it into the plant's operating procedure is at the core of Taiwan's ongoing skill development by themselves. This exercise led to developing a partnership with the universities in advancing process technology—generating proprietary ideas (patents) and the production of a highly skilled workforce. This practice was scaled by TSMC creating a mega success story through the process of creating knowledge and ideas and converting them into high-end process plants, generating higher yields.

However, in contrast to Taiwan, Indian Engineers focused on operating imported plants. As a result, despite having a state-of-the-art Semi-Conductor Laboratory, managed by the Department of Space (DoS), India could not venture into commercial silicon processing.

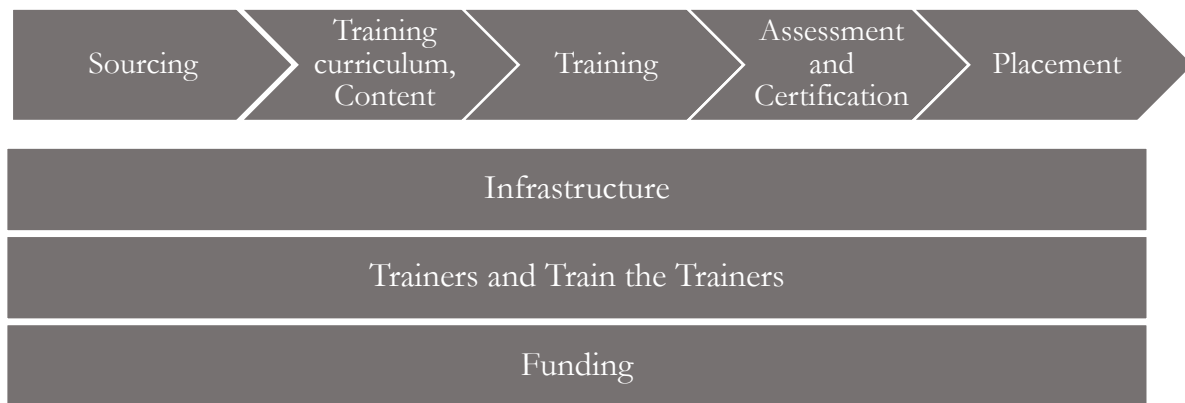
Furthermore, to scale up the initial success of learning from operating labs and turning it into higher yield, Taiwan focused on acquiring technology and innovation management capability. Instead of giving certificate training to technology professionals working at Hsinchu Science Park on management practices, National Tsing Hua University (NTHU), together with the Industrial Technology Research Institute (ITRI) and National Chiao Tung University (NCTU) proceeded to set up the Institute of Technology Management, in 2000 (TMITTaiwan, 2020). Professionals have been completing M.Sc. and PhD. Hence, it's not surprising that Dr Shih became the Professor and Dean at the College of Technology Management of National Tsing Hua University.

4.3 Skill Supply Frameworks of Selected Countries

The dominant understanding of skill development is about (i) identifying a set of skills, (ii) arranging fund, (iii) giving training to trainers, (iv) developing infrastructure for conducting training, (v) recruiting or sourcing training recipients, (vi) developing content and conducting training, (vii) performing assessment and offering certificates, and (viii) placing the trained professionals to jobs, as shown in Fig. 20. Although such skill development value chain works fine in India, due to its export oriented linear model, it does have little efficacy to meet the mission objective of BHTPA—as Bangladesh IT/ITES firms have not succeed in scaling them business through leasing programmers to multinational corporations.



Figure 20: Conventional value chain of skill development



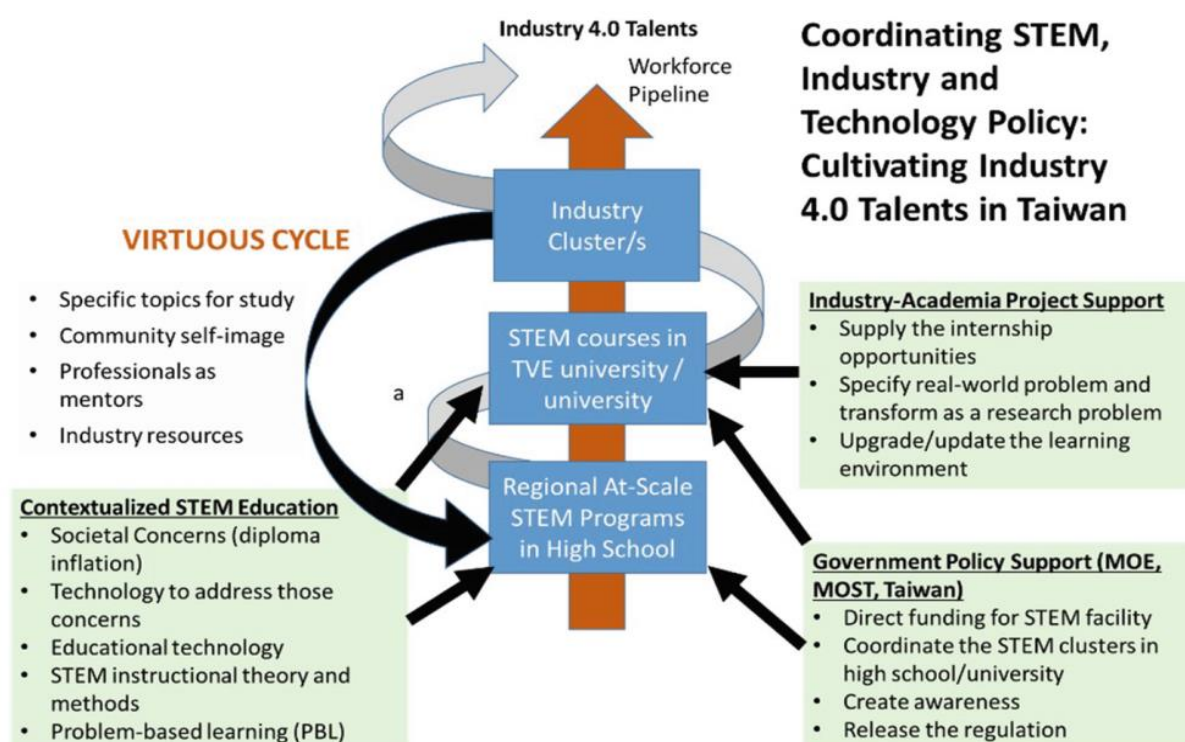
Source IMoCS analysis

4.3.1 Skill Development Framework of Taiwan's high-tech Cluster

Taiwan's high-tech success is not out of the leasing trained human resources to MNCs to perform predefined set of tasks. Instead, Taiwan's firms are after developing firms and creating skill demand. The journey of high-tech skill development started in 1973 through the establishment of ITRI. The objective was to assimilate as opposed to getting industry certification to qualify for MNC jobs. It went further with the technology transfer agreement with RCA. Yes, RCA transferred semiconductor technology to Taiwan through setting up a fab and giving training to Taiwanese engineers to operate them. But trained Taiwanese engineers did not keep doing the jobs as per the training. Instead, they focused on systematic on job learning, technology monitoring and assimilation, and advancement. Hence, very soon, Taiwanese engineers started showing better performances than what RCA had, leading to higher yield. To take it forward, Taiwan's high-tech industry has formed collaboration with universities to advance technologies and develop manpower through the same process. As a result, a virtuous cycle (Fig. 21) has been created between industry and academia for developing intellectual assets and skilled human resource through the same mechanism of collaboration.



Figure 21: Skill development framework of Taiwan



Source: https://link.springer.com/chapter/10.1007/978-3-030-39851-4_9

As it has been explained, Taiwan has developed an ecosystem with the capacity to facilitate learning from others, advancing acquired knowledge and skills, creating knowledge, assimilating them, and transferring them into innovating product and process features. Notably, in the semiconductor industry, although Taiwan started the journey of skill transfer from RCA through training, the success has been created out of the continued learning through ecosystem's R&D capacity. This is vital for developing the high-tech sector. Lesson from Taiwan indicates that continued skill development through advancement of current state is essential for developing high-tech edge. Such necessity could be not addressed through training, as trainers to meet such a necessity do not exist. Hence, BHTPA's focus of skill development should be creating such ecosystem capacity of self-skilling through technology advancement.

4.3.2 Skill Development Framework of India's High-tech Sub-sector

The overall skill development framework of India is shown in Fig. 22. For addressing work for hire or linear model, India has been flooding graduates with skill development programs for making them eligible to deliver export-oriented services.

As explained, India has created IT/ITES success story out of linear model. More or less, India does not focus on innovating and producing any high-tech products, whether in software, hardware or silicon chips. Instead, India supplies human resources to multinational corporations to support the innovation, manufacturing and operations of their IT/ITES systems. Hence, as per the technical skill requirements of the clients, they source graduates and train them with skill certification. Upon doing so, they house them in office environment from where they provide their services to the MNCs. Hence, this India's high-tech skill development framework resembles the typical model of skill development as shown in previous section in Fig. 23. As stated, India has created a large success story out of this model.

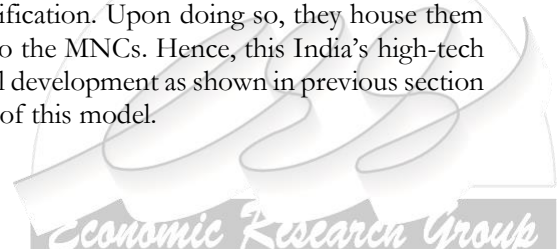
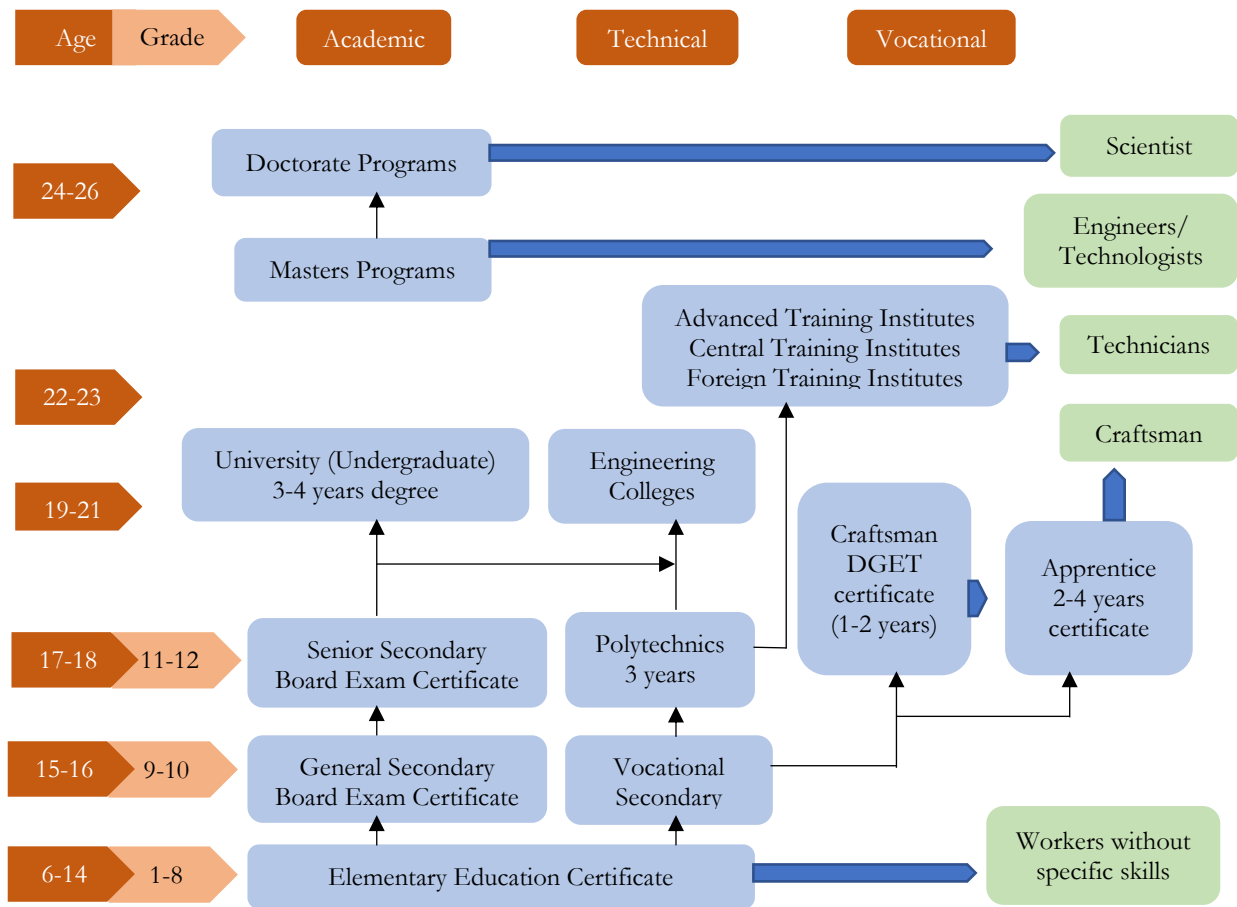


Figure 22: Skill development framework of India



Source: World Bank

But despite repeated attempts, Bangladesh could not replicate this model. Hence, this highly successful skill development model does not appear to be appropriate for meeting BHTPA's mission objective. Instead, BHTPA should focus on those skills which contribute to the organic growth of firms. For this purpose, the focus should be on conceptual aspect so that firms find better scalable growth path. But in the meantime, if the MNCs shows up on Bangladesh's shore to source trained human resources, with industry certification, BHTPA may also look into India's highly successful model.



5. Analyses under the Scope of the Study

This section discusses the skill demand and supply in the local industry as found from the analyses of the study team. It also looks at feasibility analysis, target population analysis and efficacy of delivery framework and channel. Further, it briefly compares global and local scenario and lessons learnt from the global trends discussed in the section 4.

5.1 Skill Demand in the Local Industry

More than 450+ recent job postings in the area of information technology made at the BDJobs' job site were reviewed. The review indicates that employers are looking for 1000+ IT/ITES skills. A mapping between those skills and emerging skills was performed as shown in Table 8. This mapping indicates that demand for emerging IT/ITES skills in the local market is low. For example, this dissection found only five job postings looking for learning capability. Furthermore, skills pertaining to Service Designer or Experience Designer found no demand among those job postings. Among the 105 emerging skills, as high as 41 skills were absent among those 450+ job postings. For getting further clarity, the frequencies of skills demanded by dissected job postings are provided at Appendix C. Furthermore, there is high degree of variation in frequencies of demand across skills. For example, there were 520 skills which are demanded in only one job posting each. However, there were some reported more frequently. Most cited skills are PHP, HTML, HTML5, CSS and CSS3. Graduates in CS/CSE learn them either through Internet and Web technology course or self-learning.

A survey was conducted on IT/ITES professionals working at HTP/STP tenants and other firms. Among the participating firms, 145 professionals responded. They cited 207 technical, 53 management and 52 soft skills to be currently in demand (see, Appendix I). Most of the cited technical skills fall in the skill sets obtained from the dissection of job postings at BDJobs. However, the frequency varies. Furthermore, current skill requirements also include emerging skills. Some of the emerging skills which are already being practiced by IT/ITES professionals are (i) Artificial Intelligence, (ii) Machine Learning, (iii) Deep Learning, (iv) DevOps, and (v) Docker. The list of management and soft skills being practiced by IT/ITES professionals are intriguing indeed. Often, they are overlooked in the skill development program for the IT industry. Particularly, due to high importance of self and on-job learning, such skills appear to be highly important. But they are mostly developed through the development and execution of technical skills.

With the collaboration of BHTPA, a survey questionnaire was sent to all the tenants of HTPs and STPs. Unfortunately, only ten firms responded. Nevertheless, those limited responses are useful within the context of responses gathered from IT/ITES professionals. Like professionals, firms have also reported that on-job learning is highly effective for upskilling. Like professionals, firms also reported low efficacy of standalone training programs. However, for certain skills like CCNA, CCNP, MCSA, MCSE, and GIS based software integration, firms reported importance of outside training.

From the responses of IT/ITES professionals as shown in Appendix N, there will be growing demand of emerging skills such as cloud computing, software development and design, blockchain, artificial intelligence and machine learning. Hence, the focus on developing skills which are in high demanded in the North American will prepare Bangladesh to meet the skills required by the local industry in short and medium term.



5.1.1 Learning from Job Postings at BDJobs

Linking of emerging skill demand to local market demand is done by detecting the frequency of emerging skills demanded by local job posting in the area of IT/ITES at the BDJobs, as shown in Table 9. This mapping is based on the analysis of 457 job posting samples, demanding about 1000 unique skills. Among them 95 skills fall in the category of emerging skills as pointed out by LinkedIn. This table shows mapping of these 95 unique skills to emerging IT/ITES occupations, identified by LinkedIn. Further details of skills and their frequencies are provided in Appendix C.

Table 9: Demand of IT/ITES skills in local market within the context of the emerging global demand

Sl.	Names of occupations	Frequency of skill demand in local market, in reference to BDJobs									
1	Artificial Intelligence Specialists	Machine learning	Deep learning	TensorFlow	Python	Computer Vision	Natural language processing	Pytorch	Neural net	Image processing	
	<i>Frequency</i>	5	1	1	31	0	0	1	1	0	
2	Cyber Security Specialist	Information security	Network security	Splunk	Penetration testing	Security Information and Event Management (SIEM)					
	<i>Frequency</i>	1	5	1	0	0					
3	Marketing Automation Specialist	Marketo	Salesforce marketing cloud	e-mail marketing	Digital marketing	CRM marketing					
	<i>Frequency</i>	0	0	4	19	0					
4	Robotics Engineering (Software)	Robotic process automation	UiPath	Automation anywhere	Python programming	C programming	SQL	Robotics			
	<i>Frequency</i>	1	2	2	31	17	35	0			
5	Site Reliability Engineer	Amazon Web Services (AWS)	Linux	Go programming	DevOps	Docker Products	Terraform	Jenkins	Ansible	Kubernetes	
	<i>Frequency</i>	29	27	0	25	18	4	8	7	10	
6	Data Specialist/Scientist	Machine learning	R	Python	Data mining	Data Science	Apache Spark	Big Data	Data modelling		



Sl.	Names of occupations	Frequency of skill demand in local market, in reference to BDJobs									
	<i>Frequency</i>	5	1	31	0	2	6	4	0		
7	Automation Consultant	Robotic process automation	UiPath	JIRA	Test Automation	Automation	Blue Prism	SQL			
	<i>Frequency</i>	1	2	22	5	5	2	35			
8	Service Designer or Experience Designer	Design Thinking	UX Research	User Centered Design	User experience	Customer experience design					
	<i>Frequency</i>	0	0	0	0	0					
9	Product Owner	Agile methodologies	Stakeholder management	Scrum	Product management	Business and Requirements Analysis	JIRA	Product development and management			
	<i>Frequency</i>	23	1	15	4	1	22	7			
10	Chief Strategy Officer, Growth Manager	Strategic partnerships	Merger and Acquisition (M&A)	Digital Strategy	Business strategy	Management consulting	Digital Marketing				
	<i>Frequency</i>	0	0	0	0	0	19				
11	Cloud Engineer	Amazon Web Services	Cloud Computing	Microsoft Azure	Devops	Docker products					
	<i>Frequency</i>	29	25	22	25	18					
12	Block Chain Developer	Hyperledger	Solidity	Node.js	Smart Contract						
	<i>Frequency</i>	0	0	38	0						
13	Software Engineering Manager	Product management	Process management	Project management	Technology Monitoring, Evaluation	Productivity Management	Software Marketing	Innovation, management	Communication	Motivation	Problem solving
	<i>Frequency</i>	4	0	13	0	0	0	0	27	0	6
14	Full Stack Engineer	React.js	jQuery	Laravel	JavaScript	AngularJS	MySQL	MongoDB	Node.js	Git	AWS



Sl.	Names of occupations	Frequency of skill demand in local market, in reference to BDJobs									
		<i>Frequency</i>	<i>44</i>	<i>69</i>	<i>54</i>	<i>127</i>	<i>17</i>	<i>89</i>	<i>19</i>	<i>38</i>	<i>49</i>
15	Chip Designers	Chip design verification	Logic Design	Design for Testability	Analog design	RTL design	SoC design	Physical design and verification	ASIC design	EDA tools	Building Ips; FPGA design; ASIC synthesis, Analysis
	<i>Frequency</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>

Source: Compiled by the ERG study team.

These 457 job postings have been made by 295 firms (details are in Appendix L). As the Table 9 indicates, only five job postings asked for machine learning. They have been no job posting asking for (i) Neural Net, (ii) Image Processing, (iii) Computer Vision, (iv) Natural Language Processing, and (v) Robotics. Even in cyber security, there has been very weak demand. On the other hand, at the academic and research level, there appears to be a strong supply capacity as shown in Table 11 and Appendix D and F. Hence, it may not be unfair to say that there is a weak demand in AI and Robotics. Data also indicate that there is weak demand for skills in data analytics and blockchain.



5.1.2 Learning from IT/ITES Professionals and HTP/STP Tenants

Most of the 207 technical skills mentioned by IT/ITES professionals (Appendix I) are found in the skills demanded by job postings at BDJobs. A few of those are in the emerging categories as indicated by LinkedIn analysis. In addition to technical skills, IT/ITES professionals have stressed the need for management skills (Appendix I). Relative demands, as reflected in percentages of respondents reporting a skill, for the top twelve management skills, are summarized in Table 10. A few skills like mentoring, decision making, and collaboration also contribute to self and on-job learning. Existing academic programs in CSC, CSE, ECE and other technology areas do not cover these skills. But these skills could be developed through industry-academia collaboration in undertaking joint projects. Besides, in guiding academic works pertaining to projects and assignments, faculty members may facilitate such skill development among the graduates. More importantly, during the internship period, special focus should be given in developing these skills. Hence, skill performance scorecard should include KPIs pertaining to these skills.

Among these three skill categories, soft skills are extremely difficult to develop. The study finds 52 soft skills reported by the IT/ITES professionals, as shown in Appendix I. Among them, top 14 are shown in the Table 10. Particularly, for developing soft skills, formal training has a very little role to play. Those need to be developed through the process of developing other two types of skills. Although existing academic programs are focusing and measuring technical skill performance, the weakness in soft skills runs the risk of suboptimal leveraging of technical skills. Furthermore, many of these soft skills like communication, motivation, speaking and documentation are vital for self and on-job learning. Hence, industry-university linkage is a must for addressing BHTPA's mission. Future skill demand of IT/ITES professionals is shown in Appendix N.

Table 10: Top management and soft skills

SL	Management Skills	% of Respondents Mentioning Each Skill	Soft Skills	% of Respondents Mentioning Each Skill
1	Time Management	30.34	Communication Skills	51.72
2	Project Management and Development	22.07	Critical Thinking and Problem Solving	38.62
3	Mentoring	8.97	Work with Team	24.14
4	Decision Making	6.90	Leadership	16.55
5	Client management	6.21	Interpersonal skills	8.97
6	Delegation	6.21	Motivation	6.21
7	Collaboration	4.83	Presentation Skill	6.21
8	Human Resource Management	4.83	English Speaking Skills	5.52
9	Business Knowledge, Analysis and Development	4.14	Adaptability	4.83
10	Estimation and Scheduling	4.14	Documentation	4.83
11	Strategic Vision and Thinking	4.14	Patience	4.83
12	Negotiation Skills	3.45	Creativity	4.14
13			Emotional intelligence	4.14
14			Attention to detail	3.45

Source: ERG Survey on IT/ITES professionals, 2022.

Responses of 10 HTP/STP tenants to a survey (10 respondents) indicate that there will be growing demand for 4IR skills as shown in Table M3 (in appendix M). But 0% respondents placed high importance on outside training for addressing it. On the other hand, 30% respondents placed high importance on academic

programs and industry-academia collaboration to address it, as shown in Table M1. Furthermore, although HTP/STP tenants placed high importance on soft skills (as shown in Table M6), for attaining six out seven of them, 0% respondents referred to outside training, as shown in Table M7. As shown in Appendix M (Table M1), academic programs and self-learning have been playing critical roles.

5.2 Local Skill Supply Capacity for the IT/ITES Industry

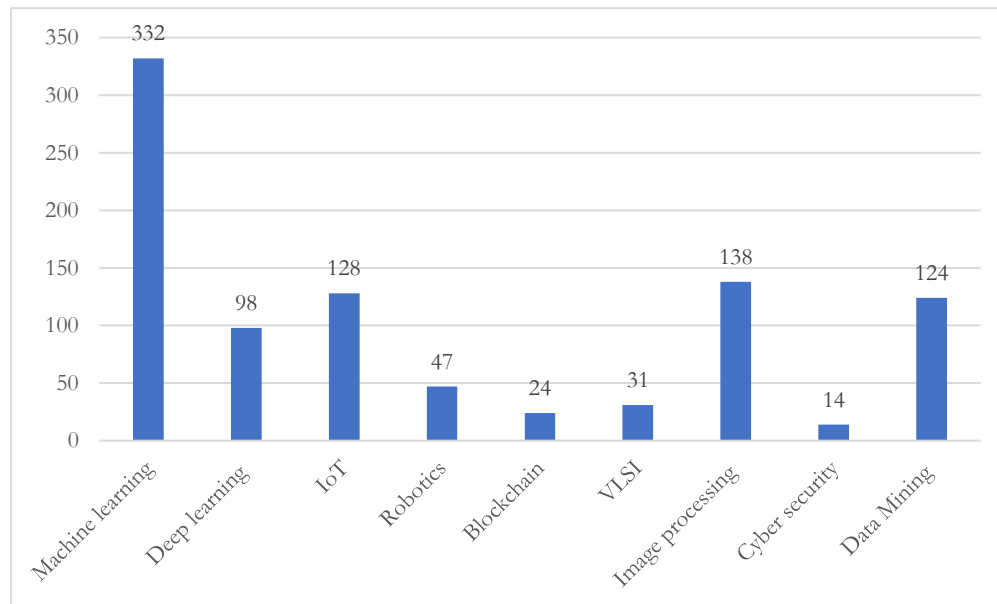
To assess the supply capacity for the IT/ITES industry, the study team has gathered data from both primary and secondary sources. As a part of the analysis, the team has profiled selected universities, faculty members of the selected departments of those universities, curriculum of universities and polytechnic institutes, capacities of training institutes, BHTPA setup laboratories, fellowships, and innovation grants of ICT division.

5.2.1 Profiling of Selected Universities

To assess the supply capacity in developing IT/ITES skills, particularly in the area of emerging technologies pertaining to the fourth industrial revolution, the study reviewed profiles of 1417 faculty profiles working in 30 universities of Bangladesh. The names of universities and related academic departments are shown in Appendix A.

As shown in Fig. 23, a large number of faculty members have expertise in 4IR related technologies. Furthermore, a good number of faculty members have expertise in Cloud Computing and Web technologies. It's also encouraging to note that 30+ faculty members in these 30 universities have expertise in VLSI, pertinent to chip designs. The expertise of these faculty members could be leveraged to develop skills among the graduates for developing the semiconductor industry. The challenge is to engage them in developing related skills among the graduates.

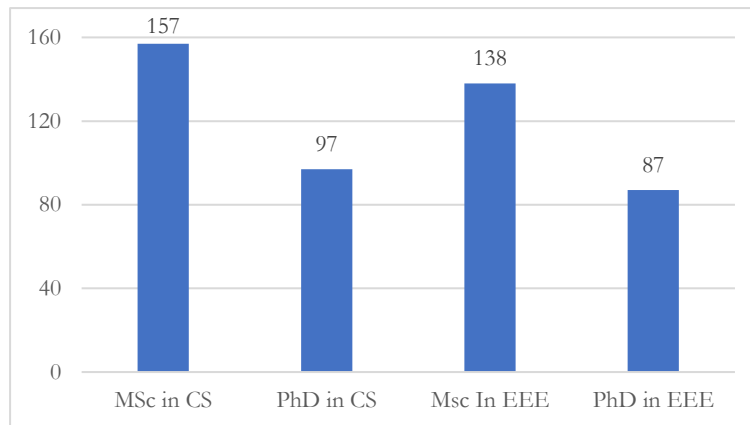
Figure 23: Number of faculty members having expertise in 4IR related technologies



Source: Compiled by the ERG study team



Figure 24: Faculty members with terminal degrees in CSE and EEE among 1417 faculty members of 30 universities



Source: Compiled by the ERG study team

Furthermore, these universities also have strength in their faculty profiles. Among these 30 universities, as high as 157 faculty members have MSc as terminal degree in Computer Science (CS). There are also 97 faculty members with PhD in computer science, as shown in Fig. 24.

5.2.1.1 Profiling of Faculty Members of Selected Universities

The review finds that a good number of the profiled 1417 faculty members have competency in emerging technologies as shown in Table 11. It appears that a substantial number of faculty members have the academic and research background in emerging technologies. Hence, these faculty members could be engaged to address skill development requirement for advancing Bangladesh's IT/ITES industries to leverage the emerging technologies pertaining to 4IR.



Table 11: Profiles of faculty members of 30 universities of Bangladesh in IT/ITES industry related skill areas

Number of faculty members having following degrees ²				Number of faculty members having expertise in following areas ³								
				Conventional Programming languages, database, web technologies	VLSI, integrated circuits, Chip design	4IR						
MSc in Computer science or computer engineering or both	PhD in Computer science or computer engineering or both	MSc in Electrical, Electronic and/or computer engineering	PhD in Electrical, Electronic, and/or computer engineering			IoT	Machine learning, Artificial intelligence	Image processing (IP), Computer vision (CV)	Data analytics (DA), Data science (DS), Mining	Robotics, Automation, cyber physical systems	Information security (IS), Cyber Security	Blockchain
157	97	138	87	Programming language: 6 Database: 31 Web tech: 36 Cloud computing: 48	VLSI:31 IC: 7 Area related to chip: 5	128	ML:332 Deep learning: 98 Neural network: 45 Natural Language Processing (NLP): 137	IP: 138 CV: 90	DA: 24 DS: 43 Big data: 36 Mining: 124	Robotics: 47 Automation: 10 CPS: 1	IS: 16 Cyber security: 14	Blockchain: 24 Cryptography: 16 Cryptocurrency: 1

Source: Compiled by the ERG team



² Only highest educational qualification has been taken into account for each faculty member to prepare this table.

³ Frequencies of expertise have been counted based on the research areas/research interests available in their profile.

5.2.1.2 Mapping of ICT Related Programs of Selected Universities

Academic programs of 30 universities have been reviewed to figure out the relevance of courses offered by these universities. The details are provided in Appendix D. It appears that there is a high density of academic courses supporting the skill development for meeting current and emerging demands. For example, among these 30 universities, as high as 24 of them offer courses in the area of VSLI supporting skill development for semiconductor chips. Similarly, more or less all these universities have been offering courses pertaining to 4IR technologies such as machine learning, artificial intelligence, IoT, and robotics.

5.2.2 Profiling of Selected Polytechnic Institutions

Academic programs of 10 Polytechnic institutions have been reviewed as shown in Appendix H. The study finds that these institutions have been offering courses in programming, software engineering, web technologies and cyber security as part of 4-year diploma programs in Engineering. The study also finds that target employers have been looking for CS/CSE graduates as opposed to graduates of Polytechnic institutions. Hence, skill upgradation of students of polytechnic institutions will have low implications on the BHPTA's mission of scaling up IT/ITES firms.

5.2.3 Profiling of Selected Training Institutions

Data pertaining to the skill development of 06 training institutions have been collected as shown in Appendix J. It appears that these institutions have trained a large number of people. Just two of them have trained more than 110,000 trainees. They have also been offering training in some of the skills demanded by the industry. But the study detects that the professionals employed in the industry finds training as less effective than self and on-job learning, academic background and internships. Furthermore, firms are interested to employ CS/CSE graduates, and these graduates do not have strong willingness to go to these training institutions for upskilling. Hence, relevance of these training institutions for upskilling to scale up IT/ITES firms does not appear to be strong.

5.2.4 Profiling of BHPTA Setup Laboratories

It has been learned that BHPTA has set up 31 laboratories in universities. Many of these laboratories have relevance to current exercise of assessing skill development and recommending means in delivering it. Relevance of these lab facilities in delivering skill development. Details are provided in Appendix E.

5.2.5 Profiling of Fellowships and R&D Grants of ICT Division

Eighty-two ICT fellowships and eighty-nine innovation grants offered by ICT division in the area of emerging technologies and IT/ITES were reviewed, and relevance to supply of emerging skills (pertaining to 4IR) was mapped. The details are provided in Appendix F. It appears that there is very high density of 4IR technology assimilation and development among in these fellowships and innovation grants. For example, among the 82 fellowships, as high as 39 fellowships and grants are for the purpose of investing AI. Hence, there appears to be supply side capacity development for 4IR technologies. Hence, BHPTA may leverage it for demand creation by catalyzing sectoral transformation.

5.3 Skill Gaps

Key informant interview indicates that Bangladesh's IT/ITES industry demands low end technical skills which do not require theories taught in the academic programs of computer science and engineering. For example, courses in the area of mathematics, compiler design, computer architecture, and liberal arts have no relevance to the nature of jobs they perform. On the other hand, among 140 credits, as high as 48 and

30 credits are allocated for teaching liberal arts and mathematics courses for the undergraduate programs of Computer Science and Engineering. It appears that industry has been demanding mostly coding, software design and testing, database, and web technology related competence. Unfortunately, most of the academic programs offer only a few courses in those areas. Hence, many of the technology skills required by the industry are being left outside the curricula of computer science and engineering, and other related academic programs. For example, a list of 39 skills which are emerging according to LinkedIn analysis and is shown in Appendix G, is not covered by academic courses. But some of them have relevance to existing courses.

5.4 Feasibility of Addressing Skill Gap

It appears that there has been a very high skill gap at the entry level. This is due to the fact that universities have been pursuing theory based liberal arts centric curricula and industry has been demanding a set of few specific technology skills. Furthermore, although theoretical foundation has been slowly progressing, technologies used in engineering real-life solutions have rapidly been changing. It's worth nothing that those technologies are derivation of theories taught in academic programs. For example, new programming languages, libraries and plugins are being developed to teach the complexity of programming and code maintenance. But they are being developed around theories taught in academic programs. But it's quite encouraging to note that professionals have been finding self-learning and on-job learning quite useful to address. Perhaps, such reality has been due to the fact of having theoretical foundation. Hence, despite having dissatisfaction about academic programs, firms have been recruiting disproportionate number of Computer Science and Engineering graduates.

To get insight about this issue, the study conducted a survey on professionals on several firms. Nature of jobs of responded professionals is shown in the Table 12.

Table 12: Nature of jobs of respondents

Broad designation of respondents	Firm type by things produced			Total sample
	Product	Service	Both	
Business Consultant/Analyst	10.00	8.16	9.09	8.82
General Manager	10.00	12.24	11.69	11.76
Programmer	20.00	0.00	5.19	4.41
Project Manager	0.00	4.08	3.90	3.68
Software Engineer	50.00	53.06	50.65	51.47
Software Product Manager	0.00	20.41	16.88	16.91
Technical Officer/Others	10.00	2.04	2.60	2.94
Number of observations	77	10	49	139

Source: Compiled by the ERG study team

Based on the responses of 145 professionals, it appears that as high as 80 percent of them have academic qualifications in undergraduate and graduate level computer science and engineering programs, as shown in Table 13. Furthermore, there has been rapid growth of concentration of degree holders of CS, CSE and other subjects over time.

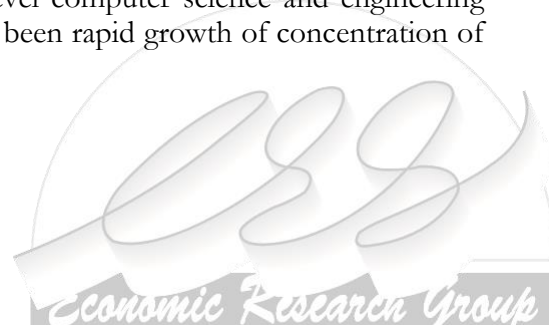


Table 13: Academic degrees of responded professionals in the survey

Degree/discipline	Completed last degree in year		All in %
	2012 or before in %	2013 or after in %	
BSc in CS, CSE, EEE. SE	55.56	71.43	69.34
Masters in CS, CSE, EEE	11.11	10.92	10.95
BBA/MBA	0.00	7.56	6.57
Diploma	0.00	0.84	0.73
Bachelors in other disciplines	22.22	0.84	3.65
Masters in others	11.11	8.40	8.76
Number of observations	18	119	137

Source: Compiled by the ERG study team

The study also finds that professionals have been finding self-learning as the most preferred means of addressing the changing skill demand to cope up with rapid technology change. As shown in Table 14, as high as almost 93 percent of the respondents have mentioned self-learning is having a high implication on their ability to cope with upskilling. Among other contributing factors, contribution of certificate training in upskilling is lower than the theoretical foundation developed by the academic programs. Furthermore, on-the-job training has similar implications to self-learning on upskilling. Hence, it's fair to say that certificate based standalone training has very low implications on upskilling of IT/ITES professionals.

Table 14: Efficacy of different channels on upskilling of IT/ITES professionals

	No response in %	High in %	Medium in %	Low in %
Academic	0.0	26.4	57.1	16.4
Internship	2.9	34.3	32.1	30.7
Project/Thesis	4.3	19.3	39.3	37.1
Certified training	4.3	20.7	41.4	33.6
Self-learning	0.0	92.9	6.4	0.7
On-the-job training	1.4	90.0	7.9	0.7

Source: Compiled by the ERG study team

Table 15: Educational background, by gender

Degree/discipline	Females in %	Males in %	Both sexes in %
BSc in CS, CSE, EEE. SE	70.0	67.2	67.4
Masters in CS, CSE, EEE	20.0	10.4	11.1
BBA/MBA	10.0	6.7	6.9
Diploma	NA	0.7	0.7
Bachelors in other disciplines	NA	3.7	3.5
Masters in others	NA	11.2	10.4
Number of observations	10	134	144

Source: Compiled by the ERG study team



Through the survey on IT/ITES professionals, the study also finds important gender related information about professionals. Both male and female professionals have similar academic background, as shown in the Table 15. It also reveals that higher percentage of female professionals have post graduate degrees. Furthermore, survey conducted on HTP/STP tenants indicate that as low as 0% respondents placed high importance on outside training for addressing skill gaps, as shown in Table M1 (appendix M).

Table 16: Relevance of various HR elements for future skill needs/career development

HR elements	No response	High	Medium	Low
Diploma	12.9	9.3	23.6	54.3
Honors	4.3	31.4	37.9	26.4
Master's	7.9	17.9	42.9	31.4
Certified training	4.3	47.9	37.1	10.7
Self-learning	2.1	94.3	3.6	0.0
On-the-job training	3.6	87.9	8.6	0.0

Source: Compiled by the ERG study team

The study also reveals that almost 90 percent professionals have been referring to self-learning and on-the-job-training as the most effective means of gaining skills for meeting their future career advancement, as shown in Table 16.

5.4.1 Can the Market Eliminate the Skill Gap?

As it has been explained, self-learning and on-the-job training have been playing a great role in upskilling. Hence, the market has been taking care of upskilling of already employed professionals. The bottleneck appears to be in the area of skill gaps of fresh graduates. It's also encouraging to note that many of the emerging skills which are not directly addressed by academic programs have roots in relevant academic courses, as shown in Table 17. Investigations in obtaining inputs from relevant faculty members spells out further details about how to integrate. Hence, they could be partly addressed through projects and assignments. Furthermore, as internship is showing higher efficacy than training in skill acquisition, internship program could be strengthened to address the skill gap of fresh graduates. Therefore, it could be reasoned that market could be strengthened through alignment of academic programs and strengthening internships to address the skill gaps.⁴

Table 17: Mapping of indicative professional courses and relevance to academic programs

Sl.	Occupations		Professional LinkedIn Courses	Relevant academic programs
1	Artificial Intelligence Specialists	Machine learning, Deep learning, TensorFlow, Python, Computer Vision, Natural	(i) Python for Data Science Essential Training; (ii) Python: Design Patterns; (iii) Machine Learning and AI foundations; (iv) Learning Hadloop.	CSE/CSC

⁴ It is generally recognized that virtual markets are more inclusive than the physical markets; and various platforms for 'freelancers' is one prime example. The virtual market for self-developments is also quite open, unless constrained by lack of resources to access. There may be instances of skills that are on high demand, but many students and fresh graduates may be unable to pay for online training services. Such cases of 'ineffective demand' are considering for supports upon strict enforcement of zero tolerance on misuse.

Sl.	Occupations		Professional LinkedIn Courses	Relevant academic programs
		language processing, Pytorch		
2	Cyber Security Specialist	Information security, Network security, Splunk, Penetration testing, Security Information and Event Management (SIEM)	(i) Cybersecurity Foundations, (ii) Learning Kali Linux, (iii) IT Security Careers and Certifications: First Steps, (iv) Troubleshooting Your Network with Wireshark, (v) Ethical Hacking: Exploits	CSE/CSC/ECE
3	Marketing Automation Specialist	Marketo, Salesforce marketing cloud, e-mail marketing, Digital marketing, CRM marketing	NA	BBA
4	Robotics Engineering (Software)	Robotic process automation, UiPath, Automation anywhere, Python and C programming language, SQL, Robotics	(i) Python for Data Science Essential Training; (ii) Project Management Foundations; (iii) Scrum: Basics.	CSE/CSC/ECE/EEE
5	Site Reliability Engineer	Amazon Web Services (AWS), Linux, Go programming, DevOps, Docker Products, Terraform, Jenkins, Ansible, Kubernetes	(i) DevOps Foundations; (ii) Learning Ansible; (iii) Advanced Linux; The Linux Kernel; (iv) Learning Go; (v) Python: Design Patterns; (vi) Linux: Bash Shell and Scripts; (vii) Python: Programming Efficiently.	CSE/CSC
6	Data Specialist/Scientist	Machine learning, R, Python, Data mining, Data Science, Apache Spark, Big Data, Data modelling	(i) Python for Data Science Essential Training, (ii) Statistics Foundations: 1, (iii) Python: Data Analysis, (iv) Data Science Foundations: Fundamentals, (v) Apache Spark Essential Training	CSE/CSC/Math
7	Automation Consultant	RPA, UiPath, JIRA, Test	NA	CSE/CSC

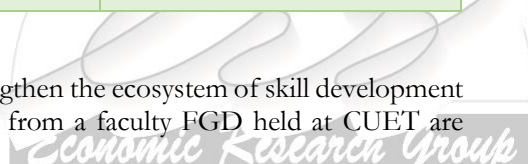
Sl.	Occupations		Professional LinkedIn Courses	Relevant academic programs
		Automation, Automation, Blue Prism, SQL		
8	Service Designer or Experience Designer	Design Thinking, UX Research, User Centered Design, User experience, Customer experience design	(i) UX Foundations: Research, (ii) Design Thinking: Understanding the Process, (iii) UX Design: 2 Analyzing User Data, (iv) UX Design: 1 Overview, (v) Planning a Career in User Experience	CSE/CSC
9	Product Owner	Agile methodologies, Stakeholder management, Scrum, Product management, Business and Requirements Analysis, JIRA, Product development and management	(i) Agile Product Owner Role: Techniques & Foundations, (ii) Scrum: Basics, (iii) Agile at Work: Planning with Agile User stories, (iv) Product Management First Step	CSE/CSC
10	Chief Strategy Officer, Growth Manager	Strategic partnerships, Merger and Acquisition (M&A), Digital Strategy, Business strategy, Management consulting, Digital Marketing	NA	CSE/CSC/BBA
11	Cloud Engineer	Amazon Web Services, Cloud Computing, Microsoft Azure, Devops, Docker products	NA	CSE/CSC
12	Block Chain Developer	Hyperledger, Solidity, Node.js, Smart Contract	(i) Learning Full-Stack JavaScript Development: MongoDB, Node, and React; (ii) Learning Go; Python for Data Science	CSE/CSC



Sl.	Occupations		Professional LinkedIn Courses	Relevant academic programs
			Essential Training; (iii) Code Clinic: Go.	
13	Software Engineering Manager	Product, process and project management, technology monitoring and evaluation, productivity management, software marketing, innovation and intellectual asset management, communication, motivation, problem solving	NA	CSE/CSC
14	Full Stack Engineer	React.js, jQuery, Laravel, JavaScript, AngularJS, MySQL, MongoDB, Node.js, Git, AWS	(i) Learning Full-Stack JavaScript Development: MongoDB, Node, and React, Learning Spring with Spring Boot, (ii) PHP: Design Patterns, C# Design Patterns: Part 1, (iii) Learning Redux8	CSE/CSC
15	Chip Designers	Skills for Chip design verification, logic design, design for testability, analog design, RTL design, SoC design, physical design and verification, ASIC design, EDA tools, building IPs, FPGA design, ASIC synthesis, Analysis and Simulation,	NA	CSE/CSC/ ECE/EEE

Source: Compiled by the ERG study team

However, there seems to be a need of developing a model to strengthen the ecosystem of skill development through industry-academia partnership. Relevant insights drawn from a faculty FGD held at CUET are shown in Box. 2.



Box 2:

Industry-Academia Collaboration for Addressing Skill Gap: Possible BHTPA initiative at CUET

The ERG team discussed the study objectives with a section of faculty members of Chittagong University of Engineering and Technology (CUET). Many faculty members proposed that small project works, pertaining to skill requirements, should be assigned to students as part of their academic activities, and this should begin from the first semester. Furthermore, internships should be extended from present provision of 15 days to 3 months to one year. Students, thus empowered, would generate ideas and nurture those into viable products around which startups could be incubated. Since mentoring by competent faculty members is needed, academic programs need appropriate revisions to accommodate their extended involvement. In addition, financial support, professional incentives, and provision of shared ownership of startups are worth considering.

The faculty members were however found inadequately exposed to the nature and challenges of R&D, and technology and innovation management. Being aware of the problems, the faculty members pointed to the necessity of offering them a model and guiding them to create innovation success so that they can learn and scale-up.

The discussion further revealed that existing incentive scheme encourages faculty members to publish academic articles. And linkage with the industry is limited to the issuance of specification/performance certificates to imported technology products. The study team therefore recommends that BHTPA initiates a 4+ years programme to turn its ICT business incubator at CUET into a model for university-based breeding ground of innovation, entrepreneurship, and startups for leveraging technology possibilities.

Such a transformation program should prepare new entrants into innovators and digital entrepreneurs, and nurture them to innovate viable products, and incubate startups for their continued advancement and commercialization. Developing, fine-tuning, and sustaining such a model is vital for making BHTPA a pioneer.



5.5 Target Recipient Groups of Skill Development

As explained, as high as 80 percent professionals employed in the IT/ITES sector have an undergraduate and a post-graduate academic qualifications in the area of computer science and engineering and other related subjects. Furthermore, similar statics are revealed in the job postings, shown in the Table 18.

Table 18: Frequency of academic qualifications sought in job postings at BDJobs

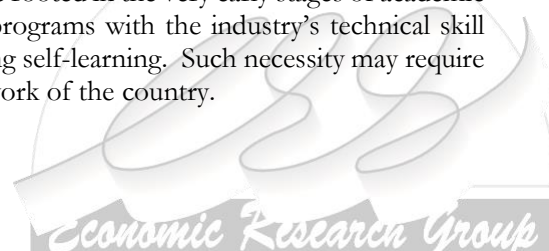
Sl.	Education Qualifications	Frequency
1	BSc/BEng in CSE, CS, EEE, ETE, ECE or IT related subject	319
2	MSc in CSE, CS, EEE, ETE, ECE or IT related subjects	65
3	Bachelor of Computer Application (BCA)	11
4	Masters in computer application (MCA)	2
5	BBA in Marketing/Accounting/MIS/Finance/Management	28
6	MBA in Accounting/Marketing/Management/Finance	11
7	Bachelor's degree in any discipline	63
8	Master's degree in any discipline	3
9	Diploma in engineering	34
10	HSC/A-Levels	10
11	SSC/O-Levels	3
12	BSc in Physics/Mathematics/Statistics/Economics	12
13	BCom in Accounting/Electronics and Telecommunication Engineering	2
14	Doctorate Degree (PhD)	2
15	Master of Information & Communication Technology (MICT)	2
16	No Specific Degree Required	23
17	Other	9
	Total	599

Source: Compiled by the ERG study team

Findings summarized above (Table 18) is a good guide to who may be targeted -- primarily BSc/BEng (or, MSc) in CSE, CS, EEE, ETE, ECE or IT related subjects.

5.6 Efficacy of Delivery Framework and Channels

As it has been explained, the study finds that self-learning and on-job training are the most effective means in addressing the upskilling of the professionals. They have also mentioned the moderate importance of the role of academic programs and internships. But the importance of certificate training in addressing the skill gap has been reported to be low. On the other hand, CEO and COO level interviews of a few high-profile IT/ITES firms reported that there has been a substantial skill gap among the fresh graduates of CSE and other related disciplines. But as they mentioned and the job posting and profiles of professionals indicate, preferred academic qualifications of IT/ITES firms are CSE and other technical disciplines. Hence, skill development initiatives need to be embedded within the academic framework. Furthermore, as self-learning plays a vital role, ability of self-learning should be rooted in the very early stages of academic life. Therefore, skill gap issues require not only linking CSE programs with the industry's technical skill requirements, but also sharpening of the soft skills for improving self-learning. Such necessity may require fine tuning of the overall human resource development framework of the country.



5.7 Comparison of local and global scenarios and lessons for IT and ITES Industry of Bangladesh

India's technology services reaching US\$ 133.7 billion during 2020-21 is remarkable. Estimated employment of 16 million graduates in software, computer, ITES, and BPO services beacons neighbors, like Bangladesh, to replicate India's such a remarkable success. Besides, Malaysia's success of developing a very large export-oriented semiconductor industry is also an encouragement for Bangladesh and many other less developed countries. But due to reliance on skill development for labor-based linear model of value addition, despite the success of exporting \$100 billion worth semiconductor, Malaysia's value addition is very low. Hence, Malaysia has remained caught in middle income trap. On the other hand, Vietnam's noteworthy success in export revenue in high-tech trade is also not encouraging for Bangladesh to achieve the dream of attaining high middle income and advanced economy state within stipulated time frame (Rokonuzzaman, 2021). Hence, although Bangladesh has embarked on setting up 39 high-tech and software technology parks, skill development focus is yet to be on scaling up value addition and growth for taking Bangladesh to the envisioned level, as outlined in the Perspective Plan 2041 and the 8th Five Year Plan.

As opposed to trading service in terms of working hours, Bangladesh needs to focus on developing and trading intellectual assets--embedded in goods, services and processes to produce them. Here is an example from Taiwan--a small economy's miracle success in technology trade out of intellectual assets. Instead of exporting silicon chip processing services by taking the advantage of wage differential, Taiwan focused on developing and trading intellectual assets through process innovation.

Hence, the enhancement knowledge and the skill base for developing and trading intellectual assets in the global market is vital for scaling up IT/ITES industry. Instead of trading intellectual assets as standalone products, the strategy should be to embed them into products and processes. Particularly, in software and digital content space, the scope of succeeding from trading intellectual assets is extremely high—due to the zero cost of copying and network externality effects. It happens that the expertise and model to succeed in intellectual asset development and trade are quite different than skill base needed for India's success of trading man-hours or Malaysia's labor based high-tech model. In pursuing the skill development agenda, this distinction deserves serious consideration from BHTPA. Otherwise, there is as strong possibility that upon replicating leaders' skill base, Bangladesh will fail to attain similar success—let alone attaining the targets set in perspective plan and the 8th Five-year plan.

Artificial intelligence and embedded systems have been showing high global growth trend but a demand for these skills in local industry are yet to pick up. Perhaps, the underlying reason has been that Bangladesh has been at lower steps of the ladder. Hopefully, in course of time, the demand for such skills will also pick up in Bangladesh. Within this context, it is encouraging to note that Bangladeshi universities have substantial supply capacity. However, academic capacity needs to be linked with the delivery of practical solutions. BHTPA may play a bridging role in this regard.

As noted earlier in section 3.1.1, APAC region has been losing ABC skilled workforce, primarily to the USA. Such outflow indicates that Bangladeshi IT/ITES firms can export services out of these skills to the US market. As mentioned, at present, there has been low demand of some of these skills in Bangladesh. Hence, BHTPA has the opportunity to lead and stimulate the demand, by increasing the supply of ABC skills.

Bangladesh's IT/ITES segments are dominated by domestic firms. Hence, there could be a gap between skill demand in Bangladesh and other selected countries discussed in section 3. However, it might be useful to have a look at Singapore's approach of skill development for future economy.

Developing Technology Scanning and Evaluation skill is overlooked in many developing countries. IT/ITES or high-tech skill development programs in Bangladesh are no exception in the hindsight. Hence, in order to scale up the demonstration and tap into new opportunities created by emerging technologies, BHTPA should focus on developing skills pertaining to this area.

Furthermore, as the demand for 4IR related skills in Bangladesh is very low, BHTPA is advised not to pursue certificate-based training for such skill development programs. Instead, BHTPA may follow the

example of Singapore. Like Singapore, Bangladesh's different economic and public sectors will likely benefit from 4IR technology base transformation. Unfortunately, often, for such transformation, foreign firms are recruited. As a result, local industry does not get the opportunity of acquiring tech-heavy role through such transformational projects. There is no denying that such exercises create tech-lite roles, but the skill base needed for tech-lite role is not exportable for the BHTPA's current and pipelined SMEs. There might be question of availability of skill base for undertaking those sectoral transformation projects by local firms. Fortunately, academic institutions have faculty members having relevant academic background. Hence, BHTPA may undertake catalytic role in establishing linkage between IT/ITES industry, academic institutions, and target sectors. Consequentially, along with sectoral performance improvement, local IT/ITES industry will enhance skill base and attain sustainable skill supply capacity.



6. Summary of Findings, Observations, and Recommendations

6.1 Summary Observations on IT/ITES Sector

1. Isolated skill development programs in producing certified professionals to be leased to foreign companies, for leveraging linear model, run the risk of failing to scale up the IT/ITES industry in Bangladesh.

2. There is a gap between emerging IT/ITES skills and existing demand and the skill base of the local industry. Hence there is a need for upskilling. However, standalone training programs have a low appeal, as reported by the IT/ITES professionals.

3. Drawing upon the responses of the stakeholders, the Study finds that self-learning and on job learning are considered highly effective for coping with the rapidly transforming skill base. Although several institutions have been offering training services, such skill development trainings are reported to have had moderate to low level of importance/contribution.

4. The industry prefers to recruit university graduates with degrees in CS, CSE and other related areas. But fresh graduates suffer from skill gap. Hence, there is a need for an intervention through university-industry linkage.

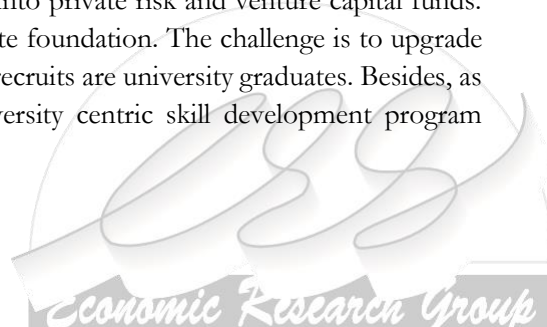
5. Generic IT/ITES skills base for the purpose of installing, operating, and repairing are of no use for the IT/ITES industry to scale up. Hence, IT/ITES skill and occupational areas stated in ISCO, as shown in Tables 6 and 7 under subsection 4.1.3.1 and subsection 4.1.3.2, are of little use for the industry.

6. Although upon getting jobs, CSC/CSE graduates have been doing very well to cope with skill upgrading through self and on-job learning, skill gap at the entry level of fresh graduates is considered a barrier to scale up IT/ITES industry. This is primarily due to the exclusion of specific skills in textbook-based academic programs at the undergraduate level.

7. Globally, semiconductor is a growing area. Two local firms engaged in chip design services are facing the shortage of skilled HR. But universities have academic courses in relevant areas and have qualified faculty members. The challenge is to upgrade lab facilities with the state-of-the-art tools, and link the university-based lab activities with the relevant firms.

8. Although there has been a growing trend of 4IR skills in the global market, there is very weak demand of such skills in the local industry. On the other hand, many local economic sectors are poised to experience transformation through procurement of 4IR technologies. Besides, universities have strong base of faculty pool having 4IR academic background.

It's worth noting that the current practice of subsidy-based customer acquisition is not a sustainable model for startups. For attaining economic aspiration, Bangladesh badly needs to graduate from trading labor and knowledge to developing and commercializing ideas. But the industry is yet to tap into this opportunity. Furthermore, startups and digital entrepreneurship need to develop the capacity of generating and trading intellectual assets for increasing valuation so that they can tap into private risk and venture capital funds. University centric local supply capacity appears to have adequate foundation. The challenge is to upgrade and link it with the industry. Furthermore, industry's preferred recruits are university graduates. Besides, as female student population density is high and growing, university centric skill development program appears to be appropriate.



6.2 Observations on Skill Development Objectives

Overall observations on study objectives are given in Table 19.

Table 19: Observations on study objectives

Sl.	Study objectives in the ToR	Observations/Sources of information
1	What are the sector trends in skill demand?	Summary of skill trend based on LinkedIn data analysis and job postings at the BDJobs have been presented.
2	What are the existing expertise levels in the industry?	Skills profiles of professionals employed in the IT/ITES industry gathered through a survey and their compilation present the existing expertise level of the industry.
3	What are the skill gaps?	Skill gaps appear to be at the requirement of the fresh graduates, as many of skills needed by the industry are not covered in the liberal arts based broad academic programs offered in Computer Science and Engineering and other related areas.
4	Which are the segments who may avail HR/Skill scale up objective?	Undergraduate and graduate students in the area of computer science and engineering and related disciplines may avail HR/skill scale up.
5	Is it feasible to close up relevant skill gaps in the market?	Although market has been doing well through self-learning and on-job learning, intervention is needed to have better skill development interface between academic programs and the skill demand of the industry.
6	Identify topics for training and prioritize those?	A list of emerging skills as gathered from the LinkedIn data and mapped to local demand could be good starting point for skill development. In addition, the survey identified several management skills, and hard and soft skills that the local firms consider important.
7	Who should be involved in the training?	It seems that a large pool of university faculty members has strong science foundation in relevant skills. On the other hand, senior industry professionals have hands on experience on practical skills. Hence, partnerships between university faculty members and senior industry professionals should be formed for address skill of gaps graduating students.
8	How to fix the performance challenge (of training programs)?	By forming partnership between university faculty members and senior industry professionals, we can ensure better performance of the various kinds of skill developments proposed in this report.
9	How best to make training available? Identify barriers to training & employment, particularly, employment to women and other potential recipients	Developing skill demanded by the industry and improving self-learning ability, we need to add projects and assignment components in related courses of undergraduate and graduate programs. Furthermore, internship program should be blended with teaching by university faculty members and practiced with the guidance of industry professionals. Barrier appears to be in forming partnerships between industry and academia, which could be addressed by provisioning of funds for developing relevant content and remunerating time of faculty members, and industry professionals, and giving stipend to participants of the Internship programs. As undergraduate programs have high enrollment of female students, availing the proposed route will better ensure the inclusion of female students in the proposed upskilling programs.

Sl.	Study objectives in the ToR	Observations/Sources of information
10	Increasing the capability of digital entrepreneurs to avail equity financing	For increasing the capacity of availing equity financing of digital startups, skill development should take place in improving R&D and innovation management, and by conducting R&D so the valuation of startups increases due to intellectual asset (IA) development and the burden of giving subsidies decreases for exploitation of start-up ideas.
11	Increasing the supply of skills in the 4IR areas	Based on skill data of job posting, there seems to be very weak demand of 4IR skill sets. Furthermore, there has been ample supply capacity through academic programs and fellowship and innovations grants offered by ICT division.
12	Scaling up IT/ITES firms	<p>Reducing skill gap of fresh graduates and improving their self-learning ability will help in scaling up.</p> <p>The skill development in the fields of intellectual assets and their trading with growing number of customers will facilitate scaling up.</p> <p>Transformation of local economic sectors with emerging (4IR) technologies will also contribute to scale up, due to skill development and flow of work orders.</p>
13	Increasing the pipeline IT/ITES firms	Identification of pipeline firms requires a prior specification of criteria that are expected to be fulfilled by the firms. In general, however, reduction of skill gaps among fresh graduates and increased motivation among them leading to increased number of startups will contribute positively. In addition, skill development of startups to enable those to engage in intellectual assets development and trading will contribute to increasing pipeline IT/ITES firms.



6.3 Observations on Skill Development Approaches

Observations on different skill development approaches are shown in Table 20.

Table 20: Observations and recommendations on different approaches of skill development

Sl.	Skill Development Approaches	Observations	Recommendations
1	Short training programs to develop skills demanded by industry.	<ol style="list-style-type: none"> 1. If there is weakness in academic foundation, skill acquisition through training will not scale up through on-job self-learning. 2. Conceptual capability needed for innovating technology solution. The latter cannot be developed through short-term training only. 3. Due to rapid change of technologies, firms face the challenge of quickly mastering state of the art skills and fine tune them for precision application. While regular upgrading is needed, it is better achieved among those with higher conceptual ability. The skill needs are to be defined on a continuous basis. Thus, identification and delivery are better assured by a university-industry nexus. 	<p>More or less all the technical or hard skills demanded by the industry have relevance to academic courses. Hence, academic courses should be linked with the sharpening of relevant skills.</p> <p>It could be done through projects works, industry-academia joint projects, and research for evaluating and advancing those skills.</p> <p>In certain cases, industry-focused Master's and R&D programs could be developed to absorb and advance state-of-the-art applied skills. Moreover, Industry-university linkages, with pro-active BHTPA engagement can define the short-term needs.</p>
2	Through academic undergraduate and post-graduate programs	As the mapping indicates, many of the emerging skills could be delivered through assignments and projects works, as part of existing courses.	Technical assistance should be provided to universities to develop projects and assignments.
3	By strengthening the Internship programs	It seems that internships are playing important role in addressing skill gaps. Current practice of internship should be extended by having more active participation of faculty members and senior industry professionals.	BHTPA may consider in facilitating academic-private business and academic-government sector linkages for effective gains out of internship programs. It is also important to assess financial supports to meet basic expenses and ensure incentives.
4	By introducing industry focused M.Sc. and professional programs	Many of technical skills and management abilities in the area of project, technology, strategy and product could not be addressed through undergraduate and internship programs.	BHTPA's intervention in facilitating the development of an industry focused M.Sc. program in a few selected universities will strengthen the ecosystem.
5	Through joint collaborative projects between	Hands-on experience on emerging skills could be obtained through demonstration projects—in partnership with industry & academia	BHTPA may consider in identifying target projects and sponsor them on a cost sharing basis.

Sl.	Skill Development Approaches	Observations	Recommendations
	industry and academia		
6	Doing applied research and sharing intelligence pertaining to business landscape, technology assessment and skills	As shared in FGD, industry will benefit from the intelligence of changing global business and technology landscape.	BHTPA may actively consider developing and maintaining a repository of applied research and market intelligence for supporting the government and build capacity in universities, Think Tanks, and industry associations.

In addition to the above, the report has hinted at two other routes to pursue skill development in a more robust and sustained manner, both of which require sector-level and policy-level interventions. These are highlighted below.

7. *Transforming local economic sectors through emerging technologies:* For leveraging 4IR technologies and creating the supply and demand of relevant skills, mega initiatives for sectoral transformation can be a useful exercise. BHTPA should desirably work in partnership with relevant Government agencies and private sector partners to select and stimulate the transformation of high potential sectors (like Singapore).

8. *Pursuing policy options for increasing local value addition:* Semiconductor industry could be kick-started by adopting policies that would enable increasing value addition in IT/ITES products sold in Bangladesh. BHTPA may consider initiating policy reform in facilitating local value addition through the semiconductor industry.



6.4 Recommendations for Skill Development for Supporting HTPA's Objectives

6.4.1 Recommended program areas for addressing BHTPA's objectives

Four specific objectives of BHTPA are:

1. Addressing skill demand for leveraging the emerging IT/ITES opportunities
2. Addressing the skill for intellectual asset (IA) development and trading
3. Promoting 4IR innovations and entrepreneurships
4. Developing skills for leveraging the semiconductor industry

Recommendations are made based on likely skill demand on short, medium and long demand, as shown below:

Timeline	Types of skills	Justification
Short term: 1-2 years	Global IT/ITES skill demand as outlined in Table 5	There is a gap between local and global skill demand as shown Table 5&9
Medium term: 2-3 years	4IR and semiconductor industry skills	At present there is weakness in 4IR skill demand as shown in skill demand in Appendices C and I. Skill demand for semiconductor will also take time.
Long term: 3-5 years	Skills for intellectual asset development and exploitation	Additional intervention is needed to create awareness

Further details are provided in Table 21.

Table 21: Recommendations for BHTPA's envisioned skill development program

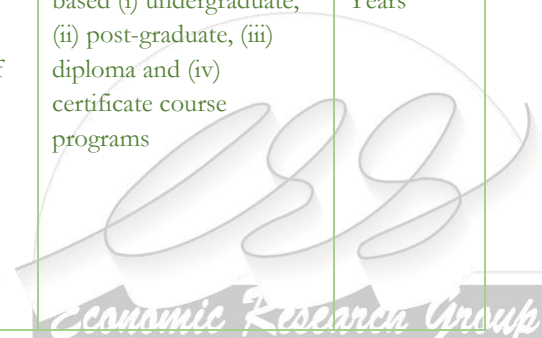
Sl.	Skill areas	Why?	How?	Who are recipients?	What are delivery Channels?	When?
1	Meeting emerging IT/ITES Skill demand	1. Local IT/ITES industry will be demanding emerging skills, as identified by the study, down the road.	1. Upon consultation with industry, integrate emerging skills in existing undergraduate and post-graduate program	1. Undergraduate and post-graduate students of EEE, ECE, and CSE. 2. Professionals already working in the industry	1. University based academic programs (Appendix G) 2. BHTPA setup laboratories (Appendix E)	1-2 years

Sl.	Skill areas	Why?	How?	Who are recipients?	What are delivery Channels?	When?
		<ul style="list-style-type: none"> 2. A list of emerging skills is not covered in the academic programs. 3. Graduates having emerging skills will have better employment opportunities in both local and global market. 	<ul style="list-style-type: none"> 2. Support universities to expand their existing courses and introduce new courses for accommodating emerging skills 3. Through industry collaboration offer relevant projects through theory courses, design courses (Capstone), and senior projects. 4. Internship program under the joint supervision of academics and senior industry professionals. 5. Offer certificate courses through relevant universities and laboratories already setup by BHTPA 6. Offer M.Sc. level thesis for technology monitoring, assessment, and prediction. 		<ul style="list-style-type: none"> 3. Internships in participation of university and industry (Appendix G) 	
2	Skill for intellectual asset development and trading,	<ul style="list-style-type: none"> 1. Due to huge supply capacity, and economies of scale and scope advantage of India due to early lead, Bangladesh has been failing to scale-up linear model. 	<ul style="list-style-type: none"> 1. Enhance undergraduate programs of EEE, ECE and CSE by enhancing relevant courses and adding new courses with focus on intellectual asset development and trading 	<ul style="list-style-type: none"> 1. Undergraduate and post-graduate students 2. Industry professionals participating in post-graduate studies and training programs. 	<ul style="list-style-type: none"> 1. University based academic programs, 2. Industry focused research labs, programs and center of excellences 3. Certificate programs 	<ul style="list-style-type: none"> 3-5 Years



Sl.	Skill areas	Why?	How?	Who are recipients?	What are delivery Channels?	When?
		<ol style="list-style-type: none"> 2. Intellectual asset development out of less costly human resources offers an alternate route to leverage technology possibilities and wage differentials. 3. Patent office data and key informant interviews indicate that Bangladesh's IT/ITES industry yet to leverage intellectual assets. 4. For scaling up, IT/ITES industry must focus on leveraging zero cost of copying of intellectual assets (software, contents) in the digital space. 5. Liner model is not sufficient for making Bangladesh a high-income country 6. For increasing valuation of startups due to intellectual asset development for leveraging private equity and venture capital fund 	<ol style="list-style-type: none"> in global innovation dynamics. 2. Offer M.Sc. programs in technology and innovation management with practical focus on target industries like IT/ITES and Semiconductor 3. Develop relevant center of excellence in a few universities and offer industry advisory and training services 4. Create market for intellectual assets. 5. Offer certificate programs in IA and patent management to industry professionals. 	<ol style="list-style-type: none"> 3. Firms as recipients of advisory services 4. Government departments through receiving advisory services for updating Science, Technology, Industry, and overall economic policies for creating market of intellectual assets. 		
3	Promoting 4IR skill base, innovations, and entrepreneurships	<ol style="list-style-type: none"> 1. 4IR innovations offer transformational opportunities and challenges in creating high paying jobs. 	<ol style="list-style-type: none"> 1. Setup research labs for developing transformational maps of different sectors. 	<ol style="list-style-type: none"> 1. Undergraduate and post-graduate students 2. Industry leaders 3. Potential entrepreneurs 	University based industry focused academic, research, training and advisory programs	2-3 Years

Sl.	Skill areas	Why?	How?	Who are recipients?	What are delivery Channels?	When?
		<ol style="list-style-type: none"> Study finds very weak 4IR skill demand in the local market, but there has been high growth in the global market. Study also finds that there is a strong academic capacity in developing 4IR skill sets 	<ol style="list-style-type: none"> Conceive innovation ecosystem and market for implementing designed transformational maps Promote sectoral transformational maps and ecosystem to industry and academia. Update existing academic and research programs for the inclusion and demonstration of transformational maps Develop and promote policies for driving the implementation of sector specific 4IR centric transformational maps. Offer training programs for absorbing transformational maps 	<ol style="list-style-type: none"> Relevant Government departments 		
4	Developing skills for semiconductor industry	<ol style="list-style-type: none"> Semiconductor is a growing high tech-tech area Due to import substitution strategy, there is a growing consumption of semiconductor components Local demand could be used to develop human 	<ol style="list-style-type: none"> Setup semiconductor bonding and testing labs in Polytechnic institutes and link them with microelectronics courses Link VLSI design courses with industry tools and techniques Make EDA tools available to selected universities 	<ol style="list-style-type: none"> Undergraduate students of EEE, ECE, CSE, and Physics Graduates' students of MSc in VLSI design Diploma students in EEE and CS of poly technique institutes. Graduates needing training for immediate employment 	Academic institution based (i) undergraduate, (ii) post-graduate, (iii) diploma and (iv) certificate course programs	2-3 Years



Sl.	Skill areas	Why?	How?	Who are recipients?	What are delivery Channels?	When?
		<p>resources for attracting foreign investment</p> <p>4. Existing firms demand scaling up skill base</p> <p>5. Development of strong foundation in VLSI design, testing, assembling and bonding will attract foreign investments</p> <p>6. Trained human resources will get job opportunities in the international market</p> <p>7. Existing firms (2) employing about 300 chip designers are facing the shortage of skilled HR supply.</p>	<p>which could be shared with others.</p> <p>4. Promote M.Sc. in VLSI designs with focus on designing practical chips and developing intellectual assets.</p> <p>5. Offer relevant short courses through relevant academic institutions</p> <p>6. Development and promotion of appropriate policies of creating the competence base through meeting local demand of semiconductor</p>			



6.4.1.1 Performance Management

The objective of the skill development is to enhance the human capital base through ecosystem strengthening so that Bangladesh IT/ITES industry scale up and diversify in emerging high-value added areas. Hence, performance management in skill development programs should focus on three strategic actors such as (i) Individuals, (ii) Skill development institutions, and (iii) Industry. The following framework is recommended for measuring and targeting next level of skill development:

Actors/Areas	Capabilities ordered in terms of levels			
	Understanding	Applying	Self-Learning	Intellectual Asset Creation
Individuals	Remember, understand, experiment and demonstrate	Analyze, evaluate and create solution as per specification	Monitor, forecast and manage learning process for self and group	Assess market, and create as well as manage intellectual assets in a systematic manner
Academic institutions	Can empower students to learn specified knowledge and skills	Can supervise students to work with the industry to solve practical problems	Can undertake assess, and predict unfolding situation and update upskilling programs	Predict unfolding innovation opportunities, undertake collaborative R&D and development intellectual assets
Industry (firms)	Through industry-academia collaboration and internship facilitate acquiring existing skills	Drive on-job learning and learning through demonstration projects in partnership with the industry	Monitor and assess emerging skills and take proactive roles to acquire, advance and promote them to clients	Acquire organization capacity for technology and innovation management, and systematic intellectual asset development and trading.

Note: there may be outlier where one may acquire higher level of ability without necessarily having expertise in the lower level. There could be further segregation in each of those levels. Entry level assessment should be done in each of those capability areas, which should be assessed and benchmarked. Assessment should be done at both entry, execution and post periods



6.4.2 Cost Elements of Recommended Skill Development Programs

Indicative cost elements are provided in Table 22.

Table 22: Indicative cost elements for implementing programs

Sl.	Programs areas	Cost elements	Observations
1	Addressing skill demand for leveraging the emerging IT/ITES opportunities	<ol style="list-style-type: none"> 1. Remuneration of time of faculty members of universities and senior industry professionals for course material development and delivery—as part of undergraduate and graduate programs. 2. Remuneration of time faculty members and industry professionals for actively supervising internship programs 3. Stipend given to participating students. 	As self-learning is found to be highly effective, faculty members and industry professionals having relevant background are competent enough to play expert role. There is no need for engaging foreign expertise.
2	Addressing the skill for intellectual asset (IA) development and trading	<ol style="list-style-type: none"> 1. Remunerating faculty time for developing courses 2. Remunerating time of senior industry professionals 3. Offering stipend to participants 	<ol style="list-style-type: none"> 1. A few guest faculty members could be involved from foreign countries. 2. No need to send trainee to foreign institutions.
3	Promoting 4IR innovations and entrepreneurships	<ol style="list-style-type: none"> 1. Sponsor research for sector transformation map development 2. Remunerate time of participating faculty members, students, and industry professionals 3. Set up few 4IR labs and/or improve existing ones 4. Fund demonstration and technology development projects for targeted sectoral transformation 5. Fund program management activities 	<ol style="list-style-type: none"> 1. No need to engage foreign professionals. 2. Universities have faculty members with 4IR competence; the challenge is to engage them in collaborative demonstration projects
4	Developing skills for leveraging the semiconductor industry	<ol style="list-style-type: none"> 1. Remunerate time of faculty members and industry professionals for integrating academic courses with industry's skill and tool base 2. Pay for license of EDA tools 3. Offer stipend for internships 4. Remunerate faculty time for opening M.Sc. programs. 5. In partnership with industry, integrate actual chip design activities in academic programs 	<ol style="list-style-type: none"> 1. Empowerment of faculty members with relevant academic degrees and industry experience will address base expertise. 2. Engage foreign industry expert through virtual platform to work with local faculty members and industry professionals to strengthen skill development base.

6.5 Recommended Training Programs as a Transition Strategy

The updating of academic programs of universities requires to go through a reasonably long process to get reviewed and approved by University Grants Commission (UGC). Furthermore, the study also finds that a few skill development activities would require significant change of academic programs. In certain cases, even new degree programs or introduction of new courses would be required. Hence, the study recommends undertaking training programs to address skill gaps in possible shortest time. However, the study finds strong reason to term this training program as a transition mechanism to address skill gaps. In addition to offering these training activities, it is recommended that BHTPA collaborate with UGC and universities to update their academic programs to build sustainable skill development capacity of the ecosystem. Hence, upon considering the global trend and local demand, the following skill development program is recommended as a transition strategy.

Table 23: Recommended Skill Development Program

Areas	Occupations	Skills	Target recipients	Duration and Channel
Scaling IT/ITES, STP/HTP tenants and increasing pipeline SMEs for HTP/STP	Cloud Engineer	Amazon Web Services, Cloud Computing, Microsoft Azure, DevOps, Docker products	Fresh graduates in engineering, computer science and other related subjects, and professionals	6 months Classrooms Online courses Blended learning
	Site Reliability Engineer	Amazon Web Services (AWS), Linux, Go programming, DevOps, Docker Products, Terraform, Jenkins, Ansible, Kubernetes		
	Automation Consultant	RPA, UiPath, JIRA, Test Automation, Automation, Blue Prism, SQL	Experience of professionals, freelancers and startups founders will partly offset academic qualifications	
	Software Engineering Manager	Product, process and project management, technology monitoring and evaluation, productivity management, software marketing, innovation and intellectual asset management, communication, motivation, problem solving		
	Product Owner	Agile methodologies, Stakeholder management, Scrum, Product management, Business and Requirements Analysis, JIRA, Product development and management		
	Full Stack Engineer	React.js, jQuery, Laravel, JavaScript, AngularJS, MySQL, MongoDB, Node.js, Git, AWS		
	Cyber Security Specialist	Information security, Network security, Splunk, Penetration testing, Security Information and Event Management (SIEM)		
	Service & Experience Designer	Design Thinking, UX Research, User Centered Design, User experience, Customer experience design		

Areas	Occupations	Skills	Target recipients	Duration and Channel
	Marketing Automation Specialist	Marketo, Salesforce marketing cloud, e-mail marketing, Digital marketing, CRM marketing	Business graduates with exposure on technology	
Intellectual assets for growth and valuation	Chief Strategy Officer and Growth Manager	Strategic partnerships, Merger and Acquisition (M&A), Digital Strategy, Business strategy, Management consulting, Digital Marketing	Graduates of science, engineering and business Experience of professionals, freelancers and startups founders will partly offset academic qualifications	6 months Classrooms Online courses
	Chief idea, Valuation, Intellectual Asset and Equity Financing Manager	Idea management, business model innovation, digital disruption, intellectual asset and property management, managing R&D & innovation, valuation methods and equity financing, strategy, communication and persuasion,		
Semi-conductor	Chip Designers	Skills for Chip design verification, logic design, design for testability, analogue design, RTL design, SoC design, physical design and verification, ASIC design, EDA tools, building IPs, FPGA design, ASIC synthesis, Analysis and Simulation;	Graduates of EEE/CS/CSE	6 months Class rooms
4IR	Artificial Intelligence Specialists	Machine learning, Deep learning, TensorFlow, Python, Computer Vision, Natural language processing, Pytorch	Graduates of EEE, CS and CSE	6 months Classrooms Online courses Blended learning
	Robotics Software Engineers	Robotic process automation, UiPath, Automation anywhere, Python and C programming language, SQL, Robotics		
	Data Specialist/ Scientist	Machine learning, R, Python, Data mining, Data Science, Apache Spark, Big Data, Data modelling		
	Block Chain Developer	Hyperledger, Solidity, Node.js, Smart Contract		

For easing the difficulty of female participation, delivering programs over online platforms should be given importance. But the level of accommodation of online delivery should not undermine the quality. Hence, blending learning should be leveraged as much as possible, without sacrificing the quality. Otherwise, female receipts may suffer the risk of falling behind their male counterparts due to failing to develop soft-skills and self-learning ability. Furthermore, on a case-by-case basis, technological assistance should be adopted in the skill development process so that people with special needs can leverage the opportunity. For example, technological assistance for reading, hearing, and writing could be adopted for facilitating target skill development among people having special need. Moreover, there is a need for enhancing self-learning ability among the training recipients for continuous upskilling, as the shelf life of skills is quite short. As soft and managerial skills play a vital role in self-learning, classroom-based learning should not be fully replaced through online delivery. In the classroom setting, group projects and other collaborative activities should be leveraged for addressing managerial, teamwork, and other soft skills.

6.5.1 Managing Training Performance

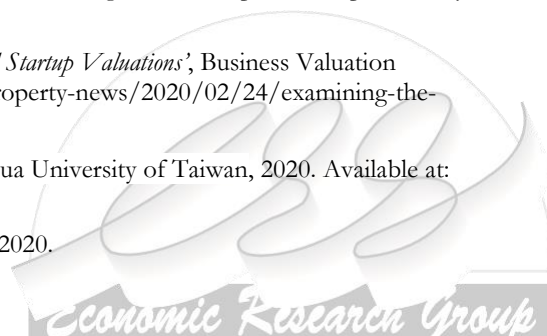
Recommendations for attaining desired training performances are as follows:

1. In addition to academic qualifications and experience, creativity and self-learning ability of the applicants should be taken into consideration in selecting the recipients. Trainings should target specialized level competence so that recipients can apply the skill in designing and developing relevant IT/ITES solutions and performing management activities.
2. Recipients should attain the capacity of developing intellectual assets and innovating solutions. It should be extended in ideation of improving existing products, innovating new ones and forming startups for leveraging the skills developed through the training program.
3. Hands on demonstration and teamwork in developing real-life solutions should be targeted. Practical relevant problems, given by the industry, should be mastered through training.
4. Faculty members of Bangladeshi universities and training institutions, preferably, to be engaged (as much as possible) so that it opens the path of linking academic institutions with the industry. Moreover, engagement of faculty members will facilitate linking training contents with relevant theories, facilitating training productivity and self-learning ability.
5. It's also recommended that training should include doing practical work in the industry through internships. Some of the relevant job postings on the online marketplace could also be used as problems to be solved by the participants during training.
6. As skills are rapidly evolving, training should target developing self-learning ability among the recipients so that recipients can keep up with on-going development in relevant skills by themselves.
7. Furthermore, training sessions may target to keep preparing and guiding participants to succeed to secure work orders of relevant jobs from online marketplace and complete them with good performance ratings.



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Appendix

Appendix A: University Faculty Profiling

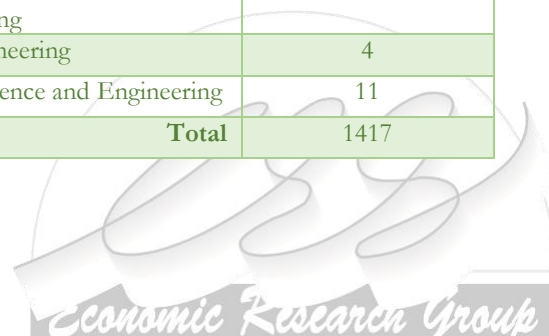
List of Universities of which profiles of 1400+ faculty members having relevance of teaching, research and academic background to Computer Science and Engineering, Electrical and Computer Engineering, Software Engineering, and other IT/ITES related areas, have been reviewed. This exercise has been done as part of assessing the potential supply capacity of emerging IT/ITES skills.

Table A1: Profiling of University Faculty Members

Name of university	Name of Department	Number of faculty member
Bangabandhu Sheikh Mujibur Rahman Science & Technology University	Department of Computer Science & Engineering	15
	Department of Electrical and Electronic Engineering	14
Bangamata Sheikh Fojilatunnesa Mujib Science and Technology University	Department of Computer Science & Engineering	3
	Department of Electrical and Electronic Engineering	2
Hajee Mohammad Danesh Science & Technology University	Department of Computer Science & Engineering	18
	Department of Electronics and Communication Engineering	9
Jessore University of Science & Technology	Department of Computer Science & Engineering	21
Noakhali Science & Technology University	Software Engineering Program	12
	Department of Computer Science and Telecommunication Engineering	19
	Department of Electrical and Electronic Engineering (EEE)	10
University of Chittagong	Department of Computer Science and Engineering	22
	Department of Electrical and Electronic Engineering	17
Patuakhali Science and Technology University	Department of Computer and Communication Engineering	5
Dhaka University	Department of Computer Science and Engineering	31
	Department of Electrical and Electronic Engineering	33
	Department of Robotics and Mechatronics Engineering	8
Shahjalal University of Science & Technology	Computer Science & Engineering	23
	Electrical & Electronic Engineering	16
Bangladesh University of Engineering & Technology	Department of Computer Science and Engineering	48
	Department of Electrical and Electronic Engineering	48
Chittagong University of Engineering & Technology	Department of Electronics and Telecommunication Engineering	13
	Department of Computer Science and Engineering	33
Dhaka University of Engineering & Technology	Department of Computer Science and Engineering	31
Khulna University of Engineering & Technology	Department of Computer Science and Engineering	32
	Department of Electrical and Electronic Engineering	42

Name of university	Name of Department	Number of faculty member
Rajshahi University of Engineering & Technology	Department of Computer Science and Engineering	37
	Department of Electrical and Computer Engineering	14
Ahsanullah University of Science and Technology	Department of Computer Science and Engineering	53
	Department of Electrical and Electronic Engineering	81
Mawlana Bhashani Science & Technology University	Computer Science & Engineering	19
Bangladesh University of Business & Technology	Department of Computer Science and Engineering	62
	Department of Electrical and Electronic Engineering	28
East West University	Department of Computer Science and Engineering	38
	Department of Electrical and Electronic Engineering	14
Canadian University of Bangladesh	Department of Computer Science and Engineering	18
	Department of Electrical and Electronic Engineering	13
International Islamic University Chittagong	Department of Computer Science and Engineering	41
	Department of electronic and telecommunication engineering	13
North South University *	Electrical & Computer Engineering	64
University of Asia Pacific	Department of Computer Science and Engineering	51
	Department of Electrical & Electronic Engineering	47
Gono Bishwabidyalay	Department of Computer Science and Engineering	12
	Department of Electrical and Electronic Engineering	7
University of Information Technology & Sciences	Department of Computer Science and Engineering	31
	Department of Electrical and Electronic Engineering	14
BRAC University	Department of Computer Science and Engineering	48
	Department of Electrical and Electronic Engineering	23
University of Liberal Arts Bangladesh	Department of Computer Science and Engineering	15
	Department of Electrical and Electronic Engineering	10
United International University	Department of Computer Science and Engineering	44
	Department of Electrical and Electronic Engineering	15
University of Creative Technology, Chittagong	Department of Computer Science and Engineering	20
Metropolitan University	Department of Computer Science and Engineering	32
	Department of Electrical and Electronic Engineering	13
	Software Engineering	4
State University of Bangladesh	Department of Computer Science and Engineering	11
Total		1417







Source: Compiled by the study team










Appendix B: Major Investments in Local Startups

The following table B1 represents the scenario of 2020. However, there have been notable improvements in the recent past. For example, recently, bKash succeeded to raise \$250 million from Japanese Softbank. Another notable success is ShopUp's \$75 million in Series B and \$22.5 million in Series A (FEShopUp, 2021). In general, there has been a growing trend in funding in startups in Bangladesh. For example, in 2021, Pathao, Paperfly, Praava, Chaldal and Shohoz raised \$35 million, \$11.8 million, \$10 million, \$10 million and \$25 million respectively (DTstartup, 2022).

Table B1: Major Investments in Local Startups

Sl	Startup Name	Sector	Fund Raised	Number of Investors	Sources of Information
1	 bKash	Fintech	US\$ 80mn+	Ant Financial, Brac Bank, money in motion and Gates foundation	LightCastle Partners Crunchbase
2	 pathao	Logistics	US\$ 12.8mn+	The Osiris Group, Gojek, Openspace Ventures, and Battery Road Digital Holdings	LightCastle Partners Crunchbase
3	 Chaldal	e-commerce	US\$ 5.5mn+	IFC, IDLC, Mir group, Y combinator	LightCastle Partners Crunchbase
4	 sheba marketplace	Service Marketplace	US\$ 6mn+	IFC, IDLC, Mir group, Y combinator	LightCastle Partners Crunchbase
5	 shohoz সবার জন্য	Logistics	US\$ 15mn+	Linear Venture, Golden gate Venture	LightCastle Partners Crunchbase
6	 solshare	Cleantech	US\$ 2.8mn+	IIX Growth Fund	LightCastle Partners Crunchbase

			US 3mn+	Sequential Capital India, Omidyar Network and Lonsdale	LightCastle Partners
7	 ShopUp	Fintech		ShopUp has raised a total of \$ 4.9m in funding over 5 rounds. Their latest funding was raised on Apr 19, 2019 from a Seed round. ShopUp is funded by 4 investors. Surge and Bill & Melinda Gates Foundation are the most recent investors.	Crunchbase
			US 7mn+	Osiris Group	LightCastle Partners
8	 SureCash.	Fintech		SureCash has raised a total of \$7M in funding over 1 round. This was a Series B round raised on Apr 22, 2015. SureCash is funded by The Osiris Group.	Crunchbase

Sl .	Startup Name	Sector	Fund Raised	Number of Investors	Sources of Information
9		e-commerce	US 2mn+	SkyCatcher	LightCastle Partners
				No information available	Crunchbase
10		Fintech	US 2mn+	Aavishkaar Venture Capital.	LightCastle Partners
				CloudWell has raised a total of \$2M in funding over 1 round. This was a Venture - Series Unknown round raised on May 24, 2016. CloudWell is funded by Aavishkaar Venture Capital.	Crunchbase
11		e-commerce			Crunchbase
				Sindabad.com has raised a total of \$8.3M in funding over 2 rounds. Their latest funding was raised on May 28, 2019 from a Series A round. Sindabad.com is funded by 2 investors. Aavishkaar Frontier Fund and The Frontier Fund are the most recent investors.	
12		Logistics			Crunchbase
				Shuttle has raised a total of \$520K in funding over 2 rounds. Their latest funding was raised on Jan 25, 2019 from a Seed round. Shuttle is funded by Robi Axiata Limited.	
13					Crunchbase
				Parking Koi has raised a total of BDT12.5M in funding over 1 round. This was a Undisclosed round raised on Sep 20, 2019.	



Appendix C: Frequency table of skills demanded by jobs postings in the of information technology (IT/ITES) at BDJobs

Mapping of local skill demand to emerging occupations is shown below. The frequency distribution of the skills demand in the local market is given below. The frequencies denote the number of job postings where the listed skill is required. The frequency is drawn from 457 samples of the job postings from Bdjobs.com

Table C1: Number of Skills in Each Frequency Range

Frequency	1	2-3	4-5	6-10	11-15	16-20	21-25	26-30	31-40	45-50	51-55	65-70	85-90	105-111
Number of skills	520	187	68	72	19	13	5	11	10	2	1	1	1	2

Table C2: Frequency Table of Skills Demanded by Job Postings in BDJobs

Sl.	Frequency Range	List of Skills
1	1 (520)	1D and 2D barcode familiarity, 3D math, 3rd Party SDK, AAA & LDAP, Adaptive interface creation, ADF, Administrative skills, ADO .Net, Adobe Creative Suite (Illustrator), Adobe CS for UI & UX, Adobe PDF Reader, Advanced Custom Fields (ACF), Affiliate Marketing, Alias, Amadeus, Amazon, amChart, Ammyy, Analytical ability, Ansible with Spinnaker, APNS, App Engine, AppDynamics, Appium, Application Security, AR/VR programming, Archive Center, ArchViz, ARM processor architecture, ASP VBScript, Asset Accounting, Asset management, Aurora, Avaloq, AVFoundation framework, AVR, B2C Business, Backend Development, Barcode & Card Printer, Batch, BDD, BI, Black hat SEO, Bluetooth connection and data synchronization, BoM, Bootst, Bower, Brava, BRD, Bugzilla, Building PSS models that generates UVM or SoC test sets, CCBA, Centrex IPPBX, CEPP-Certified Expert in Python, Certified Associate in Project Management (CAPM), CG Art, ChartJS, Chrome Dev Tools, Classroom teaching, CLI, ClickUp, COBIT, CodePush, Cognito, CommonJS, Compiler, Complexity analysis, Compliance, CompTIA A+ certification, Computer Architecture, Config Validator, Consul, Containerization, Copywriting, Core Data, Corporate Marketing, Corporate Network Architecture, Corporate Sales and Marketing, CouchDB, CPC, CPM cost models on Google, CQRS, CSI, CSTE, Cucumber, CUDA, Custom Queries and Meta Fields, Customer Handling, CVS, Cypress, D3, Dagger, Dapper .Net, DART, Data Mapping, Data Security, Data server, Data Solutions, Data warehousing, DC and DR network design and implementation, DDL and PL/SQL, Defect Reporting, Demand Management, Deployment & Operations consisting Server (Windows & Non-Windows), Design and developing website's architecture, Developing analytic Dashboards/Visual reports, Devexpress, Device bundle & CVM campaign initiatives, DFS, Digital archiving, Digital forensics, Digital market landscape, Digital products and services, Digital publishing, Digital Rights and Safety project management, Digital signal processing and transmission, Directory Services, DMS (Distribution Management System) Operation, Domain-Driven Design (DDD), DOS, DPI and firewall technology, Dream Weaver, Driver, DTD, Dynatrace, ECBA, Ecommerce Development, EFK, EFS, EGP, EJS, eKYC, Email services, Email transmission technology: SMTP, Ember.js, End-User Computing including Technology Service Desk, Enterprise Library, Enterprise Scan, Enterprise software applications, Enzyme, ESB, estRail, ESXi, Experience with Media and OTT, Ext.Net, Facilities & infrastructural management, Fargate, FDD, FHIR, Fiber, Finger Attendance & Access control Devices, Fintech, Flume, Formulating QA standard, Forseti, Frame maker, FTTX configuration and troubleshooting, FXO, FXS, Galileo, Ganglia, General web functions and standard, Git repositories, Git workflow, Google, Google Docs, Google Play Services, Google Search Console, Google Tag Manager, Graph processing, Graphical Representation, Gray hat SEO, GreenSock Animation Platform (GSAP), Grunt, Gulp, Unicorn, Gutenberg, GWT, Hadoop, Hamcrest, Hard Drive, Hasura, Hbase, HCDA, Hilt, Homestead, Host/Endpoint Security, Host-based security appliance logs and IDS alerts, HP Diagnostics, HP Loadrunner, HP SiteScope, HTTPD and NGINX, Huawei,

Sl.	Frequency Range	List of Skills
		<p>Hyper-V, I2C, IaaS and PaaS, IBM MQ, ICT of Textile & Garments, ICX operations, IDA Pro or Ghidra, IDS/IPS, IEC 62304, IEC62304 Unit, IGP, IGW, IIS, IM-Statistics Analysis, Incident Response, InertiaJS, Information Architecture, Infra support, Infrastructure consulting, InnoDB and MyISAM, Inspec, Institutional Sales Marketing, Internet banking, InVision, IP CORE backbone, IP subnet, IPLC network, ISMS security manager, ISO 13485, Istio, IT service delivery, ITIL, IT-IT Refugee Systems & Applications, IVR, JAMA, Java Microservices, JBOSS, Jest, JNCIA, JSF, JVM, K.V.M log, K6, Keras, Kestrel, KMS, Knowledge of HIPAA, Leadership skills, Light OJ and Codechef Online Judge, Light room, Linear algebra, Listening Skills, Livelink API (LAPI), LMS platforms, Load tasting, Lombok, LUA, Lumion, Macro development, Manage and conduct UAT sessions, Management of intercom, MapStruct, MariaDB, Master data management, Material UI, Matlab, MCP, Media Planning, Medical Imaging, Mercurial, Microsoft solution stack, Microsoft T-SQL, Microsoft Visual Studio, Mixed-Signal Circuits, Mocha, Model Binding, Module Migration, Mokito, Mongoose, Moodle, MoQ, MQTT network, MRTG Configuration, MS Security patches, MS Visio / Draw.io, MTCRE, Multiplayer Unity Mirror Networking, Mythic, Namespace, Native Linking, NestJS, Netbeans/IntelliJ IDEA, Network monitoring, Network printer, Network traffic, Network Troubleshooting, New Relic, NFV, NgRx, NTTN, Nunit, Business and requirement analysis, OAuth 2, Observium, OCP, Odoo, OEM Sales, OllyDbg, Online marketing funnels, Online marketing operation, Open Graph Protocol, OpenShift 3.11 & 4.6 platform, OpenStack, OpenText Content Server 10.x / 16.x / 20.x, OpenText Workflows, Operating System Cluster Administration, OPEX, Optical fiber, Optimization skills, Optimize operations of UNIX and storage systems by means of automation, ORM, OSI layer, OSI Model, OSPF, OTCS 16.x / 20.x platform, OTT, Output determination procedure, Outsourced systems, PACS, Pair Programming, PAM, PCS & Veritas Cluster, PDO, Planning and Maintenance Module (eAM) support, Play Framework and/or Akka, PLC, PMIPBA, Podman & CRI-O, Portfolio P/L management, Postfix/Dovecot, PPC, Practitest and other Project Management Tools, PR-Civil Registry System, PRI, Printer Servers, Process and memory optimizations, Process Explorer, Process Monitor, Product life cycle management, Productivity levels, ProGuard, Project Estimation, Prometheus, Prototype or Blender 3D or other 3D software, PrototypeJS, Prototyping, Protractor JS, PSD design, PSD to Wordpress/Laravel, PSR standard, PUG, Push Notification, Pytest, QoS, QTP, Query, Query DSL, Queue, Quick Develop/Test/Deploy cycles, R8, radis, Razor, React Router, Realm, RedHat, Redmine, RequireJS, Requirement Analysis, Retail sales software, Retention wall, RHEV & little-bit OpenStack, Rhino data prep, Rift, Rigging and 3D Animations, RIP, Risk Management, RocksDB, Router and Access point (Deco-m4) Management, Routing Protocol OSPF, RPC, RSS Feeds, RTOS, RTP protocols, RxKotlin, Sails.js, SAN and Backup Monitoring, SAP BoM, SAP FI, SAP MIGO of IT MRC Services, SAP PR and PO, SAP S4hana, SAP SD, SAX parsing, Scala, Schema modeling, Scraping, Scrapy Framework, ScreamingFrog, Scripts, Security Monitoring, SEMRush, SEO Audit, SERP, Server/cPanel/Hosting, Servlets, shtml, SilkPerformer, Silverlight, SIP, Skhing, SOA, Softaculous, Software Sales, Software Testing Life Cycle (STLC), Software version controlling, Solaris-LDOM, Solr, SourceTree, SPI, SPOC for CRM, SQL DML, Squish, SS7 Gateway, SSL encryption, Standardization & Audit Coordination, Stash, static routing protocol, STM32, Strategic technology planning, execution, and policy development, Streaming, Structural Digester Mitigated, Sublime Text 3, SurferSEO, Survey, Survey Report Checking, SVG, System Analyst, System Support, Taleo, Tally ERP 9, Team building qualities, Tech savvy, Technical Analysis, Technology Infrastructure Planning, Telesales, Template Engine, Tensor Flow Developer Certificate, Test environment setup/teardown, TestLink, Texturing, Themes security, Ticketing system, Tosca automation analytical skill, Traits & Design Patterns, Typography, UART, UAT phases, UAT Sign-off, Unix Platform, Upgrading BIOS, UPS, USB, User administration, User Manual, User Support, UVA, Uvision KEIL IDE, UVM-based IP verification simulation, UWP Apps, Vagrant, Vanilla PHP, Vcenter, VIVE, VLMS, Voicemail-related applications, VOIPSWITCH, Volley, VPC, VPS, Vray, VRF, VS Code, VSAM, vSphere, VSTS,</p>

Sl.	Frequency Range	List of Skills
		Vulnerability mitigation & Patch Management [Satellite/JetPatch], WAF, Web Reports, Web RTC, Web Security, webflow, WebStorm 2018, WF, White hat SEO, WHM and WHMCS, Wicket, Windows scripting, Wireless Devices (UBNT, CAMBIUM, ALTAI), WP-Engine, WPML, WPVIP, Writing cross-browser compatible code, WSDL, x64dbg, XECM SAP, XMPP, XP software, XPath, Yarn, YouTube SEO, Zabbix, Zend Certification, Zeplin, Zimbra, zOS, zVM, Celery
2	2-3 (187)	2D & 3D Modeling, Ad management, Adobe Premier Pro, Any Desk, Architecture Design, Article writing, Artifactory, ASP.NET WebForms, Auth2.0, Automation Scripts, BigCommerce, BoQ, Building eCommerce sites, Cacti, Cassandra, CASTP, COMPUTER OFFICE MANAGEMENT, Content marketing, Data Migration & Reporting System, Dependency Injection, DHCP, DHTML, DHTMLX, DICOM Protocol, Digital Ocean, Eclipse, Flask, Gap Analysis, Geographic Information Systems (GIS), gRPC, HL7 interoperability, HLDs, Hooks, IAM role, ICT for Development, Immutable.js, InDesign, Integrated game physics, ISIS, IT Audit, IT Maintenance, J2EE, Jmeter, Joomla, JPA, JSP/Servlet, JSX, Knowledge of IT technical products and Software, LDAP, Link Commission/shifting/modification/Bandwidth Up-gradation/Down-gradation/Link disconnection, LinkedIn marketing, Linux and Windows Server environments, LLDs, Load balancer, Lumen, MCSA, Memcached, Microsoft Power Platform – Power BI, Microsoft Server OS, Middleware and Backup, Monitoring system & troubleshooting in ISP domain, MS Project, MVPs, Networking technologies protocols (OSPF, QoS), Numpy, Off Page SEO, On page SEO, Online Marketing, Pandas, Performance Testing and Security Testing, Plugin Development, POCs/MVPs, Postman API testing tools, Presentation skills, Prisma ORM, Project coordination, Proxy Server, RabbitMQ, Real-time Broadcast, Repository pattern, Research and Development, Retrofit, Services layer2, layer-3, Setting & Maintenance, SharePoint site, Skhapp, SMTP, SOC processes, Software Implementation, Sound editing, SPSS, SQL and ORM Technologies, SQL schema design, SQS, Squarespace, SSIS, Statistical analyses, Subnet, Swagger, System administration, Team management, TeamViewer, Technical SEO, Technical support, TFS, Theme & Plugin Development, Track defect densities, Translating designs and wireframes, Trello, User session management, VA & PT, Validation and Verification, VanillaJS, virtual DOM, Weblogic, Wi-Fi maintenance, Windows, Wireless communication and CPE installation, Woocommerce, Xamarin, XHTML, XSLT, YouTube Marketing, Zephyr, Adobe Programs, After Effects, Asterisk, Auto Mailing, Backup and restore, Bash/Python scripting, Blazor, CMS, Computer Engineering, cPanel, Data center management, Data Management, DLP, Elastic search, ELK, Flux, Google AdSense, Google Sheets, Gradle, GUI Styles and Testing, Hosting, Imap, Ionic framework, JavaScript object model, JSON Web Token, Kafka, Kendo UI, MCSE, MERN / MEAN stack, MVVM, Nagios, Network Administration, Network Protocol, NextJS, Node, Objective C, POP3, Prince2, Project planning & implementation, QA Automation, Redis, RHCSA, Rx.js, S (ES2015+), Security Management of IT System, Selenium, Slack, Software Analysis, Software Architecture & Design, SQLite, SSH and Remote Desktop, SSRS, Tailwind, Teaching Experience, Team Foundation Version Control (TFVC), TestNG, Tomcat, TSQL, Visual Studio, Web Application Development, Windows Forms Application, Windows Service, WPF
3	4-5 (68)	Access Control & CCTV Administration, Antimalware, ASP.NET WebAPI, Business Analysis, CakePHP, Chef, Customer support, Documentation, EC2 SNS, Email writing, Express.js, Frontend development, Google Analytics, Google API, Hardware Networking, Hibernate, IT infrastructure, IT security and governance, JASPER latest version, JSON APIs, Juniper, JUnit, Lambda Expression, Layer2/Layer 3/BGP/VLAN/STP/RSTP//VRRP, LINQ, Magento BI and google data studio, Market Research, Microsoft Access, MS Outlook, MTCNA, NMS (Centreon, LibraNMS, Nagios), Object-oriented analysis and design, OLT - ONU Network, Programing language, Puppet, Quality Assurance, Sales & Marketing, SIEM, Socket.IO programming technology, SRS/BRD Sign-off, Typing skills, UML and Software Design Principles, Virtualization technology (Vmware, Hyper-v, KVM), Visio, Web Design (Responsive/Non-Responsive) & Tailwind CSS Grid System, Web Server, WebRTC, WebSockets, Application Developing and IT

Sl.	Frequency Range	List of Skills
		Planning, BGP, CCNP, Confluence, Data collection and Data Entry, DynamoDB, Email Server, Firewall, FTP, Kotlin, No specific skills required, RDBMS, RDLC, Record keeping and management, SMS integration, TDD, Telecommunication, Visual Basic, No specific skills required, IP Telephony system
4	6-10 (72)	.NET Framework, Auto Cad, Crystal & RDLC Reporting, Ethical Hacking, Gitlab, Google Marketing, Google Marketing, ISP support, MIS Development, NPM, PA System, PBX & PABX, PMP Certification, RHCE, Ruby on Rails, Software Testing Development, Swift, Troubleshooting, Video Editing, VMware, WCF Web Service, Adobe XD, Babel, Data Processing and Analysis, Figma Software, GCP, GraphQL, ISTQB Certification, Manage User accounts, Payment gateway integration, Programming/ Software Engineering, Shell scripting, SOAP, Social Media Marketing (SMM), SPRING boot, SQL Query, SVN, TCP/IP, Web services, Wordpress Theme and Plugin Development, Computer Networks, Cyber Security, Data Structure, Django, DNS, DVR, NVR & Online IP Camera configuration, Facebook marketing, Full Stack Development, Functional Testing, Integration Testing and Regression Testing, IT Support, PL/SQL, Redux, Shopify Liquid, Software QA methodologies, Unit testing, unity and Unity3D, Bitbucket, Codeigniter, Content Developing, Firebase, Internet Browsing, Maven & Sonerqube, Server Management and Maintenance, SOLID, Webpack, Writing skills, Algorithm and Data Structure, ASP.NET Core, HTTP protocol, IT System Management, Mobile App Development, NoSQL, Software development
5	11-15 (19)	Business Management & Development, Digital Design, Entity Framework, Hardware Engineer, Microservice, Bug Analyze, Fixes and Recreation, Configuring and maintaining LAN/WAN/WIFI setup and troubleshooting, DOM manipulation and implementation, Flutter, OneNote, ASP .Net, Computer hardware and software troubleshooting, VPN and VLAN, Database Administration (DBA), Optimization and Management, LESS and SASS, Adobe Illustrator, Project Documentation, Spring, System Engineer (Computer Network & System)
6	16-20 (13)	.Net Core, Animation (2D/3D), CI/CD process, Software Development Life-cycle (SDLC), Web API integration and consuming XML or JSON, XML, Installing and maintenance of OS and Software, .Net, Adobe Photoshop, TypeScript, Web Development, JSON, SQL Server
7	21-25 (5)	Critical ERP Modules (Finance, Supply Chain, Inventory, Sales and HR and CRM), ASP.NET Framework, Graphic Design, IT-Computer Literacy, WordPress
8	26-30 (11)	Microsoft Office, CCNA, GitHub, IT equipment Installation, Repair and maintenance (computer/printer/scanner/CCTV cameras), Microsoft PowerPoint, MVC frameworks, PostgreSQL, Microsoft Word, Oracle, MS SQL, Search Engine Optimization (SEO)
9	31-40 (10)	Switch and Router (Cisco/Juniper/Mikrotik), Android and IOS App Development and publishing, Ajax, C#, UI and UX Design, Bootstrap, Vue.js, Microsoft Excel, Angular Development, API Development and integration
10	45-50 (2)	React, Object Oriented Programming
11	51-55	Java
12	65-70	REST API
13	85-90	PHP
14	105-111 (2)	HTML & HTML5, CSS & CSS3



Appendix D: A section of universities offering academic programs pertaining to IT/ITES skills

Among the profiled universities please fill up the following table: Names of degree programs and related courses offered in each of those areas, pertaining to computer Science and Engineering, and Information Technology

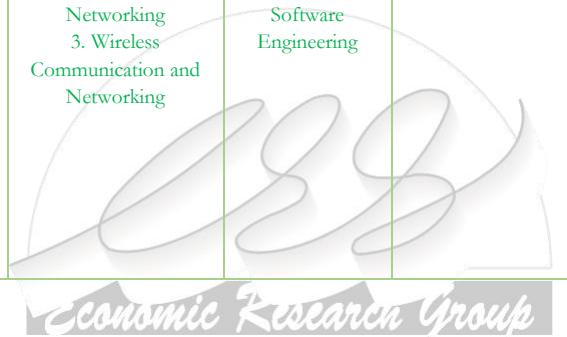
Course details are available

Only name of the courses available

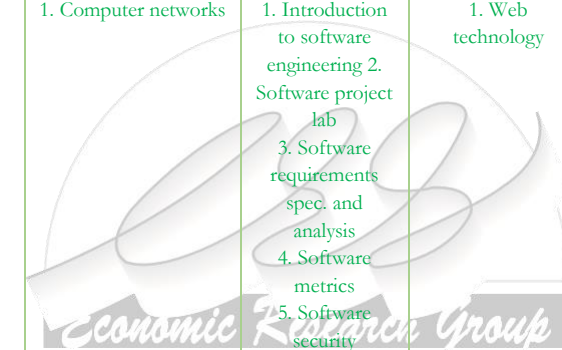
Name of courses are not available

Table D1: List of Selected Universities with Courses Pertaining to IT/ITES

Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
1	Bangabandhu Sheikh Mujibur Rahman Science & Technology University										
2	Bangamata Sheikh Fojilatunnesa Mujib Science and Technology University	B.Sc. in CSE 2018-19	1. Structured Programming Language 2. Object Oriented Programming With C++ 3. Programming with JAVA 4. Data Structure 5. Database Management Systems	1. Cryptography and Network Security	1. VLSI Design	1. Digital Image Processing	1. Artificial Intelligence 2. Machine Learning 3. Speech Processing and Recognition	1. Human Computer Interaction 2. Robotics	1. Communication Engineering 2. Computer Networking 3. Wireless Communication and Networking	1. Software Development Project 2. Software Engineering	1. Web Engineering

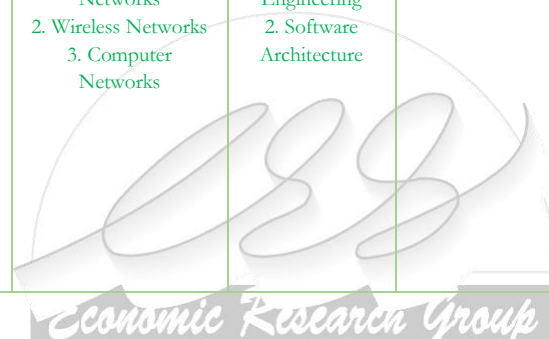


Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
3	Hajee Mohammad Danesh Science & Technology University	Undergraduate program of Computer Science and Engineering	1. Structured Programming Language 2. Object Oriented Programming 3. Database 4. Advanced Database Management System	1. Management Information System	1. VLSI Design	1. Computer Graphics and Image Processing	1. Artificial Intelligence 2. Machine Learning and Pattern Recognition 3. Natural Language Processing	1. Robotics	1. Cryptography and Network Security 2. Mobile and Wireless Communication	1. Software Development Sessional 2. Software Engineering 3. Software Testing and Quality Assurance	1. Cloud Computing 2. Web and Mobile Application Development Sessional 3. Web Engineering
		Postgraduate program of Computer Science and Engineering	1. Advanced Database Systems			1. Advanced Digital Image Processing	1. Advanced Artificial Intelligence 2. Advanced Machine Learning		1. Network Security 2. Wireless Sensor Networks	1. Software Testing and Quality Assurance	
4	Jessore University of Science & Technology	BSC in CSE (Based on first two semesters)	1. Introduction to Computer Programming 2. Data Structures								
5	Noakhali Science & Technology University	BSC in software engineering	1. Structured programming 2. Data structure 3. Object oriented concepts 4. Database management system 5. Data science and analytics - DBMS	1. Information security			1. Artificial intelligence		1. Computer networks	1. Introduction to software engineering 2. Software project lab 3. Software requirements spec. and analysis 4. Software metrics 5. Software security	1. Web technology

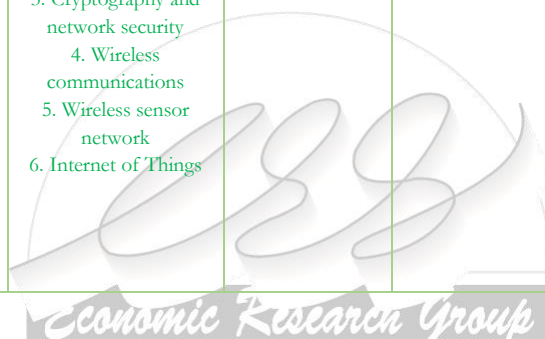


Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas									
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies	
											6. Software testing and quality assurance 7. Software design and architecture 8. Software maintenance	
6	University of Chittagong											
7	Patuakhali Science And Technology University											
8	Dhaka University	BSc in CSE	1. Fundamentals of Programming 2. Object Oriented Programming 3. Data Structures and Algorithms 4. Database Management Systems – I & II 5. Introduction to Data Mining and Warehousing		1. Introduction to VLSI Design 2. VLSI Layout Algorithms	1. Digital Image Processing 2. Computer Vision	1. Artificial Intelligence 2. Introduction to Machine Learning 3. Introduction to Data Science 4. Natural Language Processing	1. Introduction to Mechatronics 2. Robotics Science and Systems 3. Robot Learning 4. Mathematics for Robotics 5. Human Robot Interaction 6. Mobile Robotics 7. Aerial Robotics 8. Human Computer Interaction	1. Computer Networking 2. Cryptography and Security 3. Internet of Things 4. Computer and Network Security	1. Software Engineering 2. Software Design Patterns Lab 3. Software Requirements Specification and Analysis 4. Software Testing and Verification 5. Wireless Networks	1. Internet Programming Lab 2. Cloud Computing	


Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
	Dhaka University	MS in CSE	1. Advanced Database		1. VLSI Layout Algorithm 2. Decision Diagram for VLSI design	1. Computer Vision	1. Pattern Recognition 2. Image Processing 3. Machine Learning and Data mining 4. Neural Networks 5. Information Security		1. Network Routing and Switching 2. Network QoS 3. Mobile and Sensor Networking 4. Wireless Mesh Network 5. Network Performance Analysis		1. Web Application Engineering 2. Cloud Computing
9	Shahjalal University of Science & Technology	BSC in CSE (session: 2014-15)	1. Structured Programming Language 2. Data Structure 3. Object Oriented Programming Language 4. Database System				1. Introduction to Data Science 2. Artificial Intelligence		1. Communication Engineering 2. Computer Networking	1. Software Engineering & Design Patterns	1. Web Engineering
10	Bangladesh University of Engineering & Technology	BSC in CSE	1. Structured Programming Language 2. Object Oriented Programming Language 3. Data Structures and Algorithms 4. Computer Programming 5. Database		1. VLSI Design		1. Artificial Intelligence 2. Machine Learning 3. Pattern Recognition	1. Human Computer Interaction 2. Robotics	1. Computer Networks 2. Wireless Networks 3. Computer Networks	1. Software Engineering 2. Software Architecture	



Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			6. Semantics of Programming Languages								
		MSC in CSE	1. Programming Languages and Systems 2. Advanced Database Systems 3. High Dimensional Data Management 4. Data Management in the Cloud	1. Biometric Security	1. VLSI Layout Algorithms		1. Advanced Artificial Intelligence 2. Symbolic Machine Learning-I & II 3. Advanced Syntactic Pattern Recognition 4. Speech Recognition 5. Data Mining 6. Neural Networks		1. Network Science 2. Information and Social Networks 3. Computer Communications and Networks-I & II 4. Wireless Resource Management 5. Wireless Ad Hoc Networks 6. Wireless Sensor Networks 7. Network Security	1. Software Project Management 2. Software Quality Assurance 3. Software Testing	1. Cloud Security
11	Chittagong University of Engineering & Technology	Graduate program of CSE	1. Advance database systems 2. data mining 3. distributed search techniques		1. VLSI layout algorithms 2. VLSI system design	1. Computer vision 2. Advanced digital image processing	1. Big data 2. Machine Intelligence and Expert Systems 3. Natural language processing 4. Neural networks 5. Pattern recognition 6. Speech recognition 7. Advanced machine learning	1. Human computer interactions 2. Introduction to robotics 3. Social robotics	1. Advanced network technology 2. Advanced communications and networking 3. Cryptography and network security 4. Wireless communications 5. Wireless sensor network 6. Internet of Things	1. Software quality assurance	1. Cloud computing 2. Internet and web-based technologies

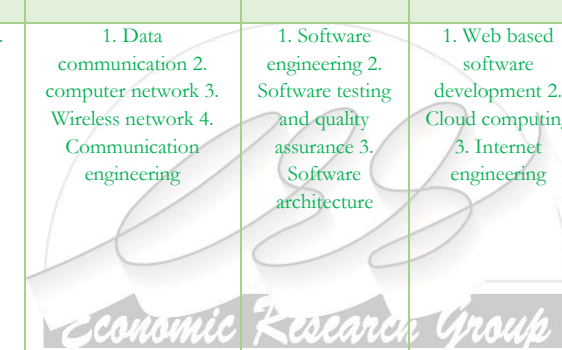


Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
		Undergraduate program of CSE	1. Structured programming 2. Object oriented programming 3. Data structure 4. Database management systems 5. High performance database	1. Informational security 2. Cyber security and forensics	1. VLSI design	1. Digital image processing	1. Artificial intelligence 2. Artificial intelligence with Python (Sessional) 3. Machine learning 4. Neural networks and fuzzy logic 5. Data mining 6. Pattern recognition 7. Data science 8. Natural language processing 9. Big data	1. Human computer interaction	1. Computer networks 2. Fundamentals of internet of things 3. Communication engineering 4. Network planning 5. Mobile and wireless networking	1. Software development with JAVA 2. Software engineering 3. Software development project (sessional)	1. Internet programming (sessional)
12	Dhaka University of Engineering & Technology	Undergraduate program of CSE (based on 4 th year syllabus only)	1. Parallel and Distributed Processing		1. VLSI Design	1. Digital Image Processing 2. Robotics and Computer Vision	1. Artificial Intelligence 2. Neural Networks & Fuzzy System 3. Machine Learning 4. Pattern Recognition	1. Human Computer Interaction 2. Robotics and Computer Vision	1. Computer Networks	1. Software Engineering	
		Postgraduate Program (CSE)	1. Distributed database system 2. Data mining and warehousing	1. Network security 2. Information system management	1. VLSI layout algorithm	1. Advanced image processing 2. Computer vision 3. Medical image processing	1. Artificial intelligence and knowledge based systems 2. Neural network 3. Machine learning 4. Deep	1. Automated planning and heuristic search 2. Remote sensing and geographical	1. Wireless sensor networks 2. Advanced computer networking 3. Wireless networking & mobile computing	1. Software project management 2. Software quality assurance	1. Cloud computing 2. IT policy

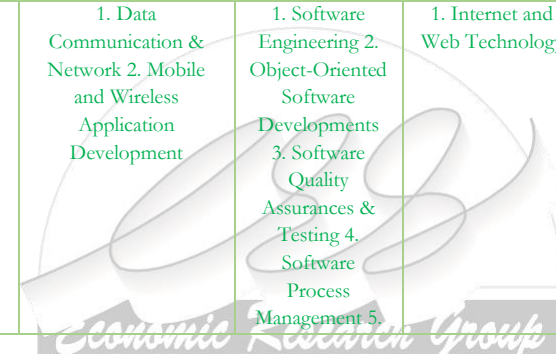
Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
							learning for natural language processing	information system 3. cyber physical system			
13	Khulna University of Engineering & Technology	Undergraduate program of CSE	1. Structured Programming 2. Object Oriented Programming 3. Data Structures and Algorithms 4. Advanced Programming 5. Database Systems	1. Information Security and Control		1. Computer Vision & Image Processing	1. Artificial Intelligence 2. Machine Learning 3. Data Mining		1. Computer Networks 2. Computer and Network Security	1. Software Engineering and Information Systems	1. Web Programming Laboratory
		Postgraduate studies in Information and Communication Technology	1. Advanced database systems 2. Data warehousing and mining	1. e-Commerce Systems and Security	1. Advanced VLSI design	1. Advanced digital image processing 2. Computer vision 3. Medical imaging systems	1. Speech processing 2. Speech recognition		1. Advanced computer networking 2. Network management and security 3. Advanced network security 4. Advanced digital communication 5. Mobile and wireless communication 6. Advanced wireless communication 7. Telecommunication networks 8. Wireless sensor network	1. Advanced software engineering	1. Web engineering
14	Rajshahi University of Engineering & Technology										
15	Ahsanullah University of Science and Technology	Undergraduate program of Computer	1. Elementary Structured Programming 2. Object Oriented	1. Cyber Security	1. VLSI Design 2. Parallel Processing	1. Digital Image Processing 2. Computer Vision	1. Introduction to Artificial Intelligence 2. Soft Computing	1. Robotics	1. Network Programming 2. Introduction to	1. Software Development-I, II III,IV, and V 2. Information	1. Web Computing 2. Cloud Computing

Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas									
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies	
		Science and Engineering	Programming 3. Assembly Language Programming 4. Database 5. Advanced Database System 5. Data Warehousing and Mining					3. Artificial Neural Networks 4. Pattern Recognition and Machine Learning 5. Mathematical Analysis for Computer Science		Computer Networks 3. Internet of Things	System Design and Software Engineering	
16	Mawlana Bhashani Science & Technology University	Undergraduate program of CSE	1. Computer Basics & Programming Fundamentals 2. Structured Programming 3. Object Oriented Programming 4. Data Structures and Algorithms 5. Database Management Systems 6. Relational Database Management System Lab		1. VLSI Design	1. Digital Image Processing	1. Artificial Intelligence & Machine Learning 2. Neural Networks & Pattern Recognition 3. Data Mining and Big Data	1. Robotics	1. Computer Network 2. Communication Engineering 3. Network Security and Cryptography	1. Software Development Project-I & Industrial Tour I & II 2. Software Engineering		
17	Bangladesh University of Business & Technology	Undergraduate program of CSE					1. Artificial Intelligence and Expert System		1. Network Engineering	1. Software development 2. Software Engineering		
18	East West University	Undergraduate program of CSE	1. Structured Programming 2. Object Oriented	1. Cyber Security, Ethics and	1. VLSI Design	1. Digital Image Processing 2. Computer Vision	1. Artificial Intelligence 2. Pattern	1. Intelligent Systems and Data Science 2.	1. Computer Networks 2. Communications and	1. Software Engineering 2. Software	1. Web Programming	

Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			Programming 3. Database Systems 4. Advanced Database System	Law 2. Cryptography			Recognition 3. Machine Learning 4. Data Mining 5. Big Data Analytics	Human Computer Interactions 3. Robotics	Networking 3. Wireless Networks 4. Advanced Network Services and Management 5. Network Security and Systems 6. Internet of Things	Testing and Quality Assurance 3. Software Architecture	
		Graduate program of CSE	1. Database Systems 2. Advanced Database System		1. VLSI Design	1. Digital Image Processing 2. Computer Vision	1. Artificial Intelligence 2. Machine Learning 3. Data Mining 4. Pattern Recognition 5. Big Data Analytics 6. Machine Learning 7. Data Mining 8. Big Data Analytics 8. Machine Learning	1. Human Computer Interactions 2. Robotics	1. Computer Networks 2. Advanced Network Services and Management 3. Wireless Networks 4. Network Security and Systems 5. Internet of Things	1. Software Engineering 2. Software Testing and Quality Assurance 3. Software Architecture	1. Web Programming
19	Canadian University of Bangladesh	Undergraduate program of Computer Science and Engineering	1. Structured programming language 2. Object oriented programming language 3. Data structure and algorithms I & II 4. Java and socket programming 5. Assembly language	1. Cyber crime and security	1. Electronics	1. Digital image processing	1. Compiler 2. Artificial intelligence 3. Machine learning 4. Data and web mining 5. Pattern recognition 6. Deep learning	1. Robotics 2. Human Machine interaction	1. Data communication 2. computer network 3. Wireless network 4. Communication engineering	1. Software engineering 2. Software testing and quality assurance 3. Software architecture	1. Web based software development 2. Cloud computing 3. Internet engineering



Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			programming 6. Database management system 7. Distributed database management system								
20	International Islamic University Chittagong	BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING (CSE)	1. Computer Programming 1 & 2 2. Database Management Systems 3. Distributed Database		1. VLSI Design	1. Computer Vision and Robotics	1. Artificial Intelligence 2. Neural Network and Fuzzy System 3. Pattern Recognition and Image Processing 4. Machine Learning and Data Mining	1. Computer Vision and Robotics	1. Computer Networks 2. Wireless and Mobile Communication	1. Software Development 1 & 2 2. Software Project Management 3. Software Quality Assurance	
21	North South University	BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING	1. Programming Language I & II 2. Database Systems 3. Concepts of Programming Language 4. Advanced Database Systems		1. Introduction to VLSI Design 2. Advanced Chip Design Methodology and Optimiza.using HDL	1. Computer Vision	1. Data Mining 2. Artificial Intelligence 3. Machine Learning 4. Pattern Recognition and Neural Network 5. Digital Image Processing		1. Data Communication & Network 2. Mobile and Wireless Application Development	1. Software Engineering 2. Object-Oriented Software Developments 3. Software Quality Assurances & Testing 4. Software Process Management 5.	1. Internet and Web Technology



Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas									
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies	
											Software System Architecture	
		MS in CSE	1. Distributed database system		1. Advanced VLSI design/Microelectronics and VLSI design	1. Computer vision	1. Advanced artificial intelligence 2. Advanced neural network	1. Introduction to Robotics	1. Advanced computer network and communication/Network architecture & protocols 2. network & computer security/Network operation & management 3. Mobile & wireless communications system	1. Software quality assurance 2. programming language design 3. formal methods in software engineering 4. advanced topics on management of technology		
22	University of Asia Pacific	Undergraduate program of CSE	1. Introduction to Computer Science & Programming Methodology 2. Structured Programming 3. Object Oriented Programming I: Java 4. Data Structures 5. Database Systems 6. Object Oriented Database		1. Design and Testing of VLSI	1. Introduction to Computer Vision	1. Artificial Intelligence and Expert Systems 2. Pattern Recognition 3. Natural Language Processing 4. Data Mining & Machine Learning	1. System Analysis and Design 2. Human Computer Interaction 3. Robotics	1. Computer Networks 2. Sensor Networks 3. Wireless Networking 4. Computer and Network Security	1. Software Engineering 2. Software Development 3. Software Design Pattern	1. Object Oriented Programming II: Visual and Web Programming 2. Cloud Computing 3. E-commerce and Web Engineering	
		Graduate program of CSE	1. Programming Language Implementation 2. Advanced Database		1. Advanced VLSI Design		1. Advanced Artificial Intelligence & Expert System 2. Neural Network &		1. Network Architecture Design 2. Advanced Topics in Computer Networks		1. Internet Engineering	

Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			Management System				Fuzzy Systems 3. Advanced Topics in Pattern Recognition				
23	Gono Bishwabidyalay	Undergraduate program of CSE	1. Structured Programming Language 2. Object Oriented Programming Language 3. Database Management Systems 4. Data ware-housing & Data Mining	1. Computer Networks & Cyber Security		1. Digital Image Processing	1. Artificial Intelligence & Expert System		1. Computer Networks & Cyber Security	1. Software Engineering	1. Web Engineering 2. Cloud Computing
24	University of Information Technology & Sciences	Undergraduate program of CSE	1. Structured Programming Language 2. Object Oriented Programming Language 3. Database Management System	1. Cyber Security 2. Cryptography		1. Computer Vision 2. Digital Image Processing	1. Artificial Intelligence 2. Foundation of Data Science 3. Neural Networks 4. Theory of Fuzzy Systems 5. Big Data Analytics 6. Machine Learning 7. Pattern Recognition 8. Information Retrieval	1. Human Computer Interactions 2. Bioinformatics & Computational Biology	1. Computer Networks 2. Internet of Things 3. Satellite Communications 4. Telecommunication Systems Engineering 5. Mobile & Wireless Networks 6. Computer Data & Network Security 9. Network Operations and Management	1. Software Engineering and System Analysis 2. Software Project Design and Development 3. Software Requirements Specification and Analysis 4. Software Testing & Quality Assurance 5. Software Security 6. Software Maintenance	1. Web Application Design 2. Internet Programming Lab 3. Cloud Computing

Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
		Graduate program of CSE	1. Programming Languages and Systems 2. Advanced Database Systems		1. VLSI Layout Algorithms	1. Computer Vision 2. Advanced Digital Image Processing	1. Data Science 2. Speech Recognition 3. Artificial Neural Networks	1. Human Computer Interactions	1. Information and Social Networks 2. Internet of Things 3. Wireless and Mobile Communication Networks 4. Wireless Resource Management 5. Wireless Ad Hoc Networks 6. Wireless Sensor Networks 7. Network Security	1. Software Project Management 2. Software Quality Assurance 3. Software Testing	1. Data Management in the Cloud
25	BRAC University	Undergraduate program of CSE	1. Programming Language 2. Data Structures 3. Object Oriented Programming 4. Database Systems 5. Programming Languages and Competitive Programming		1. VLSI Design	1. Image Processing	1. Artificial Intelligence 2. Pattern Recognition 3. Neural Networks 4. Machine Learning 5. Natural Language Processing 6. Speech Recognition and Synthesis	1. Introduction to Robotics 2. Human Computer Interface	1. Computer Networks	1. Computer System Engineering 2. Software Engineering	1. Programming for the Internet
		MSC in CSE	1. Advanced Database Systems				1. Advanced Artificial Intelligence 2. Symbolic Machine Learning 3. Advanced Syntactic Pattern Recognition 4.		1. Computer Communications and Networks		



Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
							Speech Recognition 5. Neural Network and Fuzzy Systems				
26	University of Liberal Arts Bangladesh	Undergraduate program of CSE	1. Structured Programming 2. Object Oriented Programming 3. Data Structures 4. Database Systems 5. Programming with Java 6. Advanced Programming Languages		1. VLSI Design	1. Digital Image Processing	1. Artificial Intelligence 2. Neural networks and Pattern Recognition		1. Data Communication and Computer Networks 2. Wireless and Mobile Computing	1. Software Engineering 2. Software Quality Assurance and Testing	1. Web Technology
27	United International University	UnderGraduate program of CSE	1. Structured programming language 2. Object oriented programming 3. Data structure and algorithms 4. Database management system 5. Advanced database management systems		1. VLSI design	1. Digital image processing	1. Artificial intelligence 2. machine learning 3. data mining 4. Big data analytics	1. System analysis and design 2. Human computer interaction 3. Robotics	1. Computer networks 2. Wireless and cellular communication 3. Advanced network serviced and management 4. Network security	1. Software engineering 2. Software architecture 3. Software testing and quality assurance 4. Game design and development	1. Web programming 2. Cloud computing 3. Web application security
		Graduate program of CSE	1. Object oriented programming 2. Data structures and algorithms 3. Database	1. Cyber security standards, governance and	1. Advanced VLSI design	1. Image processing 2. Image processing and its applications	1. Artificial intelligence 2. Advanced artificial intelligence 3.	1. System analysis and design 2. Computational intelligence 3.	1. Computer networks 2. Wireless communication 3. Advanced mobile communication 4.	1. Software quality management 2. Software project management 3.	1. Web programming 2. Web engineering 3. Internet architecture and

Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas									
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies	
			management systems 4. Structured programming language 5. Advanced database systems 6. Advanced object oriented programming 7. Data warehouse and business intelligence 8. Geographic information systems and spatial databases	management 2. Cybercrime and cyber terrorism				Data mining 4. Speech recognition 5. Pattern recognition 6. Machine learning 7. Neural network and fuzzy logic systems 8. Deep learning 9. Natural language processing 10. Big data 11. Genomic big data 12. Spatial data science 13. Data analytics 14. Business analytics	Service oriented business intelligence 4. Decision support system 5. Market intelligence 6. Advanced intelligent systems 7. Block chain and crypto currency 8. Robotics 9. Human computer interaction	Advanced network services and management 5. Communication theory 6. Satellite communication 7. Telecommunication engineering 8. Advanced computer communications and networks 9. Ad-hoc and sensor networks 10. network security 10. Internet of things 11. Network perimeter security 12. Vehicular networking 13. Network security monitoring 14. Network defense and counter-measures	Models of software systems 4. Software specifications and analysis 5. Software architecture 6. Software testing	protocols 4. Semantic web theory and applications 5. Cloud computing 6. Web service security 7. Cloud security
28	University of Creative Technology, Chittagong											
29	Metropolitan University	Undergraduate program of CSE	1. Structured Programming 2. Database Management System 3. Object Oriented Programming					1. Machine Learning		1. Computer Networks		
30	State University of Bangladesh	Undergraduate program of CSE	1. Structured Programming Language 2.	1. Cyber Law and Computer Forensic 2.	1. VLSI Design	1. Computer Vision and Image Processing	1. Artificial Intelligence	1. Human Computer Interactions	1. Computer Networks	1. Software Engineering	1. E-Commerce and Web Engineering	

Sl.	Names of Universities	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas								
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Image processing or Computer Vision	Artificial Intelligence, Machine learning, Natural Language processing	Robotics, Automation, Cyber Physical Systems, Intelligent Systems	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			Object Oriented Programming Language 3. Data Structure 4. Database Systems	Cryptography and Cryptology			2. Machine Learning 3. Pattern Recognition 4. Natural Language Processing 5. Neural Network and Fuzzy Logic			2. Object-Oriented Software Engineering	



Appendix E: Profiling of BHTPA Setup Laboratories

Table E1: Profiling of BHTPA Setup Laboratories

SL	University	Lab Names	Relevance to Current TNA		
			Low	Med	High
1	Jahangirnagar University, IIT	Software Testing and Quality Assurance Lab			x
2	Dhaka University, Department of Computer Science and Engineering	Animation Lab		x	
3	Shahjalal University of Science and Technology, Sylhet	Big Data Analytics Lab			x
4	Bangladesh University of Engineering and Technology	Robotics Lab			x
5	Rajshahi University of Engineering and Technology, Mechatronics Engineering Dept	Artificial Intelligence and Control Lab			x
6	Patuakhali University of Science and Technology, Department of Computer Science and Engineering	Advance Computing Lab		x	
7	Noakhali University of Science and Technology, Institute of Information Technology	Computer Network Analysis and Cyber Security Lab			x
8	Bangladesh Army University of Science and Technology, Department of Computer Science and Engineering	Digital Computer Lab		x	
9	Dhaka University, Department of Film Studies	Audio Visual Lab	x		
10	Khulna University of Engineering and Technology, IICT	High-Definition Visual Computing & Multimedia Lab		x	
11	Chattogram University of Engineering and Technology,	Robotics Lab			x
12	Bangabandhu Sheikh Mujibur Rahman University of Science and Technology, Department of Biotechnology and Genetic Engineering	Biotechnology and Genetic Engineering Lab	x		
13	Dhaka University of Engineering and Technology	Mobile Application Lab		x	
14	Maulana Bhasani University of Science and Technology, Institute of Computer Technology	Specialized Computer Network Lab		x	
15	Pabna University of Science and Technology	Digital Signal Processing and Embedded System Lab			x
16	Jatiya Kabi Kazi Nazrul Islam University, Department of Electronics and Communication	Digital Communication and Networking Lab		x	

SL	University	Lab Names	Relevance to Current TNA		
			Low	Med	High
17	Cumilla University, Department of Computer Science and Engineering	IOT based advanced computer LAB			x
18	Barishal University. Department of Computer Science and Engineering	Web Tech. Lab for IOT device development			x
19	Jagannath University, Department of Computer Science and Engineering	Establishment of Deep Learning Lab for Higher Research			x
20	Khulna University of Engineering and Technology, Department of Computer Science and Engineering	Natural Language Processing Lab		x	
21	Jashore University of Science and Technology, Department of Computer Science and Engineering	Software Development Lab and 3D Printing Lab			x
22	Dhaka University, Department of Electrical and Electronics Engineering	Computer and IOT Lab			x
23	Sheikh Hasina University, Netrokona	IOT and Computer Lab			x
24	Dhaka University, Department Of Robotics And Mechatronics Engineering,	Modern Robotics Lab			x
25	Dhaka University, Department of Botany	Genomics and Bioinformatics Lab	x		
26	Chattogram University, Department of Botany	Smart Board Lab		x	
27	University of Liberals Arts Bangladesh	State of Art IoT Lab			x
28	Daffodil University	Establishment of Specialized Lab on AR/VR, IoT, Robotics, Machine Learning & AI @ Innovation Hub			x
29	Canadian University	Proposal of High Impact IoT Research Laboratory			x
30	United International University (UIU)	Analog and VLSI IC Design and Incubation Lab			x
31	Fareast International University	FIU Artificial Intelligence Research Lab			x



Appendix F: Mapping of Fellowships and Grants of ICT Division to 4IR, Emerging, and IT/ITES Skills and Competence Base

Table F1: Mapping of ICT Fellowships to IT/ITES Skills

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
1	Md. Abdul Malek PhD Department of Agricultural Extension & Information System Sher-e-Bangla Agricultural University Year: 2017-18	Effectiveness of Image-based Plant Disease Detection System.	√					
2	Md. Salehin Ferdous Kader PhD Department of Electrical & Electronic Engineering Islamic University of Technology (IUT) Year: 2017-18	Design & Performance Analysis of Low Loss Photonic Crystal Fibre with Better Efficiency.					√	
3	Nurunnahar Akter PhD Faculty of Science, School of Computing Science University of East Anglia, United Kingdom Year: 2017-18	Using Big Health and Actuarial Data for Modelling Longevity and Morbidity Risks.	√					
4	Arnob Zahid PhD Department of Accounting & Information System University of Canterbury, New Zealand Year: 2017-18	Previous Title: A Standard Data Analytics Framework for Cloud Based Healthcare IoT Devices. Present Title: "Validating the Application of Emerging Technologies to Support Stakeholder Uptake of Precision Healthcare as a Service"		√				
5	Md. Sazzadur Rahman PhD Department of Agricultural Extension & Information System Sher-e-Bangla Agricultural University Year: 2017-18	Effectiveness of using ICT tools for disseminating rice production Information.					√	
6	Muhammad Ali Nayeem PhD Department of CSE Bangladesh University of Engineering & Technology (BUET) Year: 2017-18	A Next Generation Multi-Objective Metaheuristic Framework for Phylogeny Estimation.	√					
7	Fariha Tasmin Jaigirdar PhD	Ensuring data provenance and security in IoT Healthcare.						

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
	Faculty of Information Technology Monash University, Australia Year: 2017-18			√				
8	Sabrina Sharmin PhD Department of Physics Bangladesh University of Engineering Technology (BUET) Year: 2018-19	Study of the Change of Conduction Velocity of Myelinated Nerve Fibres due to Stretching with Possible Diagnosis of Neuromuscular Diseases.	√					
9	Ferdous Hossain PhD Faculty Engineering of Technology Multimedia University, Malaysia Year: 2018-19	Investigation of Radio Propagation Prediction Model of 5G Wireless		√				
10	Mohammad Shakil Parvej , Doctoral, Department of CSE University of Dhaka Year: 2018-19	Previous Title: Temporal Data Mining for Disaster Management: Flood in Bangladesh Present Title: A Privacy-Aware Federated Electronic ID Management Framework for Bangladesh"	√					
11	Tarekol Islam Maruf Doctoral, Department of Business Administration International Islamic University, Malaysia Year: 2018-19	The Effect of E-Service Quality And Perceived Trust on Customer loyalty Among Bangladeshi Ride Sharing Apps Users					√	
12	Mohammad Shamsul Hoque Doctoral, Department of System & Networking Universiti Tenaga Nasional (National Energy University) Malaysia Year: 2018-19	Development of framework, technique, tools and threat prediction model through cyber-threat analysis, digital forensic and machine learning for SCADA/large scale power plant system.	√					
13	Subratra Kumar Das Doctoral, Department of CSE, Jahangirnagar University Year: 2018-19	A Distributed Patient Data Management System in Heterogeneous Environment					√	
14	Nazmul Huda Doctoral, Department of Safety System Construction Engineering,	Prospects of Indigenous Tools, Knowledge and Practices in Bangladesh to Manage Floods in a						

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
	Graduate School of Engineering Kagawa University, Japan Year: 2018-19	Eurasian Trans-cultural Contextualization				√		
15	TANGINA SULTANA Doctoral, Department of CSE Kyung Hee University, South Korea Year: 2018-19	Predictive Analysis for Drug Discovery by using AI and Bigdata	√					
16	Sharmin Nahar Sarwardi Doctoral, Department of CSE, Jahangirnagar University Year: 2018-19	A decision support system for ICU pediatric congenital heart disease				√		
17	Abu Sayeed Arif Doctoral, Department of Mathematics, Jahangirnagar University Year: 2018-19	Formulations and solution of transportation problem: An algorithmic approach				√		
18	MD. DELOWAR HOSSAIN Doctoral, Department of CSE Kyung Hee University, Korea Year: 2018-19	The Role of Mobile Edge Computing in 5G Ultra-Dense Networks		√				
19	Shariful Graduate, 2019 Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology Year: 2020-21	Automatically determining risk of pneumothorax disease created by Covid-19 using deep learning	√					
20	Chaitee Basak Graduate, 2020 Department of Electronics and Telecommunication Engineering, Rajshahi University of Engineering and Technology Year: 2020-21	Designing and simulation of high performing SPR biosensor				√		
20	Md. Shamim Hossen Graduate, 2019 Department of Information and Communication Technology, Islamic University, Kushtia-703 Year: 2020-21	Reinforcement learning based malicious user detection for co-operative spectrum sensing in cognitive radio network	√					
22	Rakib Ahmed Saleh Doctoral, 2020 Faculty of Computer Science and Information Technology (Information Systems), University Putra Malaysia (UPM) Year: 2020-21	Conceptual model of citizen adaption of e-government for developed and developing countries and finding out the underlying gaps				√		
23	Narayan Ranjan Chakrabarty Doctoral, 2017	Usage of ICT in correctly determining emergency situation:						

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
	Department of Information Systems, University of Agder, Norway Year: 2020-21	Case studies of flood in Bangladesh						
24	Afrin Ahmed Graduate, 2018 Institute of Information Technology, Jahangirnagar University Year: 2020-21	Sentiment analysis of Bangla sentence using long, short term memory recurrent neural network	√					
25	Shadman Mahmud Khan Pathan Graduate, 2019 Department of Electrical and Electronic Engineering, Rajshahi University of Engineering and Technology, Rajshahi Year: 2020-21	Smart wheelchair with multiple control options and convertible bed for physically disables people			√			
26	Md. Hasibul Haque Moon Graduate, 2020 Department of Computer Science and Engineering, University of Dhaka Year: 2020-21	Developing an efficient algorithm for differentially private frequent pattern mining	√					
27	Md. Tanvir Alam Graduate, 2020 Department of Computer Science and Engineering, University of Dhaka Year: 2020-21	Hypergraph mining methodologies	√					
28	Anika Tahsin Graduate, 2020 Department of Computer Science and Engineering, University of Dhaka Year: 2020-21	Energy co-operation among base stations through multi-operation cellular network		√				
29	Surovi Aktar Graduate, 2020 Institute of Information Technology, University of Dhaka Year: 2020-21	Proposing a new method for selecting the best feature set	√					
30	Md. Shahin Alam Shuvo Graduate, 2020 Department of Computer Science and Engineering, University of Dhaka Year: 2020-21	Quality of experience aware task allocation system to mobile as node in 5G network				√		
31	Nusrat Muniya Graduate, 2020 Department of Computer Science and Engineering, University of Dhaka Year: 2020-21	Automatic text summarization	√					
32	Hasin Rehena Graduate, 2020 Department of Computer Science and Engineering, University of Dhaka	Plant disease detection system using leaf-image	√					

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
	Year: 2020-21							
33	Taukir Ahmed Graduate, 2020 Institute of Information Technology, University of Dhaka Year: 2020-21	The involvement of developers in missing link community smell: A research analysis	√					
34	Sheikh Tanjeer Mehedi Graduate, 2019 Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology Year: 2020-21	Detecting infection of SARS-COV-2 using a deep-learning model and machine learning based viral genome sequencing	√					
35	Md. Nadim Hossen Graduate, 2017 Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology Year: 2020-21	Designing sensor for detecting adulterate fuel using surface plasmon resonance based photonic crystal fiber				√		
36	Ainul Anam Shah Jamal Khan Doctoral, 2019 Department of Electrical and Electronic Engineering, Chattogram University of Engineering and Technology Year: 2020-21	Time frequency analysis of multimodal biosignals for sleep disorder detection		√				
37	Md. Samsujjoha Doctoral, 2021 Department of Soil Science, Sher-e-Bangla Agricultural University Year: 2020-21	Evaluation of change in quality of chemical in soil and of nutrition of plant grown in polluted land of industrial area		√				
38	Sharmin Aktar Mim Graduate, 2017 Department of Computer Science and Engineering, BUET Year: 2020-21	Quartet FM revisited for larger phylogenetic studies				√		
39	Mohammad Lutful Hakim Doctoral, 2020 Institute of Climate Change, University Kebangsaan Malaysia (UKM) Year: 2020-21	Developing beam steering antenna for 5G and 6G application using metamaterial				√		
40	Md. Bellal Hossain Doctoral, 2020 Space Science Center, Institute of Climate Change, University Kebangsaan Malaysia (UKM) Year: 2020-21	Development of a new double negative metamaterial inspired multiband satellite antenna				√		
41	Deepika Roy Prapti Graduate, 2020 Department of Organic and Agricultural Technology, University Putra Malaysia Year: 2020-21	Internet of Things (IOT) in fisheries: Development of intelligence database for cost effect smart	√					

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
		aquaculture for rural fish farmers						
42	Fairuj Anika Salwa Doctoral, 2021 Department of Physics, Jahangirnagar University Year: 2020-21	A study of photonic crystal and photonic crystal fibre and their application in optimal telecommunication and devices				√		
43	Md. Injamam-Ul-Hossen Doctoral, 2019 Department of Computer Science and Engineering, Khulna University Year: 2020-21	Prediction of essential protein housing metaheuristic algorithm and machine learning technique	√					
44	Shahida Islam Mou Graduate, 2020 Department of Computer Science and Engineering, Khulna University Year: 2020-21	Prediction of lung cancer using ensemble and feature selection method	√					
45	Sadiya Khan Rupa Graduate, 2020 Department of Information and Communication Technology, Bangladesh University of Professionals Year: 2020-21	A robot feature descriptor for lung cancer nodule detection and classification	√					
46	Tapatosh Ghosh Graduate, 2020 Department of Information and Communication Technology, Bangladesh University of Professionals Year: 2020-21	Using attention based bi directional long short term memory to detect sentiment of posts written in Bangla on social network and sorting out sad posts	√					
47	Md. Sajjadul Islam Protyasha Graduate, 2019 Department of Information and Communication Technology, Bangladesh University of Professionals Year: 2020-21	Detecting illness of paddy plant by using convolutional neural network	√					
48	Chinmoy Bepari Doctoral, 2019 Department of CSE, Khulna University Year: 2020-21	Machine learning for automated analysis of spectral domain optimal coherence tomography scans for improved assessment of age-related macular degeneration	√					
49	Prince Mahmud Graduate, 2019 Department of CSE, Khulna University Year: 2020-21	Hashing method for correct string matching problems	√					
50	Pritam Khan Bani Graduate, 2019	Chemical reaction optimization algorithm	√					

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
	Department of CSE, Khulna University Year: 2020-21	for minimum weight dominating set problem						
51	Laboni Akter Graduate, 2018 Department of Biomedical Engineering, Khulna University of Engineering and Technology Year: 2020-21	Detecting ovary cancer in advance using machine learning from biomarker of blood and clinical image	√					
52	Taspia Salam Graduate, 2017 Department of Information and Communication Technology, Cumilla University Year: 2020-21	Development of a zonal tin routing protocol for heterogeneous wireless sensor networks		√				
53	Tasmia Jaygirdar M.Phil, 2020 Department of Marketing, University of Dhaka Year: 2020-21	Challenges faced by traditional businesses while initiating online sales services: Bangladesh perspective				√		
54	Md. Hasan Tarek Graduate, 2020 Institute of Information Technology, University of Dhaka Year: 2020-21	An investigation technique of detecting feature subset from high dimensional data	√					
55	Afia Sajida Graduate, 2020 Institute of Information Technology, University of Dhaka Year: 2020-21	Analysis of stability of generative adversarial networks (G.A.N)	√					
56	Polash Roy Graduate, 2020 Department of CSE, University of Dhaka Year: 2020-21	Allocating work in cloud through mobile device using federate learning and subjective logic in smart city	√					
57	Mesbah Uddin Doctoral, 2020 Department of CSE, University of Chittagong Year: 2020-21	A method for developing agri-medical intelligent system using DNA based image mining method	√					
58	Mandira Chakrabarty Graduate, 2019 Department of CSE, Jagannath University Year: 2020-21	Quality-aware Bus-Driver Scheduling for intelligent Transportation System in Smart City	√					
59	Tania Sultana Graduate, 2019 Institute of Information Technology, Jahangirnagar University Year: 2020-21	A proposal for impenetrable blockchain beyond quantum for secure electrical transaction				√		
60	Saniul alam Graduate, 2019	Deep reinforcement learning based optimal power control for secure communication in	√					

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
	Institute of Information Technology, Jahangirnagar University Year: 2020-21	wireless interference system						
61	Fahiba Farhin Graduate, 2020 Institute of Information Technology, Jahangirnagar University Year: 2020-21	5G embedded secure smart healthcare system: Blockchain and machine learning based method				√		
62	Sadiya Islam Graduate, 2020 Institute of Information Technology, Jahangirnagar University Year: 2020-21	Deep reinforcement learning for resource allocation in vehicular communications under URLLC	√					
63	K. Shayekh Ibne Mijan Graduate, 2020 Institute of Information Technology, Jahangirnagar University Year: 2020-21	Indoor positioning and navigation using blue tooth low energy and cloud service in health care perspective				√		
64	Priyanka Mandal Graduate, 2019 Institute of Information Technology, Jahangirnagar University Year: 2020-21	Impact of anoxia on half-metal double perovskite				√		
65	Prosunjit Saha Graduate, 2018 Department of Computer Science and Telecommunication Engineering, Noakhali University of Science and Technology Year: 2020-21	An automated water flow assessment technique for aquaponics system using IoT		√				
66	Md. Jahidul Alam Graduate, 2018 Department of Computer Science and Telecommunication Engineering, Noakhali University of Science and Technology Year: 2020-21	Observing timeline of determining shares' prices of Dhaka Stock Exchange using statistics and method of network					√	
67	Md. Mehedi Hasan Graduate, 2020 Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology Year: 2020-21	Designing dual guided based photonic crystal fiber (PSF) using orbital angular momentum (OAM) and linear polarization (LP) for high power optical connection				√		
68	Md. Anwar Kabir Graduate, 2020 Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology Year: 2020-21	Designing photonic crystal fiber for assisting orbital angular momentum modes using terahertz frequency in case of optical fiber connection				√		

sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
69	Sumaiya Akhtar Mitu Graduate, 2020 Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology Year: 2020-21	Designing surface plasmon resonance (SPR) based sensor for analyzing future performance of optical fiber using Internet of Things (IoT) based technology		√				
70	Hasan Abdullah Graduate, 2020 Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology Year: 2020-21	Designing photonic crystal fiber refractor index-based biosensor for chemical sensing		√				
71	Mahmudul Islam Rakib Graduate, 2020 Department of Computer Science and Telecommunication, Noakhali University of Science and Technology Year: 2020-21	Observing financial time series through machine learning based feature ranking method				√		
72	Jannatul Mawa Koli Graduate, 2019 Department of Computer Science and Telecommunication, Noakhali University of Science and Technology Year: 2020-21	Assessing effect of globalization on the trade of Bangladeshi goods using modularity optimization and classification method	√					
73	Shatabdi Roy Mun Graduate, 2020 Department of Computer Science and Telecommunication, Noakhali University of Science and Technology Year: 2020-21	transfer entropy in the trade flow of exported goods from Bangladesh in international market				√		
74	Sharmin Yeasmin Graduate, 2020 Department of Computer Science and Telecommunication, Noakhali University of Science and Technology Year: 2020-21	Bangla news categorization using universal language model fine tuning (ULMFT)	√					
75	Sayed Abrar Jawad Graduate, 2020 Department of CSE, University of Dhaka Year: 2020-21	Selecting crowd-source adapted safe and intelligent road	√					
76	Ms. Faujia Aktar Hawa Graduate, 2019 Department of CSE, University of Dhaka Year: 2020-21	Amino acid interaction network prediction in protein	√					
77	Md. Johirul Islam Doctoral, 2020 Department of CSE, Jessore University of Science and Technology	Allocation of resources in multi-domain separate 5G networks and management of network slicing						

Sl	Name of the fellowship recipient, Year, Course, Department and University	Title of the research topic	4IR & Emerging				IT/ITES	NA
			AI, DA*	IoT / Sensors	Robotics	Others		
	Year: 2020-21							
78	Jannatul Nayeema Graduate, 2020 Department of Electrical and Electronic Engineering, University of Chittagong Year: 2020-21	Design and implementation of gallium arsenide and gallium nitride based high-electron-mobility transistor (HIMT) and skeuomorphic high-electron-mobility transistor (PHEMT) for 3D MMIC				√		
79	Tasnia Jabin Graduate, 2021 Department of Electrical and Electronic Engineering, Chittagong University Year: 2020-21	Synthesis and explanation of structured, figurative, electrical, and magnetic characteristics of Niobium transplanted Barium Calcium Titanate Perovskite				√		
80	Sadiya Afroj Doctoral, 2020 Department of CSE Engineering, Chittagong University of Engineering and Technology Year: 2020-21	Towards sentiment classification from low resource language using deep learning	√					
81	Sobhana Jahan Graduate, 2021 Department of Information and Communication Technology, Bangladesh University of Professionals Year: 2020-21	Preliminary prediction and management of Alzheimer using explainable artificial intelligence based multimodal sensor	√					
82	Md. Raqib Rayhan Graduate, 2021 Department of Electrical and Electronic Engineering, Khulna University of Engineering and Technology Year: 2020-21	Developing EMG and gyro based wearable human-computer interface (HCI) system for amputees			√			

Table F2: Mapping of Innovation Grants to IT/ITES Skills

Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
1	Studio Bangi House # 127/B, Road # 9A, West Dhanmondi, Dhaka. Name of Applicant: Salzar Rahman Year: 2018-19	Simple script					√	
2	MD Toriql Islam 143, Katasur, Sadek khan road,	EduBot (educational Robot)			√			

Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	Mohammadpur, Dhaka Year: 2018-19							
3	FreeFall H#174#, R#2, DOHS, Baridhara Applicant: Muhammad Imtiaz Uddin Chowdhury, CEO Year: 2018-19	FreeFall: Portable Emergency Evacuation System			√			
4	Dr. Atif Hasan Rahman Assistant Professor, Department of CSE, BUET Year: 2018-19	Continuous Monitoring and Smart Emergency Warning System for Cardiovascular Patients		√				
5	Department of Computer Science and Engineering Independent University, Bangladesh (IUB) Applicant: Tanjina Proma, Research Associate, IUB, Bashundhara, Dhaka- 1229 Year: 2018-19	National Medicine Image database creation and recognizing medicine from medicine image	√					
6	Md. Hafijur Rahman 26/12, Block - F, Babor Road, Mohammadpur, Dhaka Year: 2018-19	Web and Mobile Application Based Missing Query Platform (Lost & Found BD)				√		
7	AIMS Lab United International University Applicant: Md Monzurul Haque Faruque House #854, Road #12, Mirpur, DOHS, Pallabi, Dhaka - 1216 Year: 2018-19	A Cloud Based Smart Application for Eye Care in Bangladesh	√					
8	Adiba Mahbub Proma 5/D Chameli, Sobhanbag Officer's quarter, Dhaka-1207, Mohammadpur	An interactive system for cancer awareness, education, screening and	√					

Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	,Dhaka South City Corporation Year: 2018-19	referral in Bangladesh						
9	Youth Opportunities Level 2, Software Technology Park, Janata Tower, Kawran Bazar, Dhaka Year: 2018-19	Mentorship Platform “Growth Incubator” for the Bangladeshi Youth					√	
10	Jessore University of Science and Technology Independent Road, Jessore Entrepreneur: Md. Zaved Hossain Khan Year: 2018-19	Title of the Project: Smartphone app for detecting poultry infection with biosensor device		√				
11	Dr. M. A. Farukh Professor, Department of Environmental Science, Bangladesh Agricultural University, Mymensingh-2202 Year: 2018-19	Developing Forecasting Technology of Extreme Weather and its Impact on Coastal Areas Food Security	√					
12	Mohshi Masnad Level 7, Building#8, CSE department, BRAC University, 66 Mohakhali, Dhaka Year: 2018-19	E+Youth (Galvanizing Energy with Experience towards Youth Empowerment)					√	
13	Space and Rocket Center BD 12/5 Bosti Housing Mirpur, Dhaka. Entrepreneur: Mohammad Mozammel Haque Year: 2018-19	Developing a land observation system to observe agricultural crop during emergency situation	√					
14	AIMS Laboratory, United International University United International University, Madani Avenue, United City, Satarkul, Badda, Dhaka-1212. Entrepreneur: Nipa Roy Year: 2018-19	Adicare				√		

Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
15	Dr. Md. Wahiduzzaman Associate Professor, Institute of Information Technology (IIT), Jahangirnagar University, Savar, Dhaka. Year: 2018-19	An interactive knowledge based Virtual communication platform for Autism Spectrum Disorder (ASD) patients in Bangladesh				√		
16	AIMS lab, United International University, United City, Madani Avenue, Badda, Dhaka-1212, Bangladesh. Entrepreneur: Prof. Dr. Mohammad Nurul Huda Year: 2018-19	Machine's reception: Automatic conversation receptionist with artificial intelligence	√					
17	Mirza Rasheduzzaman Assistant Professor, Department of Electrical and Electronic Engineering, University of Liberal Arts, Bangladesh. House No. -56, Road No. – 4/A, Saat Masjid Road, Dhanmondi, Dhaka-1209. Year: 2018-19	Developing an IOT based intelligent vaccine carrier observation module for remote area.		√				
18	Rise Up Labs Applicant: Ershadul Hoque, CEO Floor # B6, Plot # 35, Sonargaon Janapath Road, Sector # 07, Uttara, Dhaka- 1230. Year: 2018-19	“Speech of 7th March in Virtual Reality”				√		
19	CERTAIN Entrepreneur: Md. Nazrul Islam Anik B.Sc. in Computer Science and Engineering, BUET No- 1029, Level-10, Multiplan Center, New Elephant Road, Dhaka Year: 2018-19	Journal Management System (JMS)					√	



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
20	United International University Entrepreneur: Chowdhury Mofizur Rahman Team member: Chowdhury Rafid Rahman, Lecturer, Department of CSE, United International University 609/11, Adabar, Dhaka Year: 2109-20	B writer guide: Machine learning based nice tool to write Bangla with English alphabet	√					
21	Nadira Anjum Chowdhury House/Holding: 13 C Babar Road F 701, Road: Babar Road, PO: Mohammadpur-1207, Dhaka North City Corporation, Dhaka Year: 2109-20	Gamified education of science and technology using augmented reality				√		
22	Dr. Pallab Kanti Poddar and Tarun Debnath Associate Professor, Department of Information and Communication Engineering, University of Pabna Science and Technology, Rajapur, Pabna-6600, Pabna, Bangladesh Year: 2109-20	Artificially intelligent baby nursing robot	√					
23	M.D. Anwar Hossen Lecturer, Daffodil International University, 78/1 (Floor -3, left side), Arambag, Motijhil-1000, Dhaka Year: 2109-20	A guide for students' development by determining their performance using cloud-based machine learning model				√		
24	Adnan Setu House No. - 143/2/A block, Road: Jhilpar, Khilgaon TSO-1219, Dhaka Year: 2109-20	IOT snacks box		√				
25	East West University Entrepreneur: Dr. Mohammad Raiyan Khan,	Dust and soiling on solar Panels: effect on output, site evaluation and				√		

Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	Jaharul Islam City Gate, 1T/2 Jaharul Islam City: Dhaka 1212 Year: 2109-20	cleaning cycle prediction						
26	Dr Hasan Sarwar & Sharmin Nahar Sarwardy House 80, Rd 8/A, Sat Masjid Road, Dhanmondi, Dhaka Year: 2015-16	Mobile Web Based Electronic Health Record System for Patient Management in Heart Disease					√	
27	Admire Informatix Ltd. Prince Tower, FD#13, 135/A, Elephant Road, Dhaka-1205. Mobile: 01819211690 (Abdul Malek) Year: 2015-16	"Rofrdurdanto Cluster firefighting & Rescue Robot" for Human Safety, Firefighting, Rescue and Reconnaissance			√			
28	Md. Jakariya, PhD Professor & Chair Department of Environmental Science & Management, North South University, Bashundhara, Dhaka-1229. Year: 2015-16	ICT based wildlife crime reporting system					√	
29	Walk Bangladesh Ltd. Flat: BC1, House-47, Road-23, Block-B, Banani, Dhaka-1213. Applicant: Shuvo Rahman, Managing Director Year: 2017-18	Walk Bangladesh						√
30	Mysoftheaven (BD) Ltd. 19-B/2-C & 2-D, Block-F, 5th Floor, Ring Road, Shyamoli, Dhaka-1207. Applicant: Mr. Md. Mofakharul Islam, Managing Director Year: 2017-18	"Will" [Integrated Web based management software with mobile apps (Android, iOS)]					√	

Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
31	Digitaldorji.com 60/9 West Madertek, Bashaboo, Dhaka Year: 2017-18	Digital Dorji				√		
32	H.M. Tamim B3, 349/A, Road No. 9, Block C, Basundhara R/A Year: 2019-20	Student companion					√	
33	Dreamerz lab 6/14(5B), Block-A, Lalmatia, Dhaka. Entrepreneur: Tanvir Hossen Khan Year: 2019-20	Human Anatomy Learning				√		
34	Pridesis IT Ltd. Level 6, 20/21 Garden Road, Kawran Bazar. Entrepreneur: Monwar Iqbal Year: 2019-20	Pride vision- Real time video intelligence for industry					√	
35	Research Archive Shyampur, Sarkar bari, Shahrasti, Chandpur. Entrepreneur: Abdur Rahman Year: 2019-20	Open-source research archive					√	
36	United International University Entrepreneur: Mohammad Touhidul Islam Mia Assistant Professor Plot#14, Road#6, Block#G/1, Mirpur-2, Dhaka-1216 Year: 2019-20	Marketbrain – Neuromarketing system based on brain computer interface				√		
37	Md. Almas Alam Lecturer, Bangladesh Army University of Engineering and Technology Village+P.O.: Bashbaria, P.S.: Bagatipara, Dist.: Natore Year: 2019-20	Augmented reality e-commerce				√		
38	Md. Riyad Hasan Student, Honors (Final year), Department of Information and Communication Engineering, Pabna University of Science	A cost-saving special tool to determine quality of water and ensuring easy usage of the tool through mobile app		√				



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	and Technology, Rajapur, Pabna Year: 2019-20							
39	Dr. Md. Mamunur Rashid Professor, Department of CSE, University of Dhaka	Artificial intelligence assistant to improve mental health of the students of university	√					
40	Sayed Hasan Lecturer, University of Information Technology and Science 112/1 Sabujbag, Dhaka-1214 Year: 2019-20	An application to prevent sexual harassment occurs through Facebook messenger in Bangladesh				√		
41	Dr. Md. Mosaddek Khan Assistant Professor, Department of Computer Science and Engineering, University of Dhaka Year: 2019-20	Guard: An artificial game theoretic method for security and its implementation	√					
42	Md. Rabiul Alam Maruf Undergraduate student, Department of Electrical and Electronic Engineering, National Institute of Textile Engineering and Research. Address: Niter student hostel, NITER, Koh-i-Noor Gate, Noyarhat, Sava, Dhaka-1350, Bangladesh Year 2020-21	Development of Antigravity device using artificial Intelligence.				√		
43	Sunny Zubayer Student of class 12, Division: Science, Dhaka College. Address: HN#13, Road#10, Block-M, South Banashree, Rampura, Dhaka-1219 Year 2020-21	Defender-Fire extinguisher robot			√			
44	Khondker Suhat Uddin	Robotpose detection-based						



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	Flat#4/A, 233, Senpara Parbata, Mirpur-10, Dhaka-1216 Year: 2020-21	driver assistant system			√			
45	YPSA (Young Power in Social Action) Entrepreneur: Rasheduzzaman Chwodhury Head office, YPSA, H#F10(P), Road#13, Block-B, Chandgaon-AA/A, Chattagrom Year: 2020-21	A multimedia talking book of 'Mujibbarsha': From Sheikh Mujibur to Bangabandhu, Independence War and Bangladesh					√	
46	The Dream Academy Entrepreneur: Md. Tariqul Habib 38-Agnibina Road, Jhenaidah Year: 2020-21	A mobile quiz game app on Bangabandhu					√	
47	Space Apps BD Entrepreneur: Ariful Hasan 46 Kazi Nazrul Islam Avenue, Kawran Bazar, Dhaka Year: 2020-21	Thalassemia Solution					√	
48	SIMED Health Ltd. Entrepreneur: Prof. Dr. M.A. Hye Dhanmondi Saat Masjid Road, Year: 2020-21	CCR: A cloud-based platform for registration, categorization and follow-up of cancer patients					√	
49	Islami University of Technology Entrepreneur: Sadiya Sharmin C/O: Dr. Mohammad Mahbub Alam Professor and Head, Department of Computer Science and Engineering, Islami University of Technology, Boardbazar, Gazipur Year: 2020-21	Developing an intelligent model to provide advance signal on potential cyber attack					√	
50	Md. Sadek Ferdous Shuveccha-67, Housing Estate, Amberkhana, Sylhet, Bangladesh Year: 2020-21	Blockchain based E-KYC and reputation system					√	



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
51	Department of CSE, Begum Rokeya University, Rangpur Entrepreneur: Dr. Md. Jasim Uddin Assistant Professor, CSE Year: 2020-21	Determining and levelling autism spectrum of primary school going children of Bangladesh				√		
52	Bikash Kumar Paul Department of Information and Communication Technology, Mawlana Bhasani University of Science and Technology, Santosh, Tangail, Bangladesh Year: 2020-21	Microstructure photonic crystal fiber for lools terahertz optical communication				√		
53	Md. Tasnim Rana 63/3, Matikata-ECB Road, Matikata, Dhaka Army Quarter, Dhaka Year: 2020-21	technological review and evaluation regarding versatile usage of hybrid aerostat					√	
54	Rayhan Ahmed Block#5, Road#26, IMED, Sher-e-Bangla Nagar, Agargaon, Dhaka-1207 Year: 2020-21	Online management of social safety net				√		
55	Md. Samiullah Lecturer, Department of CSE, University of Dhaka, Dhaka, Bangladesh Year: 2020-21	Artificial intelligence operated treatment assistant	√					
56	Dr. Md. Mahmudul Hasan Assistant Professor, Department of nutrition and food technology, Jessore University of Science and Technology, Bangladesh Year: 2020-21	Bioinformatic based prediction and detection of heritable type-2 diabetic in population of Jessore region				√		
57	Md. Rezaul Karim House/Holding#134 Village/Road: Ajimpur Road, P.O.: Newmarket 1205, Lalbag, Dhaka South City Corporation, Dhaka Year: 2020-21	Ensuring safe transportation and emergency service to citizen through a crowdsourcing service				√		



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
58	Tasnuva Tazrin Mallik 2/F, Nawab Street, Wari, Dhaka-1203. Year: 2020-21	Innovation of mobile technology for the development of mental health					√	
59	Dr. Tanzima Hashem Professor, Department of CSE, BUET Village + P.O.: Boroibari, P.S.: Kaliakair, District: Gazipur Year: 2020-21	Explanatory spatio-temporal deep learning model for safe city	√					
60	Dr. Mohammad Abdullah Adnan Department of CSE, BUET, Dhaka Year: 2020-21	Using deep learning for automatic censoring and detecting anomaly in media data	√					
61	Natural Language Processing (NLP) lab, Department of CSE, CUET Entrepreneur: Prof. Dr. Mohammad Mashiul Haque Year: 2020-21	Using deep learning for detecting and categorizing offensive Bangla text in social network	√					
62	Green University of Bangladesh Department of Electrical and Electronic Engineering, Green university of Bangladesh, 220/D, Begum Rokeya Saroni, Dhaka-1207, Bangladesh Entrepreneur: Dr. Ahmed Al Mansur, Associate Professor Year: 2020-21	Maximizing output energy of solar array using module rearranging techniques					√	
63	Dr. Sujit Bishwas Assistant Professor Department of CSE, Faridpur Engineering College, Faridpur Year: 2020-21	Building blockchain based public examination management application				√		
64	Quicks 306, South Paikpara, Mirpur, Dhaka-1216 Entrepreneur: Athar Nur Kaushik Year: 2020-21	Quicks: Artificially intelligent delivery management software	√					



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
65	Dr. Md. Hafiz Uddin Assistant Professor, Department of Mathematics, Jessore University of Science and Technology, Jessore-7408 Year: 2020-21	Contribution of non-linear evolution equation on development of plasma and telecommunication networking system					√	
66	Zeba Musfiq Juhi Ka 142/7 Khilkhet, Dhaka 1229 Year: 2020-21	Hing Ting Chot					√	
67	Chittagong University of Engineering and Technology Department of Electrical and Electronic Engineering Entrepreneur: Dr. Kazi Delwar Hossen Year: 2020-21	Method of measuring haemoglobin safe using mobile application					√	
68	BUET, Department of CSE. Entrepreneur: Dr. Abu Sayeed Mohammad Latiful Haque Year: 2020-21	Virtual internship system in a blended learning environment					√	
69	Md. Mazharul Islam 290, South Manipur, Mirpur, Dhaka-1216, Bangladesh Year: 2020-21	Machine learning based web application to pre-determine high blood pressure: Bangladesh perspective	√					
70	Mohammad Riazul Islam Department of Biochemistry and Molecular Biology, University of Dhaka, Dhaka-1000 Year: 2020-21	Detecting important gene from genome of Hilsa using artificial intelligence and deep learning	√					
71	Dr. Upama Kabir Room#422, Department of Computer Science and Engineering, University of Dhaka, Dhaka-1000. Year: 2020-21	Cychain: Blockchain based cyber security engine				√		
72	Jakia Afrin House#20, Road#03, Nikunja 2, Khilkhet, Dhaka	Cloud based interactive virtual assistant for the development of				√		



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	Year: 2020-21	health and education of the youngster.						
73	Tech terrain IT House#97, Road#5, Block F, Banani, Dhaka-1212 Year: 2020-21	Duplication reduction management system				√		
74	Aunuraran Ltd. House#677/A, Road#13, Adabar, Mohammadpur, Dhaka-1207 Entrepreneur: A.G.M. Jaman Year: 2020-21	Educhain-Blockchain based academic certificate verification				√		
75	Dr. Mohammad Abu Sayem Karal Associate Professor, Department of Physics, BUET, Dhaka Year: 2020-21	Tearing nano membrane through microcontroller electroporation to destroy tumour/cancer cell				√		
76	A.B.M. Alim Al Islam Professor, Department of CSE, BUET Year: 2020-21	Green parallel computing: electricity saving job scheduling for parallel computing structure				√		
77	Shahjalal University of Science and Technology, Sylhet Department of Genetic Engineering and Biotechnology Entrepreneur: Dr. Mohammad Jakir Hossen, Professor Year: 2020-21	Genetic sequencing of hereditary disease among Bangladeshi people and preparing databases				√		
78	United International University (UIU) United City, Madani Avenue, Dhaka-1212. Entrepreneur: Dr. Kafiul Islam; Dr. Chiranjeeb Bishwas; Dr. Farhana Sarkar; Dr. Helal Uddin Ahmed; Antara Deb Year: 2020-21	Deep depression: detecting mental disease (frustration) accurately using BCI technology	√					
79	Sanchita Sarker Village: Talshan, P.O.: Adamdighit (Post code-5890),	Detecting milk preservative using sensor based on surface plasma resonance		√				



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	P.S.: Adamdighi, District: Bagura Year: 2020-21							
80	Dr. A S M Mohsin Assistant Professor and Researcher, Department of Electrical and Electronic Engineering, Brac University, 66 Mahakhali, Dhaka, Bangladesh Year: 2020-21	Finding quality of water using modern technology (nanotechnology, IOT and machine learning)		√				
81	Dr. Md. Mosaddek Khan Assistant Professor and Researcher, Department of CSE, University of Dhaka Year: 2020-21	Using multi robot (agent) deep reinforcement learning for automatic warehouse system			√			
82	Haji Mohammad Danesh University of Science and Technology, Dinajpur Department of Electronics and Communication Engineering, School of Computer Science and Engineering Entrepreneur: Md. Mahabub Hossen, Professor Year: 2020-21	Improving intelligent robot having remote thermometer for observing health of poultry			√			
83	Dr. Mohammad Jahidur Rahman Professor, Department of CSE, Jahangirnagar University, Savar, Dhaka-1342 Year: 2020-21	A SAS based LMS platform for ICT education of applied secondary and higher secondary level				√		
84	Space lab House of Shah Alam, Village: Jamidar gram, Motherheart 4324, Mirshorai, Chottoram Entrepreneur: Mohammad Shahadat Hossain Year: 2020-21	Ground station making and receiving data through CanSat and rocket		√				
85	Dr. Mohammad Rashedur Rahman	Mapping spatio- temporal flood						



Sl.	Name and Address of the innovation grant recipients, year	Title of the research topic	4IR and Emerging				IT/ITES	NA
			AI DA	IoT Sensors	Robotics	Others		
	North South University, Plot#15, Block-B, Basundhara, Dhaka Year: 2020-21	susceptibility based on hybridized artificial intelligence	√					
86	Bangla Puzzle Ltd. Flat#4D, House#2/H/1, Road#1, Shyamoli, Dhaka-1207 Entrepreneur: Lipi Khatun Year: 2020-21	Virtual tour maker					√	
87	Yeana Studio Sunshine Apartment, 152/5, South Badda, Gulshan, Dhaka-1208. Entrepreneur: Reshma Khan Year: 2020-21	Detecting breast cancer through augmented reality	√					
88	Jahidul Islam Research Assistant and Undergraduate Student, Department of CSE, Dhaka International University Address: 105/03, West Merul Badda, Dhaka Year: 2020-21	Virtual hardware lab					√	
89	Fijar Ahmed Assistant Professor, Daffodil International University, Dhaka. Address: 4 th floor, 11/18 Salimullah Road, Mohammadpur, Dhaka Year: 2020-21	Generating employment for poor women through production and marketing of Mushroom using IOT and mobile apps technology		√				



Appendix G: Mapping of Emerging Skills to Academic Programs and Activities, Internship and Training

A list of 39 emerging IT/ITES skills, as stated in LinkedIn reports, are not covered in academic programs of computer science and engineering, and other related degree programs. But they could be addressed through additional means, as suggested by academics. Hence, it creates the opportunity for BHTPA to intervene through its skill development programs

Table G1: Mapping of Emerging Skills to Academic Programs/Activities/Internship and Training

Names of Skills	Definition	Relevant Academic Courses	How this skill development should be addressed?
AngularJS	AngularJS is a structural framework for dynamic web apps.	Internet and Web Technology Software Engineering (in project work)	Internship
Amazon Web Services or AWS	Amazon Web Services or AWS as an abbreviation is a popular Cloud Service Provider that enables on-demand services like compute, storage, networking, security, databases, etc. which can be accessed through the internet	Cloud Computing (Graduate) Distributed Computing (Graduate)	Internship Workshop/Training (Govt)
Ansible	Ansible can be used to provision the underlying infrastructure of your environment, virtualized hosts and hypervisors, network devices, and bare metal servers. It can also install services, add compute hosts, and provision resources, services, and applications inside of your cloud	Not taught	Internship
Automation Anywhere	Automation Anywhere is one of the most popular RPA vendors offering powerful and user-friendly RPA capabilities to automate the business processes that are performed by humans.	Not taught	Internship
Apache Spark	Apache Spark is an open-source, distributed processing system used for big data workloads. It utilizes in-memory caching, and optimized query execution for fast analytic queries against data of any size.	Machine Learning (Graduate)	Internship Workshop/Training
Blue Prism	Blue Prism is a UK-based software development company in the field of Robotic Process Automation. The group supplies software robots that help to automate clerical back-office processes that work exactly like a human. The Robotic Process Automation (RPA) was invented by Blue Prism.	Robotics (UG/Graduate)	Internship or Training
CRM Marketing	Customer relationship management (CRM) marketing is a term referring to the strategies and tactics, as well as to the technologies supporting the execution of said strategies and tactics, marketers use in order to manage the relationship with their customers throughout the customer lifecycle.	Not taught	Internship
DevOps	DevOps engineers manage the operations of software development, implementing engineering tools and knowledge of the	Advance Software Engineering (Graduate)	Training after 2-3 years of industry experience

Names of Skills	Definition	Relevant Academic Courses	How this skill development should be addressed?
	software development process to streamline software updates and creation.		
Digital marketing	Digital marketing is the marketing and advertising of a business, person, product, or service using online channels, electronic devices, and digital technologies. A few examples of digital marketing include social media, email, pay-per-click (PPC), search engine optimization (SEO), and more.	Not taught	Internship Training
Docker Products	Docker is an open-source containerization platform. It enables developers to package applications into containers—standardized executable components combining application source code with the operating system (OS) libraries and dependencies required to run that code in any environment.	Operating Systems	Internship Training
e-mail marketing	Email marketing is the act of sending a commercial message, typically to a group of people, using email.	Internet and Web Technology	Workshop / Training
Git	Git is software for tracking changes in any set of files, usually used for coordinating work among programmers collaboratively developing source code during software development. Its goals include speed, data integrity, and support for distributed, non-linear workflows.	Software Engineering Advanced Software Engineering (Graduate)	Workshop Internship
Go Programming	Go (also called Golang or Go language) is an open-source programming language used for general purpose. Go was developed by Google engineers to create dependable and efficient software.	Computer Programming Object Oriented Programming	Workshop Training/Internship
Hadoop	Apache Hadoop is a collection of open-source software utilities that facilitates using a network of many computers to solve problems involving massive amounts of data and computation.	Machine Learning	Internship Training
Hyperledger	Hyperledger is an open-source project created to support the development of blockchain-based distributed ledgers.	Cryptography Network Security	Training Internship
JavaScript	JavaScript is a programming language that adds interactivity to your website.	Computer Programming Object Oriented Programming	Project Work Internship
jQuery	jQuery is a lightweight, "write less, do more", JavaScript library. The purpose of jQuery is to make it much easier to use JavaScript on your website.	Computer Programming Object Oriented Programming	Internship
JIRA	Jira is a software application used for issue tracking and project management.	Software Engineering Project Management (Information System Design)	Workshop Internship
Jenkins	Jenkins is an open-source continuous integration/continuous delivery and deployment (CI/CD) automation software DevOps tool written in the Java programming language. It is used to implement CI/CD workflows, called pipelines.	Software Engineering	Training/Workshop

Names of Skills	Definition	Relevant Academic Courses	How this skill development should be addressed?
Kubernetes	Kubernetes, often abbreviated as “K8s”, orchestrates containerized applications to run on a cluster of hosts. The K8s system automates the deployment and management of cloud native applications using on-premises infrastructure or public cloud platforms.	Operating Systems	Training/Workshop Internship
Laravel	Laravel is a back-end PHP-based and open-source framework used for building a wide range of custom web applications.	Computer Programming Internet and Web Technology	Training Internship
Marketo	Marketo is a marketing software as a service (SaaS) platform designed to help businesses assess and automate marketing tasks.	Computer Programming	Training
MongoDB	MongoDB is built on a scale-out architecture that has become popular with developers of all kinds for developing scalable applications with evolving data schemas.	Database Systems Advanced Database Systems	Self-learning
Node.js	Node.js is primarily used for non-blocking, event-driven servers, due to its single-threaded nature. It's used for traditional web sites and back-end API services, but was designed with real-time, push-based architectures in mind.	Computer Programming Internet and Web Technology Web Application Development	Internship Project Work
Penetration testing	A penetration test, also known as a pen test, is a simulated cyber-attack against your computer system to check for exploitable vulnerabilities.	Computer Network Network Security	By providing assignments or project works in undergraduate and graduate courses requiring Penetration testing
PyTorch	PyTorch is an open-source machine learning framework based on the Torch library, used for applications such as computer vision and natural language processing, primarily developed by Facebook's AI Research lab.	Computer Vision Image Processing Machine Learning	By providing assignments or project works in undergraduate and graduate courses requiring PyTorch
R	R is a programming language for statistical computing and graphics supported by the R Core Team and the R Foundation for Statistical Computing.	Computer Programming Capstone Design Project	Workshop
React.js	React.js is an open-source JavaScript library that is used for building user interfaces specifically for single-page applications.	Internet and Web Technology Web Application Development	Internship
Robotic process automation	Robotic process automation is a form of business process automation technology based on metaphorical software robots or on artificial intelligence /digital workers	Robotics Artificial Intelligence	Training Internship

Names of Skills	Definition	Relevant Academic Courses	How this skill development should be addressed?
Scrum	Scrum is a framework for project management that emphasizes teamwork, accountability, and iterative progress toward a well-defined goal.	Software Engineering Project Management	Workshop Internship
Salesforce marketing cloud	Salesforce Marketing Cloud is a customer relationship management (CRM) platform for marketers that allows them to create and manage marketing relationships and campaigns with customers.	Internet and Web Technology	Workshop
Splunk	Splunk is used for monitoring and searching through big data. It indexes and correlates information in a container that makes it searchable, and makes it possible to generate alerts, reports and visualizations.	Big Data Artificial Intelligent Machine Learning	By providing assignments or project works in undergraduate and graduate courses requiring Splunk Internship
Security Information and Event Management (SIEM)	SIEM is a security solution that helps organizations recognize potential security threats and vulnerabilities before they have a chance to disrupt business operations.	Cryptography Computer and Network Security	Training
Smart contract	A smart contract is a self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code. The code and the agreements contained therein exist across a distributed, decentralized blockchain network.	Cryptography Network Security	Workshop
Solidity	Solidity is designed based on existing programming languages like C++, Python, and JavaScript, so it uses similar language structures found in these languages, most likely to make it easy for developer adoption.	Computer Programming Data Structure	Training/Internship
TensorFlow	TensorFlow is a free and open-source software library for machine learning and artificial intelligence.	Neural Network Machine Learning Artificial Intelligence	By providing assignments or project works in undergraduate and graduate courses requiring TensorFlow
Terraform	Terraform is our tool of choice to manage the entire lifecycle of infrastructure using infrastructure as code. That means declaring infrastructure components in configuration files that are then used by Terraform to provision, adjust and tear down infrastructure in various cloud providers.	Computer Programming Operating Systems	Training
Test automation	Test automation is the practice of automatically reviewing and validating a software product, such as a web application, to make sure it meets predefined quality standards for code style, functionality (business logic), and user experience.	Software Quality Assurance Software Testing	Internship

Names of Skills	Definition	Relevant Academic Courses	How this skill development should be addressed?
UiPath	UiPath is a robotic process automation tool for large-scale end-to-end automation.	Information System Design Software Engineering Robotics	Training/Workshop Internship



Appendix H: Profiling Courses of Polytechnic Institutes

Among the profiled 20 polytechnic institute, names of degree programs and related courses offered pertaining to computer Science and Engineering, and Information Technology are shown in the following Table.

Table H1: Profiling of Courses of Polytechnic Institutes

Note: No information was found for courses related to “Image processing or Computer Vision”, “Artificial Intelligence, Machine Learning, Natural Language Processing” and “Robotics, Automation, Cyber Physical Systems, Intelligent Systems”

Sl.	Names of Polytechnic Institute	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas					
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
1	Barisal Polytechnic Institute, Barisal	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Database Application; Programming Essentials; Object Oriented Programming; Programming in Java; Database Management System	Surveillance Security System; Cyber Security & Ethics	PCB Design & Circuit Making	IT Support II; DATA COMMUNICATION SYSTEM; Network Administration & Services	Principals of Software Engineering; SYSTEM ANALYSIS & DESIGN	Web Design; Web Development; Web Development Project
2	Patuakhali Polytechnic Institute, Potuakhali	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Database Application; Programming Essentials; Object Oriented Programming;	Surveillance Security System; Cyber Security & Ethics	PCB Design & Circuit Making	IT Support II; DATA COMMUNICATION SYSTEM; Network Administration & Services	Principals of Software Engineering; SYSTEM ANALYSIS & DESIGN	Web Design; Web Development; Web Development Project

Sl.	Names of Polytechnic Institute	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas					
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			Programming in Java; Database Management System					
3	Bangladesh Sweden Polytechnic Institute, Rangamati	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Database Application; Programming Essentials; Object Oriented Programming; Programming in Java; Database Management System	Surveillance Security System; Cyber Security & Ethics	PCB Design & Circuit Making	IT Support II; DATA COMMUNICATION SYSTEM; Network Administration & Services	Principals of Software Engineering; SYSTEM ANALYSIS & DESIGN	Web Design; Web Development; Web Development Project
4	Chandpur Polytechnic Institute, Chandpur	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Database Application; Programming Essentials; Object Oriented Programming; Programming in Java; Database Management System	Surveillance Security System; Cyber Security & Ethics	PCB Design & Circuit Making	IT Support II; DATA COMMUNICATION SYSTEM; Network Administration & Services	Principals of Software Engineering; SYSTEM ANALYSIS & DESIGN	Web Design; Web Development; Web Development Project
5	Dhaka Mohila Polytechnic Institute, Dhaka	4-YEAR DIPLOMA-IN-ENGINEERING	Database Application;	Surveillance Security System;	PCB Design & Circuit Making	IT Support II;	Principals of Software Engineering;	Web Design; Web Development;

Sl.	Names of Polytechnic Institute	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas					
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
		PROGRAM in Computer Technology	Programming Essentials; Object Oriented Programming; Programming in Java; Database Management System	Cyber Security & Ethics		DATA COMMUNICATION SYSTEM; Network Administration & Services	SYSTEM ANALYSIS & DESIGN	Web Development Project
6	Shariatpur Polytechnic Institute, Shariatpur	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Database Application; Programming Essentials; Object Oriented Programming; Programming in Java; Database Management System	Surveillance Security System; Cyber Security & Ethics	PCB Design & Circuit Making	IT Support II; DATA COMMUNICATION SYSTEM; Network Administration & Services	Principals of Software Engineering; SYSTEM ANALYSIS & DESIGN	Web Design; Web Development; Web Development Project
7	Khulna Polytechnic Institute, Khulna	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Database Application; Programming Essentials; Object Oriented Programming; Programming in Java;	Surveillance Security System; Cyber Security & Ethics	PCB Design & Circuit Making	IT Support II; DATA COMMUNICATION SYSTEM; Network Administration & Services	Principals of Software Engineering; SYSTEM ANALYSIS & DESIGN	Web Design; Web Development; Web Development Project

Sl.	Names of Polytechnic Institute	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas					
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			Database Management System					
8	Sylhet Polytechnic Institute	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Database Application; Programming Essentials; Object Oriented Programming; Programming in Java; Database Management System	Surveillance Security System; Cyber Security & Ethics	PCB Design & Circuit Making	IT Support II; DATA COMMUNICATION SYSTEM; Network Administration & Services	Principals of Software Engineering; SYSTEM ANALYSIS & DESIGN	Web Design; Web Development; Web Development Project
9	Naogaon Polytechnic Institute, Naogaon	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Technology	Programming Language-I; Programming Language-2; Programming Language-3; Database Management System			Data Communication and Computer Network-1; Data Communication and Network -2	Computer System Software; System Analysis Design and Development	Web Design; Web Development
10	Feni computer Institute, Feni	4-YEAR DIPLOMA-IN-ENGINEERING PROGRAM in Computer Science & Technology	Database Application; Programming Essentials; Scripting with Python;	Information Management & Security System		Network Administration & Services; Data Communication System	System Analysis and Design; Software Testing	Web Design; Web Programming

Sl.	Names of Polytechnic Institute	Names of related degree programs (undergraduates, Masters, Diploma, certificate)	Courses related to following areas					
			Programming Languages, Databases	Information or Cyber Security	VLSI, Chip design	Wireless Communication, Internet of Things (IoTs), Computer Networks	Software Engineering, Software Quality Assurance, Software Testing	Internet, Web technologies
			Advanced Database Management System; Programming in Advanced Java; Programming in Java; Database Management System; Object Oriented Programming					



Appendix I: Skill Profiling of IT/ITES Professionals: Current Skills

Through questionnaire-based survey, skill requirements in performing current jobs of IT/ITES professionals have been gathered.

Skill categories: (i) Technical, (ii) Management and (iii) Soft

Respondents: 145

Table I1: Technical or hard skills

SL	Technical Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
1	Programming	24	16.55
2	Java, JavaScript	18	12.41
3	Database Design, Administration, Management and Analysis	16	11.03
4	Angular, SQL	13	8.97
5	Software Development and Design	12	8.28
6	C#, Git	11	7.59
7	Other	10	6.90
8	Cloud Computing, Python	9	6.21
9	Artificial Intelligence and Machine Learning/Deep Learning, HTML, Programming languages, React	8	5.52
10	Agile, Android, AWS, CSS, Data Analysis, Data Structure and Algorithm, ERP Software, Scrum Master	7	4.83
11	.NET, MySQL	6	4.14
12	Automation Testing, Business Related Software Knowledge, DevOps, Google Products, Kotlin, Networking, Swift, Web Designing and Development	5	3.45
13	.Net Core, ASP.Net MVC, Bugs and Glitches Identification, C, C++, Cyber Security, Docker, Microsoft Excel, iOS Development, JQuery, Manual Testing, Microsoft Word, MS SQL, Node.js, Objective C, Object-Oriented Programming, OS, PHP, SDLC, Software Testing and Debugging, System analysis & design	4	2.76
14	API, Azure, Blockchain, Bootstrap, Django, Github, GitLab, Linux, Microservice, Node, Oracle, PL/SQL, React.js, Redis, Research & Development, Source Controlling, TypeScript, Unity, Version Controlling, Vue.js	3	2.07
15	Apache Kafka, App development, ASP.Net, ASP.Net Core, Automation, CI/CD, Design Patterns, Digital Marketing, Distributed systems, DSA, Embedded engineering, Entity Framework, Full Stack Developer, IoT, IT skills, Jira, Kanban, MacOS, Message Queue, MongoDB, Open Source	2	1.38

SL	Technical Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
	Libraries, PostgreSQL, RabbitMQ, Selenium Automation, SQL query, SQL Server, STLC, SVN, Technical Knowledge, Technology Knowledge, VS code, Xcode		
16	Adobe Photoshop, Ajax, Apache Netbeans, Architect Solution, ASP.Net Web API, Asterisk, ASTPP, Asynchronous Programming, Big Data, Circuit design, Codebase and Debugging, Complex query, Computer Vision, cpanel, CQRS, CSE Basics, DART, Data Security, DBeaver, Debugging, Domain Driver Design, Electron.js, Figma, Firebase Analytics, Firebase Cloud Messaging, Firebase Crashlytics, Firmware design, Flutter, Freeswitch, Frontend Development, Gradle, Grails, Graphic Design, GraphQL, Groovy, Hapi.js, Hibernate, IAX2, IIS, Adobe Illustrator, JasperReports, JDBC, Jenkins, JPA, JWT, Kubernetes, Maven, Memory Management, Microsoft Powerpoint, MS Project, MS Test, Multi-processing, Multi-threading, MVVM Structure, Network Administration, NFT, nopCommerce, NoSql, Object-Oriented Design (OOD), PCB Design, Performance Tuning, Persistent Storage, Postman, Prometheus, Quality Assurance, RDLC and Crystal Reporting, RDMS, Redmine, Restful API's, RESTful web service, Robot-framework, Salesforce, SAP, Scripting, SE, Server Administration, Shader Programming, SignalR, Software requirement analysis, Solidity, Source Code Knowledge, Sourcetree, Spring, Spring Boot, Stack Flexibility, Swing, System specifications, Test Case design, Test Plan, TestNG, Trello, uClinux, UI/UX, UNIX, Visio, VoIP, Web, Windows, Windows Server, Xml	1	0.69

Table I2: Frequency of Management Skills required for current jobs of IT/ITES Professionals

SL	Management Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
1	Time Management	44	30.34
2	Project Management and Development	32	22.07
3	Mentoring	13	8.97
4	Other	12	8.28
5	Decision Making	10	6.90
6	Client management, Delegation	9	6.21
7	Collaboration, Human Resource Management	7	4.83

SL	Management Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
8	Business Knowledge Analysis and Development, Estimation and Scheduling, Strategic Vision and Thinking	6	4.14
9	Negotiation Skills, Planning and Estimation, Stress management	5	3.45
10	Requirements Analysis, Forward planning and Strategic Thinking, People management, Resource management	4	2.76
11	Cross-functional Working, Conflict Management, Idea Generation, Work prioritization, Work-load management, Multi-tasking, Organized, Risk management	3	2.07
12	Managing Multiple Projects Simultaneously, User Feedback Management, Test Management, Recruiting, Monitoring, Organization Management, PMP	2	1.38
13	Networking and Knowledge Gathering, Accounting, Team Management, Budgeting, Business Scaling, Commitment, Confrontation Skills, Quality Control, Customer Relation Management, Finance Management, IT Service Management, Managing Software Development Life Cycle, Marketing, Ownership, Product Management, Reporting, Research, Revenue Management, Reviewing	1	0.69

Table I3: Frequency of Soft Skills required for current jobs of IT/ITES Professionals

SL	Soft Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
1	Communication Skills	75	51.72
2	Critical Thinking and Problem Solving	56	38.62
3	Work with Team	35	24.14
4	Leadership	24	16.55
5	Interpersonal skills	13	8.97
6	Motivation, Presentation Skill	9	6.21
7	English Speaking Skills	8	5.52
8	Adaptability, Documentation, Patience	7	4.83
9	Creativity, Emotional intelligence	6	4.14
10	Attention to detail, Public Speaking, Self-awareness	5	3.45
11	Autonomy, Written Communication, Other, Fast Learner, Integrity, Networking and Knowledge Gathering, Writing Skills	4	2.76
12	Dedication, Logical thinking, Responsibility	3	2.07

SL	Soft Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
13	Internet Browsing, Commitment, Decision Making, Disciplined, English Writing Skills, Helpful, Multi-tasking, Open-Mindedness, Proactive, Punctual, Work ethics	2	1.38
14	Accountability, Accuracy, Listening Skills, Attentive, Confidence, Conflict Management, Curiosity, Dynamic, Typing Skill, Hard worker, IQ, Learning Mentality, Meticulous, Professional Etiquette, Reading	1	0.69



Appendix J: Profiling of Training Institutions

Table J1: Profiling of Training Institutions

Sl.	Names and locations of the training institutions	Training experience and capacity related information							
		How many people trained so far?	Placement statistics	Skills delivered	Recipients	Funding sources of past training programs	Current skill development capacity		
							List of skills	Number of trainers	Classroom and lab capacity
1	BASIS Institute of Technology & Management (BITM)	50,000 +	Job placement ratio is 60% +	1. Web Application development 2. Web Design Track 3. Internet Marketing 4. IT Administration 5. Mobile Application Development 6. Project Management 7. Game Development 8. Software Architecture	Running students of different level, Fresh graduate, Job holder and others people.	National Human Resource Development Fund	1. Web Development 2. Mobile App Development 3. Network & Security 4. Software testing 5. Data Science 6. Database Design 7. Graphic design (UX Design) 8. Digital Marketing 9. Soft skills (Like Business communication) 10. Project Management 11. Internet of Things (IoT) 12. Robotics 13. Programming language 14. BlockChain Technology 15. AR, VR 16. Software Development 17. Machine Learning (etc.)	Around 20	Executive Training Room 400 sq. ft, with a small group meeting table - Capacity 30 Laptops - Wi-Fi Hotspot - 1 Multimedia Projector; - 4, group meeting table - Large glass board Lab: (12 Lab) Each lab is: - 600 sq. ft, with properly illuminated lighting to conduct long duration training session - Capacity of 30+ Trainee - 30 Computers

Sl.	Names and locations of the training institutions	Training experience and capacity related information							
		How many people trained so far?	Placement statistics	Skills delivered	Recipients	Funding sources of past training programs	Current skill development capacity		
							List of skills	Number of trainers	Classroom and lab capacity
									- High speed internet connectivity - 1 Multimedia projector
2	BDJobs training institute	NA	NA	IT (Microsoft Power BI, Mobile data collection using KoBoToolbox, reporting automation with MS Excel, MS Excel dashboard and reporting technique, Advanced excel table, charts, pivottable, pivot chart and dashboard reporting); Project Management; Telemarketing and Telesales; Marketing and Sales; Soft Skills (English communication in digital platform, managing in turbulent times, effect communication	For a sustainable future, leadership skills,.	NA	NA	NA	NA



Sl.	Names and locations of the training institutions	Training experience and capacity related information							
		How many people trained so far?	Placement statistics	Skills delivered	Recipients	Funding sources of past training programs	Current skill development capacity		
							List of skills	Number of trainers	Classroom and lab capacity
				skills, corporate management					
3	IBCS PRIMAX Software (Bangladesh) Ltd.	NA	6675	Oracle, Cyber Security, Red Hat Enterprise Linux, IT Audit, Governance & Risk Management, Web Development (PHP & Laravel), Networking (CCNA, CCNP)	NA	NA	NA	275	NA
4	Creative IT Limited	50000 +	16000+	Graphic design (digital image editing, UI/UX design, motion graphics); Networking (CompTIAA+, CCNA, CCNP, MikroTik); Web & Software (responsive web design, web development, apps development, NERN Stack Development, Python), Film & Media (YouTube video making, digital film making); Digital marketing (digital	NA	NA	NA	100+	NA



Sl.	Names and locations of the training institutions	Training experience and capacity related information							
		How many people trained so far?	Placement statistics	Skills delivered	Recipients	Funding sources of past training programs	Current skill development capacity		
							List of skills	Number of trainers	Classroom and lab capacity
				marketing, affiliate marketing, social media marketing); Robotics & Automation (Robotics); 3D Animation & Visualization; Cyber Security; English language (Communicative, spoken, writing, phonetics)					
5	Leads Technology Limited	NA	NA	CCNA, Analyzing and visualizing data with Power BI, Python (for data science and machine learning, AI and Deep Learning), Oracle DBA; Web development; Object oriented programming; Blockchain application development; Microsoft Excel; Java; Software Testing & Quality Assurance using Selenium; Android	NA	NA	NA	NA	NA

Sl.	Names and locations of the training institutions	Training experience and capacity related information							
		How many people trained so far?	Placement statistics	Skills delivered	Recipients	Funding sources of past training programs	Current skill development capacity		
							List of skills	Number of trainers	Classroom and lab capacity
				App Development, Information Systems Security; Secure Software Lifecycle; Motion Graphics; Basic electrical design for buildings with Autocad; Ethical hacking and cyber security; Web applications with Laravel 8 & PHP8; creating report using crystal report & PL/SQL ; UI/UX design; Youtubing; Project management.					
6	MARS Solution	6000 +	About 600 as per requirement of the stakeholders under Skills and Employment initiative (SEIP) Program and BHTPA	3D animation & film making; SAP use; Professional customer service; Knowledge, Performance skills and Attitude (Increase Knowledge, enhance performance Skills and change Attitude on related	Students, and Employees of different Public & private sectors.	Enlisted Stakeholders and Company generated funds.	Graphic design & freelancing; web design & development; digital marketing; affiliate marketing; Microsoft office management; Android apps development; ASP.NET; Python programming, CCNA, ISP setup	45 (Inhouse and enlisted (Extremal) Trainers	1. Number of classrooms/labs- 2 2. Number of students in a room/lab- 25

Sl.	Names and locations of the training institutions	Training experience and capacity related information							
		How many people trained so far?	Placement statistics	Skills delivered	Recipients	Funding sources of past training programs	Current skill development capacity		
							List of skills	Number of trainers	Classroom and lab capacity
				contents/topics of the training course).					

Note: NA refers to non-availability of data, as they not been provided by the responding institutions.



Appendix K: Framework for Skill Mapping

K.1 Framework for Mapping Digital Skills and Occupations

For mapping skills to occupations, International Labor Organization (ILO) (ILO Classification, 2012) has come up with International Standard Classification of Occupations (ISCO) having four levels.

Skill Level 1: It refers to performing simple manual tasks. Within the context of digital skills, it has very little significance, or it may involve making phone call or turning fan or light on.

Skill Level 2: It involves operating machinery. Pertaining to digital skills, it may refer to operating smartphone, handling ATMs, sending money with mobile applications, and office applications in performing certain tasks.

Skill Level 3: Occupations requiring skill level 3 involves operating performing complex tasks that requires a factual, and procedural knowledge. With respect to digital skills, it may refer to performing business process outsourcing jobs or functional jobs in different sectors like financial services with the help of digital technologies.

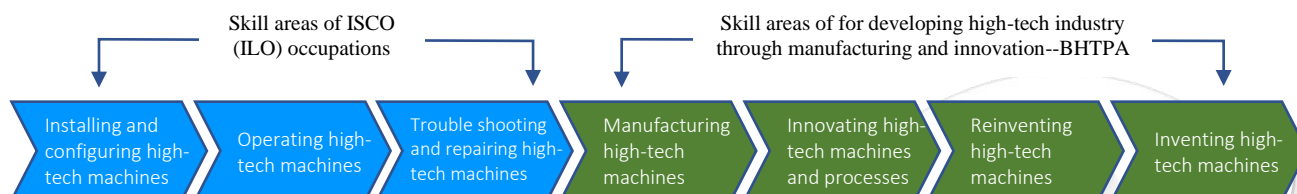
Skill Level 4: It involves performing tasks that require complex problem solving, decision making and creativity. For example, it may refer to installation, configuration, and troubleshooting operations of digital systems like data center or cloud platform.

It seems that all these four levels of skills, as outlined by ISCO, refers to the usages of digital technologies in performing jobs at different level of complexities. At the best, it refers to jobs of system analyst or development of simple customized digital applications. They do not have much focus on system design, technology assessment, innovations, and development, management, and trading of intellectual assessments. Hence, such skill classification has very little or no relevance to HTPA's skill development mission for supporting (i) development of a pipeline of ITS and ITES SMEs capable of leveraging private equity and venture capital, (ii) agglomeration of ITS and ITES SMEs in Dhaka's Vision 2021 Tower Software Technology Park, and (iii) promotion of digital entrepreneurship more broadly among young professionals and women. Target groups of this skill development are (i) young professionals, (ii) employees, entrepreneurs, and (iii) firms who are in the IT/ITES and Hi-Tech industry supply chain.

As shown in the following value chain of digital solutions, occupations, and skills as outlines in the ISCO are mostly for the purpose of installing, operating, and repairing digital technology systems and devices. But such tec-lite skills have very little relevance to BHTPA's objectives of scaling up HTP/STP tenants, creating scalable pipeline SMES, and fostering digital entrepreneurship and startups. For addressing BHTPA's objective, we need to increase skill supply in the area of manufacturing, innovation, reinvention, and invention. Hence, skills that BHTPA should work on hardly fall within ISCO taxonomies, as shown in the following Appendix Figure 1.

High-tech skill value chain:

Figure K1: Value chain of digital devices and Systems and skill requirements



Source: developed by the study team

K.2 Frameworks for Digital Skills

According to EU DigComp 2.1 and Digital Literacy Global Framework (DLGF) (DigitalSkill, 2020)), there are eight level of digital competences.

Foundation: It involves Level 1 and Level 2, pertaining to identifying and using g software, hardware and digital devices for organizing digital contents, and browsing managing digital contents.

Intermediate: Level 3 and Level 4 refers to engaging with digital tools for communicating, and collaborating. It also involves developing and integrating digital content as well as understanding copyrights, licenses, and programming.

Advanced: Having the digital competence sat Level 5 and Level 6, someone is capable to protecting devices, personal data, privacy, and health as well as the environment. They are able to solve problems in digital environments, and innovate using digital tools and keep abreast of the digital evolution. It also refers to resolving digital issues, creatively using digital technologies, bridging personal gaps in digital skills as well as computational thinking.

Highly specialized: Level 7 and Level 8 refer to competences involving operating specialized digital technologies as well as working with digital content for specific career-related fields.

Table K1: Mapping of level of proficiency to educational levels

Sl.	Level of Proficiency	Education Levels
1	Foundation	Primary and lower secondary
2	Intermediate	Upper secondary, post-secondary technical programs like certificate, diploma and associate degrees; vocation education and training
3	Advanced	Non-university tertiary programs like Polytechnique and community colleges; undergraduate programs like Bachelor in STEM
4	Highly Specialized	Post graduate programs like Masters and Doctoral programs in STEM.

Source: Adapted from DigitalSkill, 2020.

It appears that Foundation and Intermediate level refers to usages of digital tools. Advanced and highly specialized levels refer to some aspect of digital innovation, entrepreneurships, SMES and startups pertaining to HTPA's mission. Further clarity could be obtained from the mapping shown in Appendix Figure 2. HTPA's mission pertain to the skill development for specialized and professional occupations. The focus should be on conceptual and intuition, instead of experimental and applied for usages of digital tools and devices. Hence, many of the conventional digital skill development program lasting over limited number of hours such as Intel® AI Academy for 4-5 hours or Cisco Networking Academy for 4-5 months does not appear to be appropriate. Instead, the focus should be in establishing linkages between industry and academia having focus on:

- Engineering courses, specifically electrical and computer engineering courses (4-year courses) - these would constitute the core of the advanced digital skills programs
- Mathematics, science and related undergraduate courses (3-year courses) in universities and technology courses in tertiary institutions

With respect to EU e-Competence framework, skill development may need to target providing at the postgraduate level (Masters and doctorate level) focusing on advanced computer science/engineering, applied mathematics and related fields, and cater to occupations such as data scientists and AI engineers.

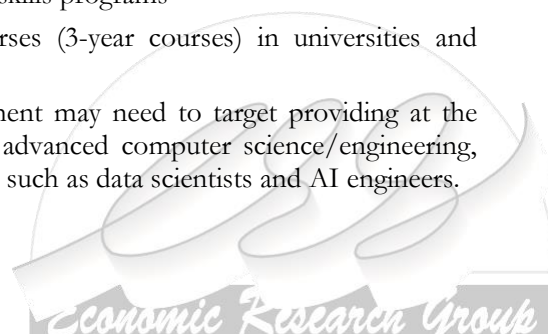
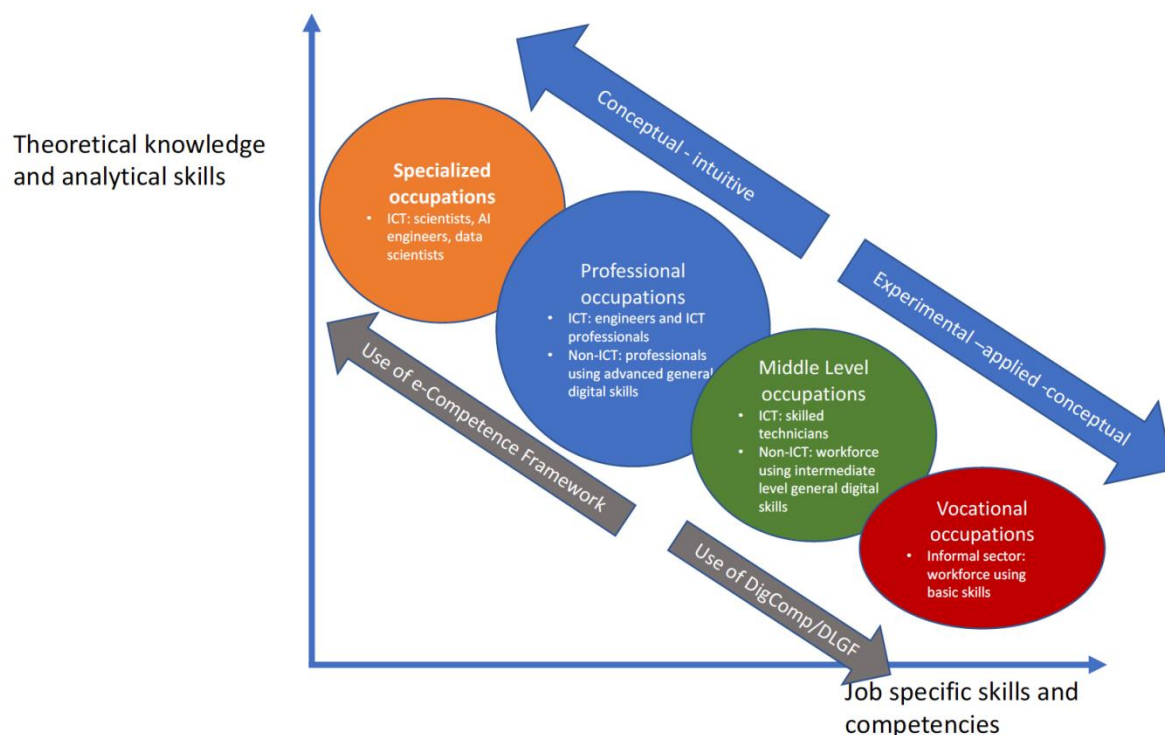


Figure K2: Types of Digital Skills and Occupations



Note: Adapted from Mikhail 2007.

Hence, in designing skill development programs for addressing HTPA’s objective, we need to draw a clear demarcation between (i) Digital Skill Framework for General Workforce, and (ii) Digital Skills for High-tech Occupations.

There is no denying that the availability of high-quality postgraduate programs in Bangladesh is quite limited to address skill gaps for attaining HTPA’s objectives. But review of faculty profiles of selected universities indicate that those universities have a good number of faculty members and also relevant undergraduate courses. Hence, the focus for skill development program should be to leverage them. by linking with industry’s immediate and long-term agenda.

As it has been explained, skill demands in the IT/ITES industry has been rapidly changing. Besides, World Economic Forum finds that “50% of all employees will need reskilling by 2025, as adoption of technology increase” (SkillsWEF, 2020). Does it mean that we need to frequently send IT/ITES professionals to training for upskilling? Fortunately, the answer is NO. More than 90% professionals have been finding on-job and self-learning are the most effective means of upskilling. Hence, we should focus on conceptual capacity out of sound theories so that graduates can easily keep upskilling by themselves.



Appendix L: Job postings by organizations in Bdjobs

Total number of firms: 295

Total number of job postings: 457

Table L1: Number of Job Postings in Bdjobs by Organization

Organization	No. of Job Postings	Organization	No. of Job Postings
eGeneration Limited	24	Farazy Hospital Ltd.	1
INTELLI Global Services	11	Gakk Media Limited	1
BJIT Ltd.	9	General Pharmaceuticals Ltd.	1
Banglalink	6	GLEEonline	1
JP Infotech Sdn. Bhd.	5	Golden Harvest Group	1
Kona Software Lab Limited	5	Gononet Online Solutions Ltd.	1
LEADS Corporation Limited	5	Grameen Communications	1
BRAC IT Services Limited	4	Green Life Hospital Ltd.	1
Encode Ltd.	4	Grype Solutions	1
Isharify Ltd	4	G-Technologies	1
Sheba Technologies Limited	4	GUARDIAN NETWORK Bangladesh	1
BDTASK	3	Helping Ants Ltd.	1
bKash Ltd.	3	hSenid Mobile Solutions (Bangladesh) Pvt Ltd	1
BRACNet Limited	3	Hyper Helios	1
DigiConnect Pvt Ltd	3	I-Global Services	1
Doodle Inc.	3	Idea Informatics	1
E. B. Solutions Ltd.	3	Impel IT Solutions Ltd.	1
Four H Group.	3	ImpleVista BD	1
Intellier Ltd.	3	Incepta Pharmaceuticals Ltd.	1
MassiveStar Studio Ltd.	3	InterCloud Limited	1
MediaSoft Data Systems Ltd.	3	iPro Technologies Limited	1
PORTWEST, Ireland	3	ISHO Limited	1
Premium Connectivity Ltd.	3	Islam Garments Ltd. (Unit-2)	1
Renessa Info Systems Limited	3	IT Grow Division Ltd	1
Aan-Nahl	2	ITCity	1
ADN Diginet Ltd	2	IYLMA INNOVATION LTD	1
Ambala Foundation	2	Japan Marketing & Consultancy Ltd	1
BDCOM Online Limited	2	JCX Developments Ltd.	1
Binge.ae	2	Jijoty (BD) Limited	1
Central@linknet	2	Kite Games Studio Ltd.	1
CloudCoder	2	Kolpolok Limited	1
Comilla Online	2	Kovair Software Bangladesh Ltd.	1
Datapath	2	Lavender Online	1
Easy Payment System	2	Leadswin Limited	1
Enosis Solutions	2	LinkStaff Co. Ltd.	1

Organization	No. of Job Postings	Organization	No. of Job Postings
Fiber @ Home Ltd.	2	Lithe-tech Ltd	1
Genex Infosys Limited	2	Liz Fashion Industry Ltd.	1
IBCS-PRIMAX Software (Bangladesh) Ltd.	2	Madras Security Printers Pvt. Ltd (BRTA driving license project)	1
JoomShaper.com	2	Magpiely	1
Live Technologies Ltd.	2	MAJUMDER GROUP OF INDUSTRIES	1
Nanosoft	2	Mamun Group.	1
Naztech Inc. Ltd	2	Mavishaa	1
NNS Solution Ltd.	2	MEDIA365 LIMITED	1
One Sky Communications Limited	2	Mercury IT International Limited	1
Orbit IT Limited	2	Micple Company Limited	1
Oxford International School	2	Motion View	1
PC Care & Engineering Limited	2	mPower Social Enterprises Ltd.	1
Ranks ITT Ltd	2	Mysoftheaven (BD) Ltd.	1
RensSoft Solutions Limited	2	National Electric BD Ltd., A Concern of National Group (Russia)	1
Runway Express Inc	2	New Moinamoti Residential Hotel	1
ServicEngine Ltd.	2	Neways International Company Limited	1
Signature Aviation Ltd.	2	Nexdecade Technology (Pvt.) Ltd	1
SIMEC System Limited	2	Next IT LTD	1
SOFT-BD	2	Next Online Ltd.	1
Systech Digital Limited	2	NGen IT	1
Tele Plus IT Solution	2	Nirupon Limited	1
The Computer System	2	Noiz Group Ltd	1
Tirzok Private Limited	2	NOiZE Jeans Ltd.	1
Troubleshoot Initiative of Sshtech	2	NVL Trading Pvt. Ltd.	1
Venturas Ltd.	2	OBSERVE GROUP	1
Wipro IT Services Bangladesh Limited	2	Oichi International	1
ZXY International	2	Omni Solutions Ltd.	1
Aamra Networks Limited	1	ONE DIRECTION IT	1
ADDIE Soft Limited	1	One Stop IT Solution	1
AHC Securities Limited	1	OneLittleWeb Ltd.	1
Ahsanullah University of Science and Technology	1	OnnoRokom Software Ltd.	1
Air Top Travel Agency	1	Orient BD Limited	1
Alim Industries Ltd.	1	Our Online.Net	1
Amin & Jahan Corporation Ltd.	1	Palmal Group of Industries	1
Amin Mohammad Foundation Limited	1	Panna Group	1

Organization	No. of Job Postings	Organization	No. of Job Postings
Amin Tech Ltd	1	Paragon Group	1
Antaranga Dot Com Ltd.	1	Pin Wheel	1
Anwar Enterprise Systems Ltd	1	Pirthe Limited	1
Arclite Systems Ltd.	1	PLANET INTERNET GATEWAY LIMITED	1
ARSUK EURO LTD	1	Pointer IT LTD	1
ASA	1	Posh Furniture and Interior Limited	1
Asia Pacific Communication Limited	1	PRAN-RFL Group	1
Asian Tourism international	1	PRIME HOSPITAL LTD.	1
Azolution Software & Engineers Ltd.	1	Primo Tech Limited	1
Bangladesh Foundry & Engineering Works Ltd.	1	Progeny Technologies Ltd.	1
Bangladesh Specialized Hospital Ltd.	1	ProLeadsBPO	1
Bashundhara Ad-din Nursing Institute	1	Purple Algorithm Ltd. (Marketing Affiliate of GIC)	1
Belmonte Group	1	Q-Soft Precise Assistance	1
Benchmark Group of Companies	1	Renssoft Solutions Ltd.	1
Beny & Shiny	1	Reserveit BD	1
BGIFT Institute of Science & Technology	1	REVE Systems	1
Binate Solutions Ltd.	1	REXO IT	1
Bit Mascot (Pvt.) Ltd.	1	RN Century Ltd	1
Bitchip Digital	1	Rokomari.com	1
Bitopi Group	1	RONGOBUY	1
Blaze Mark Communication	1	RootNext Solutions	1
BRAC Bank Limited	1	SAHARA IT	1
BURO Bangladesh	1	Samsung R&D Institute Bangladesh Ltd.	1
Business Automation Ltd.	1	Sattar Jute & Fibres Ltd	1
bZm Graphics	1	Scholars Zone	1
Career Paths Dhaka	1	Services and Solutions International Ltd. (SSIL)	1
Caritas Bangladesh	1	Shadhin Music Limited	1
Catalyst Solutions (sister organization of Adiva Graphics)	1	Shampan IT Solutions	1
CBM International Ltd. (A Concern of TEAM Group)	1	Shangu Group	1
ChefOnline	1	Shikhbe Shobai Solutions	1
Clementine Data Solutions Ltd.	1	Shorborno Holdings Limited	1
Cloud Height Technologies Limited	1	Shurjomukhi Limited	1
Codexcube.com	1	Silicon Orchard Ltd.	1
CodexPro	1	Sindabad.com	1
Color Style Bangladesh Limited	1	SK Associates	1

Organization	No. of Job Postings	Organization	No. of Job Postings
Combosoft	1	Smart Software Limited	1
Conquest Limited	1	Smart Web Source	1
Convince Computer Limited	1	Soft IT Care	1
Corporate Projukti Limited	1	Softmax Online School	1
Creativeitem	1	Software Company	1
CyberNetikz	1	Software Solutions and Logistics Enterprise (SSLE)	1
Data Grid Limited	1	Sokrio Technologies Limited	1
DataSoft Systems Bangladesh Limited	1	Square InformatiX Limited	1
Datazo Infotech Limited	1	STANDARD GROUP	1
DBL Ceramics Ltd.	1	Star Gate Networks	1
Deshi Systems Ltd.	1	Starlink Engineering Ltd.	1
Development Organisation of the Rural Poor - DORP	1	State University of Bangladesh (SUB)	1
Dhaka Central International Nursing College & Institute	1	SYSCON SOLUTION LTD.	1
Dhaka Royal Club Limited	1	Talent Pro	1
Diamond World Ltd.	1	Target40 Group	1
Dimik Infotech Ltd.	1	TCL Global	1
Dipon Group	1	Technext Limited	1
DK Technology Ltd.	1	Technosoft Integration	1
Dohatec New Media	1	Technovicinity Limited	1
Dokmi	1	TechnoVista Limited	1
Dream71 Bangladesh Limited (Dhaka)	1	Techzu Private Limited	1
Duronto TV	1	Tekarsh Bangladesh Ltd.	1
DX Distribution Ltd.	1	Telnet Communication Ltd.	1
Dynamic Solution Innovators Limited	1	The University Campus	1
Dynamicflow	1	ThemeTags	1
ebhubon Ltd	1	THT-Space Electrical Company Ltd.	1
EchoLogyx Ltd.	1	Tirzok Private Limited.	1
Education and Development Foundation-Educo	1	Triple A Tech	1
Educube Consultancy	1	TwinBit Limited	1
Ejogajog Limited	1	United Nations High Commissioner for Refugees (UNHCR) Representation in Bangladesh	1
E-learning & Earning Ltd.	1	Variation Communications Ltd.	1
Elham Group	1	Victory Media & Communications Limited	1
Emumba Inc	1	VIYELLATEX group	1
Enkaizen	1	Voices for Interactive Choice and Empowerment	1
Eon Foods Limited	1	W3 Engineers Ltd.	1

Organization	No. of Job Postings		Organization	No. of Job Postings
Eon Group of Industries	1		Walton Digi-Tech Industries Ltd.	1
Epyllion Group	1		weDevs	1
Ether Technologies Limited	1		Windstream Communication Limited	1
Euphoria Infotech Bangladesh Pvt.Ltd.	1		Winner Overseas Limited	1
Exotico Solutions	1		XpeedStudio	1
Express One	1		Zishan Overseas Tour & Travel	1
Fair Pattern Inc.	1		Unnamed MNC	15
Fakhruddin Textile Mills limited	1		Unnamed	13
FAQ Private Limited	1			



Appendix M: Summary of Skills of HTP Tenants

Based on 10 respondents only:

Table M1: Relative Importance of practices in addressing skill demand

Practice	Low	Medium	High
Recruiting high-quality fresh graduates of local institutions	5	1	3
Internships	3	5	1
On-job and self-learning	3	3	3
Industry-academia collaboration through real-life projects	5	1	3
Joint R&D and innovation projects with universities	4	3	2
Outside standalone skill specific training	4	5	0
Engaging mentors	3	4	2
Recruiting returnee expatriates	6	2	1
Recruiting foreigners	7	2	0

Table M2: Current level of the 4IR skills among the existing employees

4IR Skills	Low	Medium	High
Sensors, microcontrollers, embedded computing, connectivity, and IoT	6	0	2
AI, machine learning, and deep learning	3	3	2
Data analytics	3	2	3
Image processing and computer vision	3	3	2
Robotics	5	2	1
Distributed ledger and Blockchain	5	0	3
Robotic process automation (RPA)	4	3	1
Augmented reality and virtual reality	5	1	2

Table M3: Future demand for 4IR Skills

	Low	Medium	High
<i>demand for</i>			
Sensors, microcontrollers, embedded computing, connectivity, and IoT			
2024	0	2	7
2027	0	1	8
2030	0	1	8
AI, machine learning, and deep learning			
2024	0	2	6
2027	0	1	6
2030	0	1	7
Data analytics, Image processing and computer vision			
2024	0	3	5
2027	0	2	6
2030	0	2	6
Robotics			

	Low	Medium	High
2024	1	3	4
2027	1	2	5
2030	0	3	5
Distributed ledger and Blockchain			
2024	0	3	5
2027	0	2	6
2030	0	2	6
Robotic process automation (RPA)			
2024	1	2	5
2027	1	2	5
2030	1	2	5
Augmented reality and virtual reality			
2024	0	3	5
2027	0	2	6
2030	0	2	6

Table M4: Current level of the 4IR skills among the existing employees

4IR Skills	Low	Medium	High
Sensors, microcontrollers, embedded computing, connectivity, and IoT	6	0	2
AI, machine learning, and deep learning	3	3	2
Data analytics	3	2	3
Image processing and computer vision	3	3	2
Robotics	5	2	1
Distributed ledger and Blockchain	5	0	3
Robotic process automation (RPA)	4	3	1
Augmented reality and virtual reality	5	1	2

Table M5: Current Level of soft skill among Technical Professionals

Soft Skills	Low	Medium	High
Empathy and design thinking	0	6	4
Active learning and self-learning	0	6	4
Analytical thinking and innovation	3	3	4
Reasoning, problem solving and ideation	3	2	5
Resilience, stress tolerance and flexibility	1	6	3
Ethics, values and loyalty	0	3	7
Leadership and social influence	1	5	4



Table M6: Importance of soft skill among Technical Professionals

Soft Skills	Low	Medium	High
Empathy and design thinking	0	2	8
Active learning and self-learning	0	2	8
Analytical thinking and innovation	1	2	7
Reasoning, problem solving and ideation	0	1	9
Resilience, stress tolerance and flexibility	0	1	9
Ethics, values and loyalty	0	0	10
Leadership and social influence	0	1	9

Table M7: How have the technical professionals acquired the skills?

Soft Skills	Educational Degrees	On-job learning	Outside training
Empathy and design thinking	3	10	0
Active learning and self-learning	2	10	0
Analytical thinking and innovation	5	10	0
Reasoning, problem solving and ideation	4	10	0
Resilience, stress tolerance and flexibility	2	10	0
Ethics, values and loyalty	4	9	0
Leadership and social influence	2	10	2



Appendix N: Skills Need for Career Advancement of IT/ITES Professionals

Through questionnaire-based survey, skill requirements for career advancements of IT/ITES professionals have been gathered.

Skill categories: (i) Technical, (ii) Management and (iii) Soft

Respondents: 145

Table N1: Frequency of Technical Skills required for career advancement of IT/ITES Professionals

Sl. No.	Technical Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
1	Cloud Computing	22	15.17
2	Other	19	13.10
3	Programming	16	11.03
4	Artificial Intelligence and Machine Learning/Deep Learning, Software Development and Design	13	8.97
5	Blockchain, Database Design Administration Management and Analysis, Data Structure and Algorithm	8	5.52
6	Cyber Security, Data Science	7	4.83
7	Automation, Big Data, Design Patterns, System analysis & design, Technology Knowledge	6	4.14
8	Automation Testing, DevOps, JavaScript, Microservice, React.js	5	3.45
9	Agile, Architect Solution, CI/CD, Git, Scrum Master, SQL	4	2.76
10	Angular, Azure, CSS, Debugging, Docker, ERP Software, Java, Networking, Programming languages, Research & Development	3	2.07
11	.NET, 4IR Skills, Bootstrap, Container-based application, Design Principles, Flutter, HTML, IoT, JQuery, Kubernetes, Manual Testing, Node.js, Oracle, Python, SDLC, TypeScript, Vue.js, Web	2	1.38
12	.Net Core, Adobe, Ansible, Apex, ASP.Net MVC, AWS, Bugs and Glitches Identification, C, C++, CKAD, Computing, CQRS, Critical Thinking and Problem Solving, Cross-Platform, CSM, Data Security, DevSecOps, Digital Marketing, Distributed systems, Domain Driver Design, Embedded engineering, Entity Framework, Firmware design, Full Stack Developer, Github, GraphQL, IntelliJ, iOS	1	0.69



Sl. No.	Technical Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
	Development, JWT, Kanban, Linux, Load Testing, Message Queue, Microsoft Excel, Microsoft Powerpoint, Microsoft Word, MongoDB, MS SQL, MS Test, Neural Network, Object-Oriented Programming, PCB Design, Performance Tuning, Presentation Skill, RDMS, SignalR, Software Testing and Debugging, Tensor flow, Test driven development, Version Controlling, Video Editing, Visual Studio, VoIP, VS code, Web Designing and Development		



Table N2: Frequency of Management Skills required for career advancement of IT/ITES Professionals

Sl. No.	Management Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
1	Project Management and Development, Time Management	22	15.17
2	Business Knowledge Analysis and Development, Team Management	9	6.21
3	Organized, Work-load management	8	5.52
4	Delegation, Other	7	4.83
5	Collaboration, Management, Mentoring	6	4.14
6	Client management, Negotiation Skills, People management, Strategic Vision and Thinking	5	3.45
7	Decision Making, Estimation and Scheduling, Forward planning and Strategic Thinking, PMP, Risk management	4	2.76
8	Commercial awareness, Conflict Management, Multi-tasking, Planning and Estimation	3	2.07
9	Resource management, Stress management, Task Management, Work prioritization	2	1.38
10	Accounting, Budgeting, Competence, Confrontation Skills, Critical Thinking and Problem Solving, CSPO, Development and Developer management, Evaluation, Human Resource Management, Idea Generation, Marketing, Product Development and Management, Professionalism, Quality Control, System Administration, User Feedback Management	1	0.69

Table N3: Frequency of Soft Skills required for career advancement of IT/ITES Professionals

Sl No.	Soft Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
1	Communication Skills	42	28.97
2	Critical Thinking and Problem Solving	34	23.45
3	Leadership	27	18.62
4	Work with Team	16	11.03
5	Adaptability	11	7.59
6	Interpersonal skills	9	6.21
7	Dedication, Self-awareness	7	4.83
8	Emotional intelligence, English Speaking Skills, Fast Learner, Other, Patience, Presentation Skill	5	3.45
9	Continuous Learning	4	2.76

Sl No.	Soft Skills	Frequency of Jobs for Each Skill	% Of Respondents Mentioning Each Skill
10	Accountability, Disciplined, Documentation, Logical thinking, Motivation, Open-Mindedness	3	2.07
11	Attention to detail, Confidence, Creativity, Decision Making, Listening Skills, Networking and Knowledge Gathering, Public Speaking, Stress management, Writing Skills	2	1.38
12	Accuracy, Angular, Curiosity, Hard worker, Helpful, Innovation, Integrity, Intuition, Meticulous, Punctual, Responsibility, Technology Knowledge, Work ethics, Written Communication	1	0.69

