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Cambodia Development Resource Institute

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DEMAND FOR AND SUPPLY OF DIGITAL SKILLS IN CAMBODIA

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABBREVIATIONS

ACC	Accreditation Committee of Cambodia
ADB	Asian Development Bank
AGV	Automated Guided Vehicles
AI	Artificial Intelligence
ASEAN	Association of Southeast Asian Nations
ATET	Average Treatment Effect on the Treated
CADT	Cambodia Academy of Digital Technology
CDRI	Cambodia Development Resource Institute
CIA	Conditional Independence Assumption
CIP	Classification of Instructional Program
CSES	Cambodia Socio-Economic Survey
DiD	Difference in Difference
EDF	Entrepreneurship Development Fund
4IR	Fourth Industrial Revolution, or Industry 4.0
GDP	Gross Domestic Product
HEI	Higher Education Institution
ICT	Information and Communication Technology
ILO	International Labour Organization
IPWRA	Inverse Probability Weighted Regression Adjustment
4IR	Fourth Industrial Revolution
ISIC	International Standard Industrial Classification
ISCO	International Standard Classification of Occupations
KII	Key Informant Interview
LMS	Learning Management System
MEF	Ministry of Economy and Finance

MOC	Ministry of Commerce
MoEYS	Ministry of Education, Youth and Sports
MoLVT	Ministry of Labour and Vocational Training
MoP	Ministry of Planning
MPTC	Ministry of Posts and Telecommunication
NGO	Non-Governmental Organisation
NIPTICT	National Institute of Posts, Telecommunications and ICT
NIS	National Institute of Statistics
NSTC	National Science and Technology Council
OLS	Ordinary Least Square
O*NET	Occupational Information Network
PEP	Partnership for Economic Policy
PPS	Probability Proportional to Size
PSM	Propensity Score Matching
PSU	Primary Sampling Unit
RCT	Randomized Control Trial
RDD	Regression Discontinuity Design
RGC	Royal Government of Cambodia
R&D	Research and Development
SDF	Skill Development Fund
MSMEs	Micro, Small and Medium-sized Enterprises
S&T	Science and Technology
STEM	Science, Technology, Engineering and Mathematics
TRI	Technological Readiness Index
TVET	Technical and Vocational Education and Training
UNESCO	United Nations Educational, Scientific and Cultural Organization
WDI	World Development Indicator
WEF	World Economic Forum
WTO	World Trade Organization

EXECUTIVE SUMMARY

Under the Capacity Building Research and Development Fund of the Ministry of Posts and Telecommunications and with support from the United Nations Development Programme Cambodia and the Russian Federation, the Cambodia Development Resource Institute in collaboration with the Cambodia Academy of Digital Technology (formerly known as the National Institute of Posts, Telecoms and Information and Communication Technology) has conducted a research study to assess current and future demand for and supply of digital and ICT skills. The study further investigates the challenges firms of all sizes, universities, and TVET institutions face in preparing themselves and their students for digital technology adoption under the framework of the Fourth Industrial Revolution (4IR).

The study employs a multi-stakeholder approach using the conceptual framework by Chhem et al. (2018), postulating that institutions, technology and innovation, and human resource development are the three components necessary for preparation and adoption of the Fourth Industrial Revolution. Given time and financial limitations, this exercise examines institutional frameworks and human capital development, leaving technology and innovation for further studies. The definition of digital skills by ECORYS (2016) is also adopted, which proposes three components: basic skills, workforce skills, and professional skills. A mixed methods approach of quantitative and qualitative analyses is used, drawing on information from the latter approach to complement and contextualise estimated results from the former. For the quantitative analysis, micro-econometric modelling is employed to answer the research questions.

The quantitative analysis relies on two survey datasets: firms and students/graduates. For the firm survey, a stratified random sample was used to select the desired sample size. The stratification was undertaken at four levels: sector, enterprise size, geographical location, and firm registration. Since finding informal firms is difficult and time-consuming, the survey focuses only on formal firms that are registered either with the Ministry of Posts and Telecommunications or the Ministry of Commerce, or both. Three hundred firms were sampled as part of the study, however, only the owners/managers of 202 firms were interviewed. For the student/graduate survey, a two-stage stratified random sample was employed, with higher education and technical vocational education and training (TVET) institutions as primary sampling units (PSUs). PSUs were randomly selected based on probability proportional to size, with size being the number of enrolled ICT students. A total of 1,022 student and graduate respondents were interviewed.

The following findings were observed:

- Businesses in information and communication technology, and thus their employment opportunities, are thriving, particularly over the last decade. The top five services or products ICT firms have offered include retail sales and maintenance of ICT devices; software, application and ICT systems (i.e., human resources, payroll, tax, accounting, and finance); graphic and multimedia design; network, telecommunications, and internet; and digital marketing.

- While not yet currently in high demand, new businesses in cloud services, data management systems, and financial technology (fintech) are emerging given the fast-changing technological advancement.

- Almost all sample firms are optimistic that their demand for ICT-related skills and occupations will increase in the next two years at an average rate of 30 percent per annum. Interviewed owners/managers of the ICT firms are more positive in their future hiring of ICT positions at an average rate of 40 percent between 2021 and 2022, compared to 20 percent for non-ICT firms. Occupations that the interviewed employers expected to hire for in the future include ICT sales professionals, software and application developers, e-marketing professionals, and web developers and programmers. Although it is not directly evident from the results of the firm survey that there are future demands for data science specialisation, demand for the skill was raised to some extent by the key informants.

- ICT graduates have higher employment opportunities with relatively higher wage premiums to those of non-ICT graduates with similar levels of education, experience, and other socio-economic characteristics, at least in the short term. The average wage premium of graduates with ICT majors is estimated at around 10 percent, with a 95 percent confidence interval.

- Although the wage premium is higher, the absolute level remains low, averaging USD450 per month. The wage level, however, varies according to education level, work experience, and position. For instance, managers in an ICT firm could earn, on average, USD1,000 per month.

- Despite the constant growth, tertiary enrolment in STEM majors, including ICT majors, is relatively low in Cambodia. Among the examined individual and family factors, gender, age, and self-efficacy in mathematics are found to be good predictors of enrolment in ICT-related majors. Enrolment in STEM majors continues to be male dominated, while female students mainly enrol in the non-STEM majors of business, accounting, and other social science majors.

- Nearly one-fourth of ICT curricula at higher education institutions (HEIs) is devoted to general subjects. Very few universities provide dedicated courses related to soft skills such as critical thinking or problem-solving skills. In addition, subjects related to new technologies such as machine learning, artificial intelligence, fintech, and data science are limited and almost non-existent for elective courses. This happens amid increased global demands for such skills which might further intensify skills shortages in Cambodia if interventions by the government and relevant stakeholders to equip more young Cambodians with knowledge and skills in advanced technologies are not put in place in a timely manner.

- Higher education institutions face several challenges in keeping up with the current trends of technological changes. These include limited support from the government, limited financial and human resources, and uneven ability and preparedness of students who enrol in the STEM programmes in terms of mathematics and digital literacy.

- Related to job searching, students' anxieties about their future career prospects include labour market competition, lack of work experience, and limited English proficiency. To connect students to the world of work, many schools have made internships compulsory and established offices to support students' career prospects.

The following recommendations are made based on these findings:

Government

- Continue to support and strengthen industry-university and university-university linkages. This could help to address two bottlenecks: (1) narrow the existing vertical and horizontal skills mismatch, and (2) ensure that school curricular are updated and relevant. A promising mechanism is establishing a sector skills council for ICT, which would help define occupations in this sector and determine required skills and qualifications to inform curriculum development and programme delivery at TVET institutions and universities. With their strong network and knowledge of the ICT industry, the council will also help place students for internship opportunities and tap industrial resources for education and training.

- Capitalise and equip universities/TVET institutions, particularly ones in the provinces. Lack of human and financial resources are often cited causes of low digital technology adoption by universities and TVET institutions in the provinces. This also has adverse effects on the implementation of school STEM and ICT curricula.

- Ensure inclusive STEM education for girls and students in/from rural areas. Gender and geographically sensitive approaches are needed in designing STEM policy and programmes. The government together with development partners has initiated and implemented a range of programmes aiming to narrow the gender gap in terms of enrolment in STEM education. Given the evidence, more needs to be done.

- Better equip students at upper secondary school with basic ICT and digital skills and mathematical competency. This would enable them to better adapt and adopt digital literacy and the skills necessary for both their higher education and career.

Educational Institutions (HEIs and TVET Institutions)

- Consult constantly with employers to understand market needs of digital and ICT skills, which could help inform curricular content and subject choice. HEIs and TVET institutions could either use the sector skills council for ICT or organise consultative workshops with employers as possible channels to collect information.

- Modernise curricula to include subjects in new technologies such as data science, fintech, artificial intelligence, and cyber security.

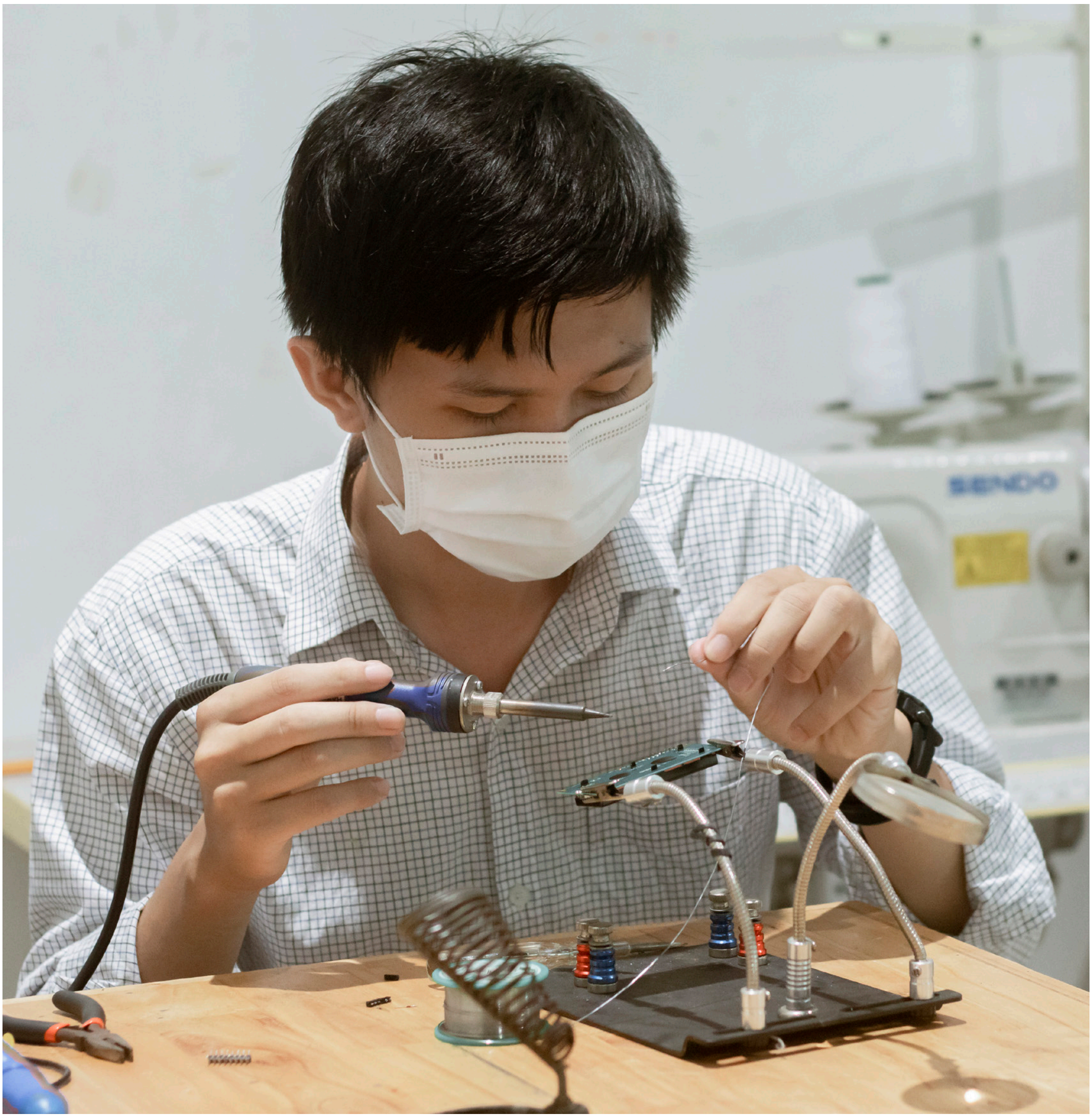
- Collaborate with employers to provide internship or apprenticeship opportunities to students.

- Combine hard and soft skills both at school and at work. Aside from technical skills, curriculum of higher education and TVET institutions should encompass soft skills in communication, critical thinking, and problem-solving. Surveyed employers indicate that soft skills are one of the most important sets of skills in addition to technical skills acquired by employees.

Private Sector

- Participate in the sector skills council for ICT with the government and educational institutions to help promote industry-university linkages to narrow skills mismatch and shortage and to improve curricula of educational institutions so that students and graduates have the right skills when they enter the world of work.

- Continue to provide on-the-job training to help address skills shortages and mismatch given fast-changing technological advancement. This would also help boost firm productivity and sales, and is particularly crucial for workforce upskilling and reskilling in the ICT and digital-related sectors.



01 Introduction

1.1. Background

The Fourth Industrial Revolution (4IR) has transformed economies, societies, and job markets around the globe, and Cambodia is no exception. It has brought opportunities and threats to the existing ecosystem, spurring both excitement and, sometimes, resistance. Cambodia could leverage the Fourth Industrial Revolution to increase its economic competitiveness and productivity, which is the backbone of strong and robust long-term economic growth and development. Nonetheless, the Fourth Industrial Revolution with its technologies like robots, artificial intelligence, and the use of big data, could significantly change the labour market structure in terms of supply of and demand for skills and the way people, young and old, are educated. Robots, for instance, could replace humans, resulting in a high unemployment rate if the unemployed and the employed involved mainly in routine and repetitive tasks do not reskill and upskill. Specific skills could become obsolete quickly, making it difficult to predict with high accuracy future skills needs. Although no one is certain about employment impacts of the Fourth Industrial Revolution and the prospective demands for related skills it brings, it is evident that future job markets will undergo a significant transformation due to technological disruption and change.

Although Cambodia is a developing economy with a relatively small market, there is optimism that it has high potential to seize opportunities presented by the 4IR. Four factors contribute to this: (1) an increasing number of the educated youth population with fast absorption of digital technology, (2) an increasing use of smart phones, ICT-related equipment, and internet usage, (3) potential technological transfers from foreign direct investments, and (4) early adoption of the digital economy in key sectors, most prominently in finance.

The Royal Government of Cambodia has also expressed strong support for the undertaking and has emphasized the importance of the digital economy in boosting economic growth and improving long-term productivity of factor inputs (i.e., labour, capital, and land). The Cambodia Vision 2050, the Rectangular Strategy Phase IV, the National Strategic Development Plan (2019-2023), the Industrial Development Plan (2015-2025), the Cambodia National ICT Masterplan 2020 and Cambodia Trade Integration Strategy (2019-2023), the Digital Government Policy, and the Policy Framework on Digital Economy and Society are some of the policy documents aiming to strengthen the digital economy in Cambodia. The Policy Framework on Digital Economy and Society (2021-2035) has been approved by the government, while the Digital Government Policy is being drafted and is expected to gain approval in 2021. Recently, the Ministry of Economy and Finance has introduced several initiatives aiming to kick-start adaptation and adoption of the Fourth Industrial Revolution. These include the establishment of the SMEs Bank and the issuance of sub-decrees on the Provision of Tax Incentives for SMEs in priority sectors; the Skill Development Fund aiming to minimize skill gaps in key sectors (e.g., manufacturing, construction, and electronics); the Techo Start-up Centre to support creation of starts-up, and (4) the Entrepreneurship Development Fund and Khmer Enterprise.

In addition, under the guidance and leadership of the Ministry of Posts and Telecommunications, key policy frameworks and programmes have been launched and implemented. These include the Capacity Building Research and Development Fund, Universal Service Obligation Fund, and digital innovation centres at the Cambodia Academy of Digital Technology. The Ministry of Industry, Science, Technology and Innovation has also launched Cambodia's Science, Technology & Innovation Roadmap 2030, aiming to contribute to economic transformation and productivity improvement. Overall, the main objectives of these policies and initiatives are to promote adaptation and adoption of digital technology, to create a conducive ecosystem for digital start-ups, and to bridge the digital divide.

The COVID-19 pandemic has also presented both challenges and opportunities for the public and private sector to adopt a more innovative mindset to maintain, if not increase, the competitiveness necessary for survival during this difficult time. Examples include private businesses adopting various e-commerce platforms to advertise and sell goods and services even during the lockdown periods. The e-commerce segment of the digital economy has experienced rapid growth over the last three years and particularly during the pandemic, with improved internet access, increased use of smart phones, social media platforms, and other digital infrastructure, and an increased demand for goods and services. The recently adopted e-commerce law has set the groundwork for further and deeper reforms and strategies.

Financial technology (fintech) is another promising area which has presented opportunities for businesses and the economy. For instance, Cambodia has made notable progress in payment systems that make retail, inter-bank, and cross-border digital transactions possible. In May 2021, the National Bank of Cambodia released the 2020 report on payment transactions, showing that payment transactions made through the Fast Payment System in the first quarter of 2020 increased 374 percent year-on-year, to a total of 21,363 transactions. The report also indicated a decline in cheque transactions of about 5.9 percent during the same period (National Bank of Cambodia, 2021). Further, there has been fast adoption of digital transactions and payments among commercial banks and microfinance institutions (MFIs).

Despite the optimism, Cambodia needs to address several challenges if it wants to optimize the benefits of the Fourth Industrial Revolution. First, Cambodia is at a very early stage of a digital economy. It would thus take several years to put in place the necessary ecosystem for it to thrive. Second, adoption of digital technologies by firms has been found to be low. Cambodia has a limited quantity of secure servers, limited use of digital services (e.g., in finance), and a lack of ICT enabling skills or supportive legal/regulatory frameworks. It is believed that: "There will be more jobs that require the use of ICT. Technology will continue to be a source of entrepreneurship and of better jobs. The automation of tasks will also mean greater use of ICT in production. IT solutions that aggregate products and/or suppliers, facilitate e-commerce, and reach new customers can widen market access, especially for rural firms seeking to reach urban markets, and create jobs in the process." (World Bank, 2018, 2019).

Third, hard and soft infrastructure are necessary. Cambodia needs to increase internet coverage and usage, and to lower the cost. Connectivity of the various types of infrastructure is needed to ensure efficiency and effectiveness of the ecosystem. Fourth, policy and regulatory environments have to be in place. The government is in the process of developing several relevant policies and Master Plans (e.g., Master Plan on Information and Communication Technology and Law on Telecommunications) that could guide the adoption process and help achieve the goal of transforming Cambodia into a digital economy and society. Lastly, digital literacy and capabilities need to be strengthened, for human capital will be crucial to harnessing the benefits of the Fourth Industrial Revolution. The development of this must be inclusive to increase economies of scale.

Against this backdrop, there is more to be done, through both programmes and applied research, to support the realisation of the 2050 Vision and the full adoption of the Fourth Industrial Revolution. Identifying current and future demand for and supply of ICT and digital skills, and understanding challenges in the digital technology adoption of both suppliers and demanders of ICT, digital skills and knowledge are crucial exercises to be continuously carried out. The research undertaken here contributes to this goal.

1.2. Research Purpose and Objectives

This study investigates digital and ICT skills supply and demand, as well as assessing the overall level of digital literacy in Cambodia. From the demand side, it analyses the scope and extent of common positions sought after, position requirements, and salaries offered by ICT and non-ICT firms. From the supply side, it identifies ICT-related subjects and skills universities and technical vocational education and training (TVET) institutions offer to students, and how these educational institutions support students in advancing their professional careers. The results of this research could help inform the government, development partners, private sector, higher education and TVET institutions, about current and future digital and ICT skills needs and the possible skills gaps and shortages which need to be further addressed.

In particular, the study aims to:

On the demand side:

- Understand the current ICT job market in Cambodia, including common positions and skills needs of employers, position requirements, and salaries offered.
- Identify challenges faced by the private sector to recruit qualified ICT staff and staff with basic digital literacy and skills.
- Identify the existing mechanisms that deal with the challenges of recruiting qualified ICT staff and how companies address these.

On the supply side:

- Identify the ICT-related subjects and skills that universities/TVET institutions offer to students, and the skills students acquired during the programme.
- Examine challenges and concerns ICT students are facing in their career advancement.
- Investigate how these universities/TVET institutions support students in advancing their professional careers.
- Identify support and challenges faced by universities to produce qualified ICT students and how universities/TVET institutions tackle these challenges.
- Assess the labour market outcomes of ICT students in comparison to non-ICT students.

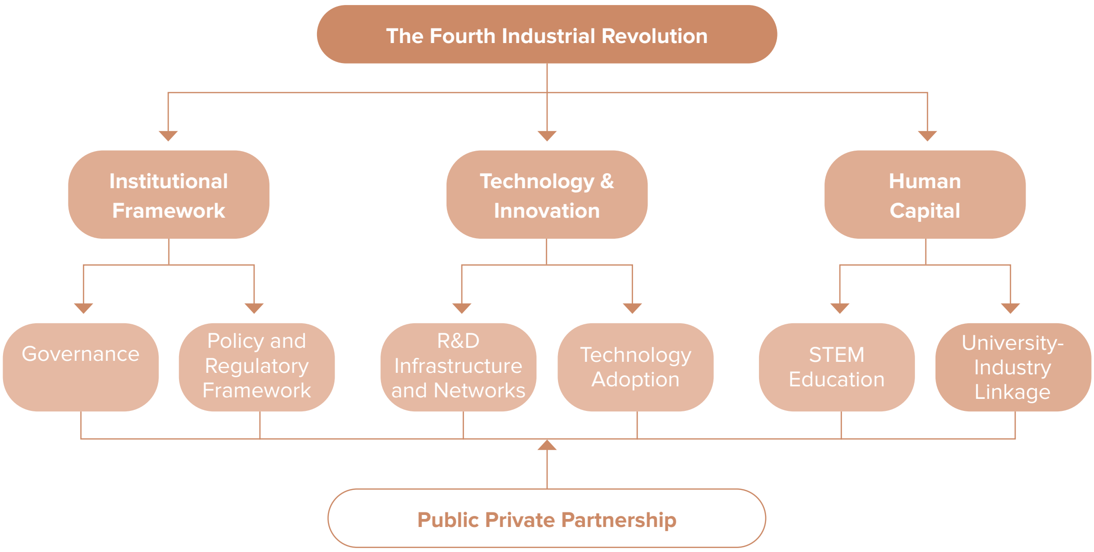
For government and development partners:

- Examine existing and prospective policies and regulations of the government in support of digital literacy.
- Investigate how various government bodies could coordinate more effectively in achieving goals set under the digital economy framework.
- Identify the role of development partners and private sector in enhancing digital literacy, skills, and capabilities.

02 Conceptual framework

Figure 1 highlights a framework necessary to support digital technology adoption under the Fourth Industrial Revolution. Three components and their interaction are crucial: an institutional framework which demands for effective governance and a conducive policy and regulatory environment; technology and innovation, focusing on building infrastructure for research and development and networks combined with swift technological adoption; and human capital, incorporating science, technology, engineering and mathematics (STEM) and linking employer demand to educational institution supply. The realisation of these components strongly calls for effective collaboration between the public and private sector.

Figure 1:The Fourth Industrial Revolution Framework



Source: Chhem et al. (2018)

This framework is used to guide the research design of this assessment. However, the scope of study is limited to the investigation of institutional framework and human capital, leaving R&D infrastructure and innovation for further studies.

With respect to its institutional framework, one of the main challenges for Cambodia in response to the 4IR is the effective coordination among various government ministries and agencies (Chhem et al., 2018). The Department of Technique, Science and Technology of the Ministry of Industry, Science, Technology and Innovation, and the General Secretariat of the National Science and Technology Council (NSTC) of the Ministry of Planning are two government bodies that deal with certain aspects of science and technology development. The Ministry of Economy and Finance has been tasked to formulate policies and regulation in support of the digital economy and governance. An inter-ministerial committee, chaired by the Deputy Prime Minister and Minister of the Ministry of Economy and Finance, has further been established by the government directive. One of the main responsibilities of the committee is to formulate relevant policies and regulation for digital economy and digital governance. The Ministry of Posts and Telecommunications, which is responsible for the telecommunications and ICT (digital) sector, also plays an important role in efforts to increase awareness and adoption of technologies in the Fourth Industrial Revolution.

Under the Fourth Industrial Revolution, new ways of providing education and developing human capital are indispensable. It demands for both technical and soft skills. Learning how to learn is a way to cope with the highly disruptive nature of the 4IR. Chhem et al. (2018) recommend the following policy priorities to enhance Cambodia's human capital:

- Training outstanding STEM teachers to drive the STEM education agenda.
- Prioritising STEM education in general education, vocational training and higher education.
- Integrating STEM education with other disciplines such as economics, commerce, and finance to optimise career pathways.
- Preparing learners and STEM graduates to meet the demands of the 4IR.
- Building university-industry linkages to undertake applied research, technical collaborations, and R&D partnerships.
- Enhancing basic S&T knowledge and skills for all Cambodians.

The World Economic Forum (2016) predicts that the following skills are required for the future of jobs: (1) complex problem solving, (2) critical thinking, (3) creativity, (4) people management, (5) coordinating with others, (6) emotional intelligence, (7) judgment and decision making, (8) service orientation, (9) negotiation, and (10) cognitive flexibility. These cannot, however, be realized without strong and effective collaboration between public and private sectors. There have been initiatives to link both entities, but more needs to be done to optimize the linkage, especially with respect to skills development and on-the-job training.

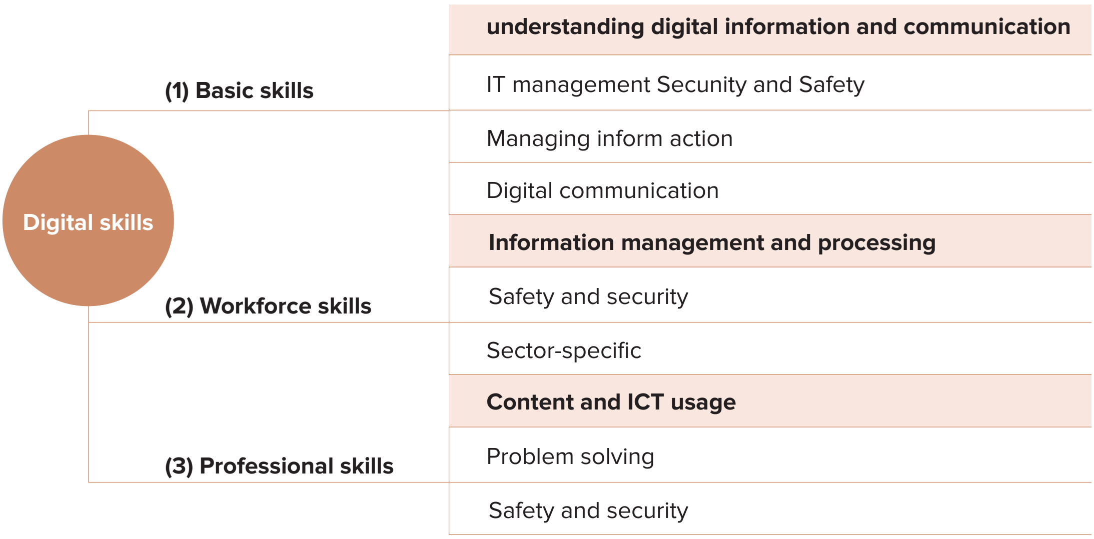
There is no clear distinction between digital skills and digital literacy. Other terms such as ICT literacy, ICT skills, e-skills, e-literacy, 21st century skills, and digital competence are used interchangeably (Chinien and Boutin, 2011). Digital literacy, like literacy and numeracy, is the ability to use ICT to support innovation in industrial, business, and creative processes (Martin and Grudziecki, 2006). It also includes "a continuum of skills ranging from basic, operational skills to higher-order cognitive, social and attitudinal skills and abilities." (Ala-Mutka, 2011)

Digital skills are still a broad term. With an increasing number of studies and technologies that have emerged, the term has been broadened (ECORYS, 2016). Development Economics (2013, 3) considers digital skills "as the attributes that allow individuals and businesses both to use digital equipment and to access, create or share digital information via the internet and thereby benefit from opportunities in the modern economy." Using a systemic approach to synthesise findings of empirical studies on digital skills, ECORYS (2016, 23) categorises digital skills into three main areas. The first category is basic digital literacy skills, which everyone needs to be 'digitally literate'. These skills allow us to, for example, communicate and search for information using digital applications. The second category is digital skills for the general workforce, which incorporate the first category along with "skills needed in a workplace and generally linked to the use of applications developed by IT." The last category is digital skills for ICT professions that includes both the first and second category, and skills needed to work across a diverse IT sector such as digital skills related to the development of new digital technologies, and new products and services (ECORYS UK, 2016).

In addition, UNESCO (2018) defines digital skills as: "a range of abilities to use digital devices, communication applications, and networks to access and manage information. They enable people to create and share digital content, communicate, collaborate and solve problems for effective and creative self-fulfilment in life, learning, work and social activities at large." Law et al. (2018, 6) postulate that "digital literacy is the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment, decent jobs and entrepreneurship. It includes competences that are variously referred to as computer literacy, ICT literacy, information literacy and media literacy."

In this study we employ the digital skills definition and mapping by ECORYS (2016). Figure 2 highlights this framework.

Figure 2: Digital skills mapping



Source: ECORYS UK (2016)

03 Data

The study uses survey data from 202 firms and 1,022 students and graduates, which was collected between August 2020 and January 2021. Stratified random sampling was employed to select the desired sample size for both surveys to: (1) obtain unbiased estimates for different subdivisions of the population with some known level of precision; (2) ensure that the final total sample includes establishments from all different sectors and other desired criteria, and that it is not concentrated in one or two industries, sizes and/or regions; and (3) exploit the benefits of stratified sampling where population estimates, in most cases, are more precise than using a simple random sampling method (i.e., lower standard errors, other things being fixed).

For the firm survey, the four levels of stratification include: industries, firm size, geographical location, and registration. The proposed stratification is to ensure nationally representative data of formal IT and non-IT firms operating in the country. Industrial Standard Classification Code (Rev. 4) is used to categorize firms. All firm sizes (micro, small, medium, and large) are covered using the enterprise definition outlined in the SME Development Framework by the Ministry of Industry, Science, Technology and Innovation (MISTI) in 2017. The total value of assets and number of employees are used for enterprise classification. Since data on assets is, to the authors' knowledge, not reliable and usually contains a significant proportion of missing values, we use number of employees as a classifying indicator. A combination of a sampling frame of companies from the Ministry of Posts and Telecommunications (MPTC) and the Ministry of Commerce (MoC) is utilised. Table 1 provides distribution of the surveyed firms.

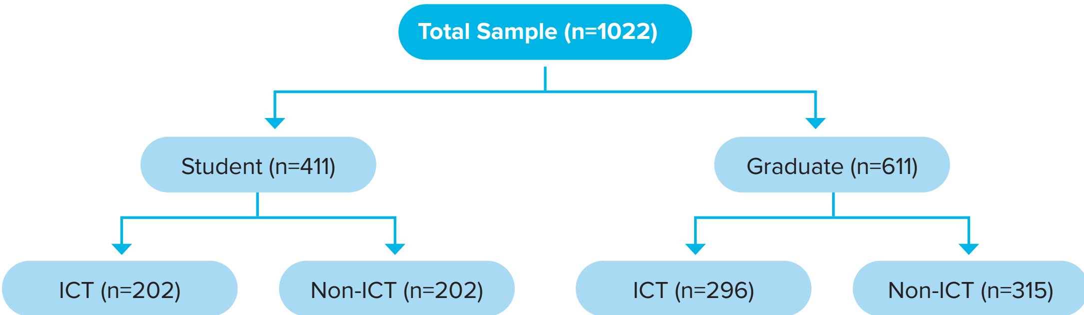
Table 1: Distribution of Sample Firms

	All	ICT	Non-ICT
Sample	202	135	67
Micro (<11)	95	68	27
Small (11-50)	86	57	29
Medium (51-100)	12	6	6
Large (>100)	9	4	5

Source: Authors' preparation using data from the firm survey

For the student/graduate survey, a two-stage stratified random sampling design was applied to gather a national representation of students and graduates of higher education institutions (HEIs). The first stage involved selecting HEIs as primary sampling units (PSUs). At the second stage, respondents were randomly selected by student status stratum (student vs. graduate) and major stratum (ICT-related or non-ICT related). The sampling frame is final year post-secondary students enrolling in either higher diploma/associate degree or bachelor's degree programmes. In the 2019-20 academic year, the MoEYS and MLVT statistics recorded more than 1,100 second-year students enrolling in the higher diploma/associate degree programme, and approximately 40,000 senior students. Figure 3 highlights distribution of the surveyed students and graduates.

Figure 3: Distribution of student/graduate sample size



Source: Authors' calculation using data from the student/graduate survey

As shown in Figure 3, the study surveyed 1,022 respondents (411 students and 611 graduates). Of the 411 students, 202 enrolled in ICT-related majors, while the remaining enrolled in non-ICT majors. For the graduate sample, 296 respondents were in ICT-related majors, and 315 were in non-ICT majors.

Key Informant Interviews (KIIs) with HEIs

The selection of higher education institutions (HEIs) for the key informant interviews (KIIs) is based on the list of HEIs that agreed to participate in the student/graduate survey. Only 18 of the 22 HEIs accepted the request for face-to-face interviews. KIIs with HEIs' management staff were conducted between August 2020 and January 2021 - a temporary postponement due to COVID-19 restrictions. School management participating in the KIIs included vice presidents or deputy directors in charge of academic affairs, chief academic officers, deans of ICT faculty/departments, and IT officers. With consent from the participants, the KIIs were guided by a semi-structured interview protocol and were recorded when approved. On average, interviews lasted between one hour and one hour and a half. Recorded interviews were later transcribed and imported to NVivo for analysis. Information from the KIIs with HEI management was also used to triangulate and verify information collected from the student/graduate survey.

Tool for Data Collection

The study utilises an online platform to collect necessary primary data. Specifically, it employs KoBo Toolbox, a suite of tools which is free and has over 20 types of questions. It also allows for skip logics and validation criteria. It can be used either offline or online - a compulsory feature since selected students and firms may be situated in remote or no-service areas. Data can be collected through any browser on any device, or through the KoBoCollect app on Android devices. Further, data is available immediately after synchronisation when devices are connected to the internet. It therefore allows for the ability to monitor and clean data simultaneously to ensure data quality.

It should be noted that in this study the surveys were implemented through a browser since the process is simpler and has more versatility in matrix question design. Each of the study's trained enumerators was equipped with a tablet device for their fieldwork. They were asked to synchronise data at the end of the day for data monitoring and quality checks by the survey team. Appendices A and B provide detailed sampling design and research methods, respectively. This includes the propensity score matching method used to quantify the wage premium between ICT and non-ICT graduates.

04 Findings

4.1 From Firm Survey

4.1.1 Profile of Sample Firms

Table 2 presents characteristics of sample firms that participated in the firm survey. Of the 202 interviewed firms, 66.8 percent operate ICT-related businesses, while the remaining are non-ICT. Classified using number of employees (full and part-time), the majority of the interviewed firms are micro and small. Micro-ICT firms account for 50.4 percent of total interviewed ICT firms (40.3 percent for small ICT firms). Only 7.4 percent are of medium and large size. For the non-ICT sample, 83.6 percent are micro and small, 9 percent medium, and 7.5 percent large firms. The distribution partly reflects the fact that most enterprises operating in Cambodia are micro and small. The results also indicate that the majority of the sample firms are young and have been in operation for the last decade. This is particularly applicable to ICT firms with, on average, 3-5 years of operations. This is indicative that the ICT sector has newly emerged and continues to present new opportunities. With respect to firm ownership, 75.2 percent of the sample firms are domestically owned with a Cambodian stake of between 81 and 10 percent of the total firm equity (78.4 percent for ICT firms and 74.6 percent for non-ICT firms).

In terms of their business models and operations, the majority of the interviewed firms sell their services or products to final consumers domestically (Table 3). Few ICT and non-ICT firms partake in production value chains as either producers of semi-finished services or products, or producers of mostly finished ones. Approximately 92.6 percent of services or products produced by ICT firms are sold in Cambodia, compared to 76 percent for non-ICT firms. ICT firms export only 6.7 percent of their services or products compared to 16.9 percent by non-ICT firms. Most interviewed firms source their raw materials in Cambodia (70.9 percent for ICT firms and 85 percent for non-ICT firms).

Table 2: General characteristics of sample firms

Desciption	All	ICT	Non-ICT
BY employee size			
➢ Micro (<11)	47.0%	50.4%	40.3%
➢ Small (11-50)	42.6%	42.2%	43.3%
➢ Medium (51-100)	5.9%	4.4%	9.0%
➢ Larg (>100)	4.5%	3.0%	7.5%
By Cambodia ownership			
➢ <20	149%	13.3%	17.9%
➢ 21-40	2.0%	3.0%	00.0%
➢ 41-60	3.0%	2.2%	4.5%
➢ 61-80	2.5%	3.0%	1.5%
➢ 81-100	75.2%	77.8%	70.1%
Start year			
➢ Befor 2000	3.0%	2.2%	4.5%
➢2001-2010	10.9%	8.1%	16.4%
➢2011-2021	86.1%	89.6%	79.1%
Obs.	202	135	67

Source: Authors' preparation using data from the firm survey

Table 3: Business characteristics of sample firms

Desciption	All	ICT	Non-ICT
Value chain (# of firms)			
➢ Sale to final consumers	94.6%	96.3%	91.0%
➢ Semi-Finished goods/services	2.5%	2.2%	3.0%
➢ goods/services	1.0%	0.0%	3.0%
➢ Mostly Finished goods	2.0%	1.5%	3.0%
Market (% of total sales)			
➢ Sales in Cambodia	84.3%	92.6%	76.0%
➢ Indirect exports	4.0%	0.7%	7.2%
➢ Direct exports	11.8%	6.7%	16.9%
Sources of raw material (% of all sourses)			
➢ Domestic	78.1%	71.1%	85.0%
➢ Foreign	21.9%	28.9%	14.8%
Obs.	202	135	67

Source: Authors' preparation using data from the firm survey

In terms of operations, more than half of the sample firms reported that their revenue would decrease in 2020 year on year, averaging 52.8 percent for ICT firms and 43.9 percent for non-ICT firms (Table 4). This might be due to the COVID-19 pandemic outbreak which began in early 2020 and included several waves of community infections thereafter. Despite this, there are firms that were optimistic that sales and revenue would increase in 2020. The majority of the interviewed firms were optimistic that sales and revenue would rebound in 2021 (70.6 percent of ICT firms and 64.8 percent of non-ICT firms). Only 10.1 percent of ICT firms reported that their sales and revenue might drop in 2021 compared to the same period last year.

Table 4: Business and operations of the sample firms

Desciption	All	ICT	
Sales in 2019 (in USD1,000)			
➤ <10	15.0%	17.2%	10.0%
➤ 11-500	68.4%	69.9%	65.0%
➤ 501-1000	9.8%	7.5%	15.0%
➤ 1001-5000	4.5%	3.2%	7.5%
➤ >5000		2.2%	2.5%
Sales trend in 2020			
➤ Increase	26.4%	29.4%	20.4%
➤ The same	12.9%	14.7%	9.3%
➤ Decrease	60.7%	56.0%	70.4%
Sales trend in 2021			
➤ Increase	68.7%	70.6%	64.8%
➤ The same	19.0%	19.3%	18.5%
➤ Decrease	12.3%	10.1%	16.7%
Average percentage change in 2020			
➤ Increase in 2020	50.2%	61.7%	38.6%
➤ Decrease in 2020	48.3%	52.8%	43.9%
➤ Increase in 2021	46.5%	61.5%	31.6%
➤ Decrease in 2021	39.4%	52.5%	26.3%
Obs.	202	135	67

Source: Authors' preparation using data from the firm survey

Table 5 illustrates specific services and products provided by ICT firms that participated in the firm survey. The results show that the majority of firms offer sales, installation, and maintenance of ICT devices (27.7 percent of all services or products reported) and software, web development, application, and ICT systems (26.7 percent). Another three popular services or products offered are graphic and multimedia design (9.4 percent), network, telecommunication, and internet (9.4 percent), and digital marketing (7.4 percent).

Table 5: Services and products of the ICT firms

Sales, installation and maintainebce of ICT devices	27.7%
Software, web development, application and ICT system	26.7%
Graphic and multimedia design	9.4%
Network, telecommunications, internet and WIFI	9.4%
Digital marketing	7.9%
Online delivery, order and shopping	6.3%
ICT service and consulting	4.2%
Cloud service	3.1%
Data management system/related services	2.1%
Fintech	2.1%
Job website/recruitement	1.0%

B. Sub-Sector of non-ICT firms

Transport and Storage	35.8%
Manufacturing	19.4%
Financial and insurance activities	16.4%
Tourism, accommodation and food services	16.4%
Agriculture	11.9%

Source: Authors' preparation using data from the firm survey

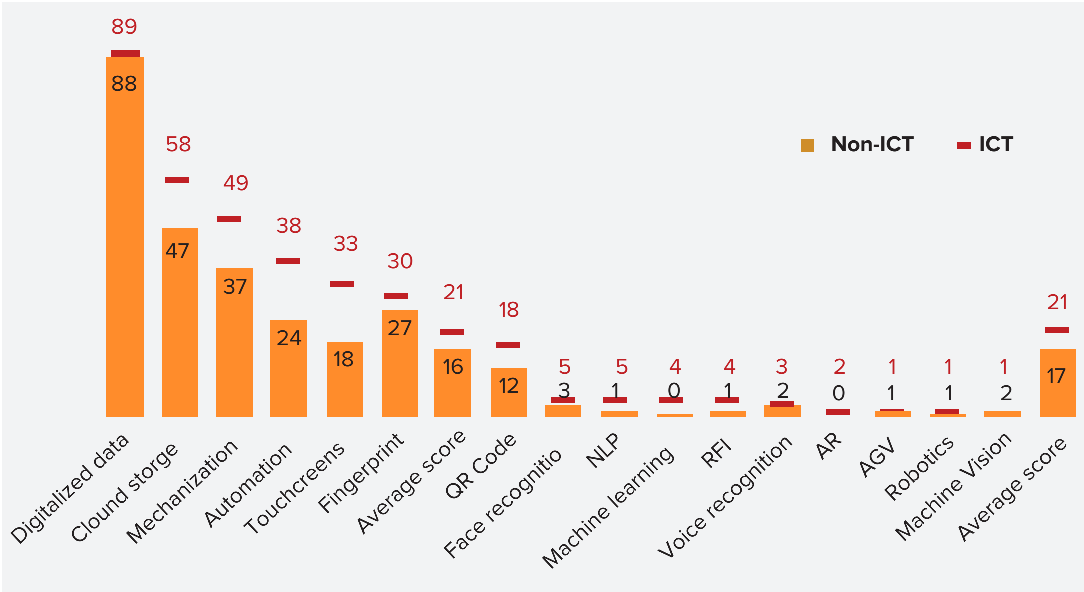
Sample firms were also asked the use of a range of technologies in their operations. The average score was then calculated measuring the level of technological adoption to understand types of technologies and the extent to which the technology is employed in production and operations. Respondents were asked to rank a range of technologies from touchscreen to automated guided vehicles (AGV). Nonetheless, it should be noted that not all new technologies are relevant or applicable to the surveyed firms. Companies might need to adopt different types of technology given the nature of their operations. In other words, if a firm does not adopt a certain technology, this does not necessarily imply low technological adoption. It can imply that such technology is not relevant to produce services or products the firm is offering.

Figure 4 shows the average score indicating the level of firms' adoption of new technology. The score is a standardized score where 0 indicates no adoption of new technology, and 100 suggests maximum adoption. A score of 50 implies a medium level of adoption. The results indicate that digitalised data and cloud storage are the two most used technologies for ICT and non-ICT firms, followed by mechanisation, automation, and fingerprint technology. Few firms employ advanced technologies like AR, Robotics or AGV[1].

ICT firms have a higher level of technological adoption compared to that of non-ICT firms, with an average score of 21 to 16. Nonetheless, the higher level of adoption occurs across low levels of digital technologies. The level of adoption of advanced technologies is similar between ICT and non-ICT firms.

[1]Refer to Appendix F for definition of new technology used in the firm survey.

Figure 4: Firms' adoption of new technology



Source: Authors' preparation using data from the firm survey

4.1.2 Current Workforce in ICT Occupations

This section examines workforce composition in ICT occupations and the ICT workforce employed by non-ICT firms. This allows for further understanding of the occupations that are commonly employed and sought after by ICT and non-ICT firms.

Table 6 shows that the five most prevalent ICT occupations in ICT firms are software and applications developers and analysts, ICT servicers, ICT managers, ICT technicians, and graphic and multimedia designers. Software and applications developers and analysts are the most prevalent, accounting for 14.0 percent of the total number of occupations reported. This is followed by ICT servicers (6.7 percent), ICT managers (6.0 percent), ICT technicians (5.3 percent), and graphic and multimedia designers (4.6 percent).

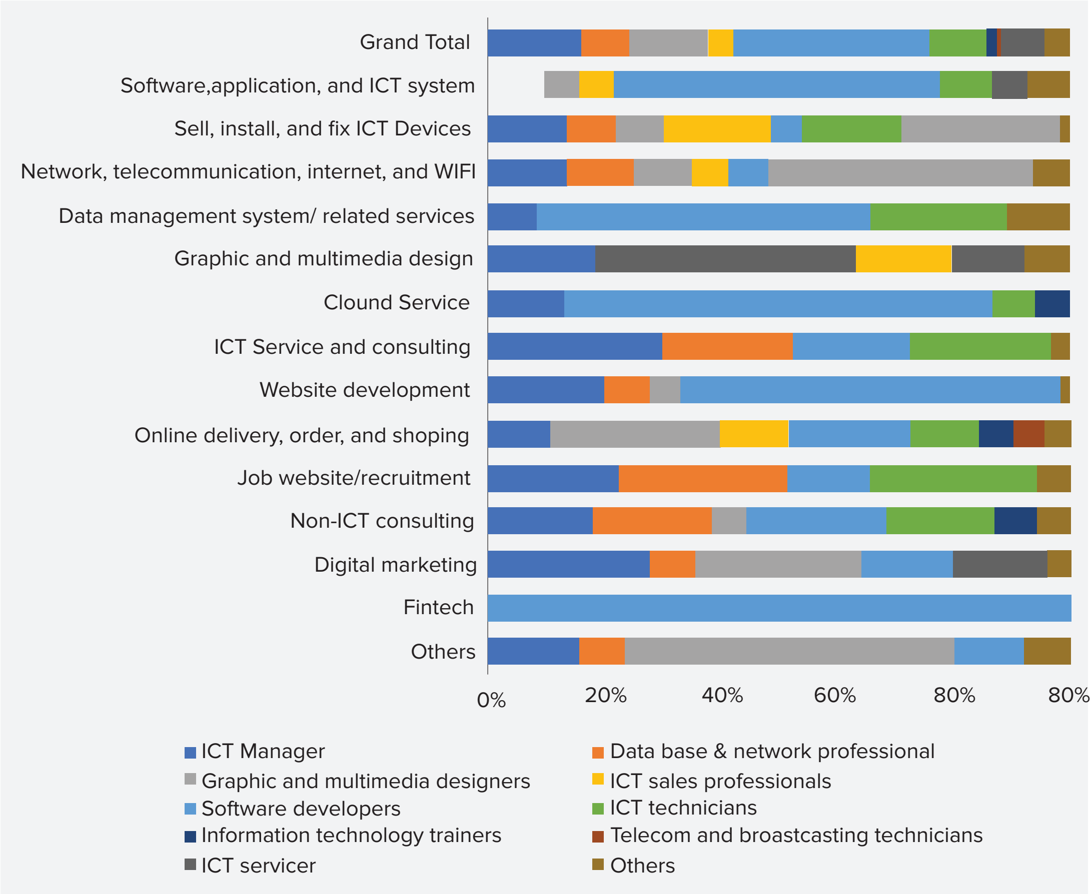
Table 6: Types of occupations in ICT firms

1330 ICT Manager	6.0%
1 Other Manager	7.3%
2152 Electronics engineers	1.0%
2153 Telecommunication engineers	0.2%
2166 Graphic and multimedia designers	4.6%
2356 Information technology trainers	0.8%
2434 ICT sales professionals	4.2%
251 Software developers	14.0%
252 Database & network professional	2.5%
2 Other professional	12.0%
351 ICT technicians	5.3%
352 Telecommunication and BCT technicians	0.1%
3 Other technician	10.6%
SL2 Clerks, service and sales workers	21.8%
7422 ICT Servicer	6.7%
9 Elementary occupations	3.1%

Source: Authors' preparation using data from the firm survey

The results also indicate that the sample firms employing the most ICT employees are those specialising in software, applications, and ICT systems (Figure 5). By far, software and application developers have the highest proportion of all employees in this subsector. The companies in the subsector of selling, installing, and fixing ICT devices employed the second highest number of ICT employees, most of whom are ICT servicers, ICT sale professionals, ICT technicians, and ICT managers. The subsector of network, internet, Wi-Fi, and telecommunication has the third largest number of ICT employees. ICT servicers have the highest percentage of the total ICT employees in this subsector. The subsectors of database management/related services and graphic and multimedia design have the fourth and fifth largest number of ICT employees. Intuitively, the graphic and multimedia design firms mostly employed graphic and multimedia designers.

Figure 5: Occupational types of ICT firms by services



Source: Authors' preparation using data from the firm survey

Table 7 shows that the majority of employees both in ICT and non-ICT sectors obtained a bachelor's degree, amounting to 71.2 percent among employees of the ICT firms and 50.4 percent among employees of the non-ICT firms. Among the non-ICT firms, 58.6 percent of ICT employees have a bachelor's degree (42.2 percent for non-ICT staff). Further, 14.7 percent of ICT employees and none of the non-ICT employees in ICT firms had a master's degree. Table 8 presents monthly salaries by sector and occupation. Among the surveyed ICT firms, ICT managers could earn on average USD938 per month, followed by software developers (USD695) and ICT trainers (USD675) as the next highest salaries.

Table 7: Employees' education of ICT and non-ICT firms

Education level	ICT sector		Non ICT sector	
	ICT staff	Non-ICT staff	ICT staff	Non-ICT staff
Post-doctorate	0.2%	0.0%	0.0%	0.0%
Doctorate	1.9%	0.0%	1.5%	0.0%
Master's degree	14.7%	0.0%	14.3%	0.0%
Bachelor's degree	70.9%	71.4%	58.6%	42.2%
Associate degree	1.9%	2.9%	2.0%	4.4%
TVET post-secondary	0.8%	1.4%	1.5%	2.2%
TVET pre-secondary	0.2%	1.4%	0.5%	0.0%
Upper secondary (completed)	3.0%	18.6%	4.9%	15.6%
Upper secondary (not completed)	2.1%	2.9%	4.4%	15.6%
Lower Secondary schol	1.5%	0.0%	6.4%	20.0%
Primary school (grade 1-6)	2.4%	0.0%	4.9%	0.0%
Never been to school	0.6%	1.4%	1.0%	0.0%

Source: Authors' preparation using data from the firm survey

Table 8: Monthly salary by sector and occupations

Occupation	ICT	Non-ICT
1330 ICT Manager	$938	$875
1 Other Manager	$1,222	$1,117
2152 Electronics engineers	$605	$300
2153 telecommunications engineers	$600	
2166 Graphic and multimedia designers	$531	$200
2356 ICT trainers	$675	$550
2434 ICT sales professionals	$466	$392
251 Software developers	$695	$350
252 Database & network profesionals	$558	$433
2 Other professionals	$501	$640
351 ICT technicians	$467	$400
352 Telecommunications and BCT technicíar	$575	
3 Other technicians	$386	$469
SL2 Clerks, service and sales workers	$315	$284
7422 ICT servicer	$313	$230
9 Clerks, service and sales workers	$82	$80

Source: Authors' preparation using data from the firm survey

4.1.3 Digital Skills Gaps and Shortages

This section investigates whether a digital skills gap and shortage exist, and the extent of the gap and shortage. Specifically, it shows the leading digital skills gap and shortage, underlying reasons behind the issue, effects on firms' performance, and firms' coping strategies in addressing the problem.

Table 9 presents the average score of challenges sample firms face in their businesses and operations. Owners/managers of the surveyed firms were asked to rank each challenge on a scale from 1 to 5, with 1 being that the reported challenge does not affect business operations and 5 being that the firm is most affected by the challenge. The results show that the top five challenges affecting business operations are the outbreak of COVID-19, a shortage of skills, high production costs, high wages, and the digital skills gap. There seems to be no statistically significant difference in these challenges between ICT and non-ICT firms, except regarding the limited digital skills of employees. That is, owners/managers of the interviewed ICT firms tend to be more concerned about the lack of this skill among employees than those representing non-ICT firms.

Table 9: Challenges reported by the sample firms (average score)

	All	ICT	Non-ICT
COVID-19	3.6	3.6	3.6
Limited digital skills of employees	2.9	3.0	2.5
Hight wage	2.8	2.8	2.6
Hight production conts	2.7	2.7	2.8
Lack of skilled labour	2.7	2.7	2.6
Access to business and market information	2.7	2.5	2.5
Hight turnover rate of skilled professionals	2.4	2.4	2.2
Lack of internet infrastructure	2.3	2.2	2.5
Access to technology	2.3	2.3	2.3
Access to the relevant training and consultancy	2.3	2.4	2.1
Potential loss of preferential martket access	2.2	2.0	2.5
Poor logistics and transport network	1.9	1.7	2.2
Labour conflict (e.g strike)	1.3	1.3	1.3

Source: Authors' preparation using data from firm survey

As shown, the skills shortage and gap remain a challenge despite continued efforts by the government and other stakeholders to address them. This study further examines the types of skills—general and digital—surveyed firms require in their daily operations. Table 10 illustrates general skills gaps reported by owners/managers of the surveyed firms, disaggregated by ICT and non-ICT employees. The results show that a lack of soft skills among ICT and non-ICT employees is common. For instance, for ICT firms, improvements in communication, language, and leadership and management skills are some of the most cited general skills gaps. A similar set of skill gaps is also evident among ICT and non-ICT employees in the non-ICT firms, particularly in communication, problem-solving, and foreign language. The results seem to indicate that soft skills are one of the important sets of skills employers are seeking, in addition to specific and technical skills acquired by employees.

Table 10: General skills gaps

	ICT Firms		Non-ICT Firms	
	ICT employees	Non-ICT employees	ICT employees	Non-ICT employees
General attitude to work	5.9%	7.6%	7.2%	11.0%
Communication Skills	16.0%	15.1%	10.1%	13.0%
Self-management	6.0%	9.2%	10.1%	7.0%
People skills	5.3%	6.3%	7.2%	6.5%
Problem solving	11.5%	10.1%	13.0%	13.8%
Literacy	0.7%	1.5%	2.9%	3.0%
Numeracy	0.7%	1.8%	0.0%	3.0%
Technical/job specific skills	8.5%	7.6%	8.7%	6.5%
Teamwork	6.7%	5.0%	7.2%	5.0%
Leadership and management	10.6%	3.7%	5.8%	7.5%
Digital skills	13.2%	8.5%	7.2%	8.5%
Languages	14.8%	13.7%	20.3%	15.0%
Obs.	**714**	**542**	**69**	**399**

Source: Authors' preparation using data from firm survey

As highlighted in Section 2, this study assesses digital skills gaps using the framework by ECORYS UK (2016), which classifies digital skills into basic, workforce, and professional. Basic digital skills refer to literacy skills that are needed by every citizen to become digitally literate. Specifically, these include the skills needed to perform basic digital functions like using digital applications to communicate or carrying out a basic internet search. The second category is digital skills needed for the general workforce. These include all skills in the first category plus skills needed in a workplace. The third category is digital skills for ICT professions, which focus on digital innovation and creativity. These encompass skills in the first and second categories plus skills needed in a more diverse digital and IT environment.

Table 11 presents the results of digital skills gaps reported by owners/managers of the surveyed firms. The digital skills gaps vary across sectors and types of employees. The gaps seem to exist for all, and particularly for ICT and non-ICT employees of the ICT sector. With respect to basic digital skills, using software, managing digital identity, retrieving and storing information, evaluating information, and browsing, searching, and filtering information are the most cited gaps among ICT employees. Some of these skills gaps are also common among the non-ICT employees in the ICT sector. In terms of digital skills gaps for the general workforce, insufficient skills to adapt and adopt to changes in workplace environments is the main challenge (e.g., the introduction of new technologies or new processes of working that require ICT-specific skills). Lastly, the professional skills gaps are focused on the ability to innovate and create, particularly in developing and re-purposing content, applications and programming, and creating and innovating using technology.

Table 11: Digital skills gaps

Digital Skills	ICT Sector: ICT employees	ICT Sector: Non-ICT employees	Non-ICT Sector: ICT employees	Non-ICT Sector: Non-ICT employees
Basic Skills				
Literacy	5	6	0	2
Numeracy	3	8	0	6
Writing	4	15	2	10
Communication skills	7	13	1	14
Understanding the basic laws and ethics applying to use ICTs	8	4	0	4
Hardware	12	4	0	1
Software skills	32	16	1	8
Protecting personal data	9	9	0	3
Health (e.g ergonomies of ICT usage)	9	6	0	1
Environment issues (e.g. relating to disposal of ICTs)	9	5	0	2
Identifying, evaluating and proeuring relevant, ICTs	6	5	0	1
Browsing, searching and filering information	13	9	0	3
Evaluating information	14	6	0	2
Retrieving and stering information	14	9	0	5
Interacting and collaborating through ICTs	8	5	0	2
Sharing information and content	7	7	1	2
Engaging in online citizenship	5	6	1	2
Netiquette	10	8	1	1
Managing digital identity	16	10	1	2
Workforce Skills				
Using relevant apps to create documents	7	10	0	3
Using information of various digital formats effectively and effciently	8	10	0	2
Legal, contractual and ethical conditions relating to the workplaces	13	7	0	2
Digital skill specific to changing workplace enviroments	20	12	1	2
Professional Skills				
Developing and re-purposing content	27	13	0	1
Adopting appropriate good practice regarding copyright and licensing	12	7	0	1
Applications/programming skills	24	15	1	3
Evaluating and using physical versus cloud-based ICD infrastruchures	11	9	0	2
Solving information, software and technical (hardware) problems	14	13	0	2
Creativity and innovation using technology	21	8	2	2
Reviewing and evaluating ICT developments	9	7	0	2
Protecting sensitive information	14	7	0	2
Cybersecurity-Securing IT infrastructures	8	8	0	2
Policies and practies for securing extended information infrastructures	9	7	0	2

Source: Authors' preparation using data from firm survey

Regarding skills shortages, among job vacancies of ICT occupations in ICT firms, software developers are the most vacant position, followed by ICT sales professionals, graphic and multimedia designers, ICT managers, and servicers (Table 12). ICT sales professionals are the ICT occupations with the most vacancy in non-ICT firms. The ICT occupations that are difficult to recruit are ICT servicers, telecommunications engineers, software developers, and ICT sales professionals. The likely reasons for skills shortages reported are the introduction of new technology, failure to recruit employees with the required skills, development of new services or products, and the introduction of new processes.

Table 12: Job vacancies

Occupation	ICT	Non-ICT
1330 ICT manager	30	4
1 Other Manager	19	9
2152 Electronic wngineers	6	0
2153 Telecommunications engineers	5	0
2166 Graphic and multimedia designers	29	0
2356 ICT trainers	6	1
2434 ICT sales professionals	48	18
251 Software developers	69	0
252 Database & network professionals	29	1
2 Other professionals	39	22
351 ICT technicians	26	1
3 Other technicians	70	18
SL2 Clerks, service and sales workers	130	98
7422 ICT servicer	36	0
9 Elementary workers	1	1

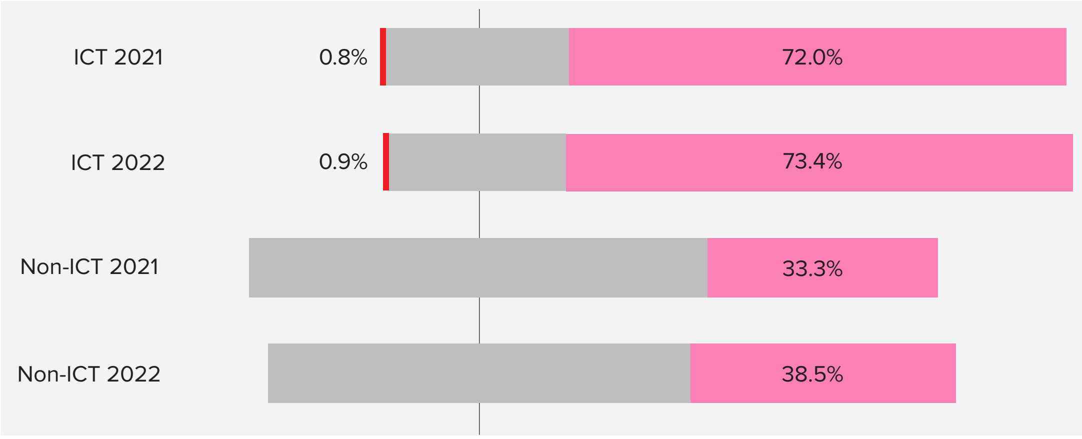
Source: Authors' preparation using data from firm survey

It should be noted that the digital skills gaps and shortages impact firms' performances and investments, particularly for the ICT sector. The results indicate that 46.7 percent of the ICT firms reported strong effects on their growth as a result of the persistent digital skills gaps and shortages, whereas 24.4 percent reported moderate effects. In addition, 42.2 percent of the interviewed owners/managers of ICT firms reported that the digital skills gaps and shortages would have strong effects on firms' current and future investment.

4.1.4 Future Demand for ICT Skills and Occupations

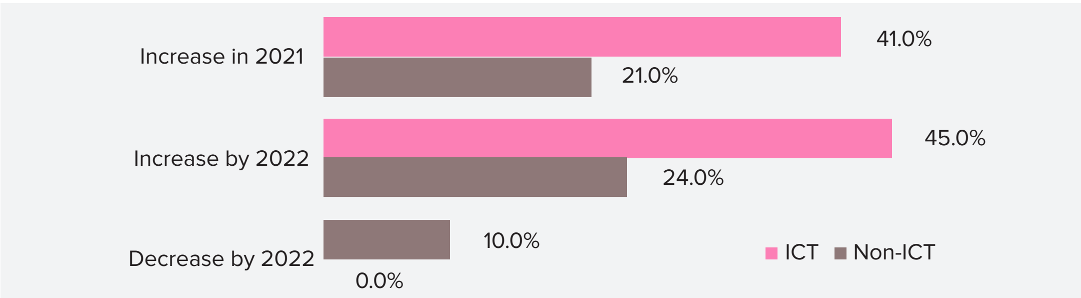
Sample ICT and non-ICT firms were asked to estimate their prospective demand for ICT skills in 2021 and 2022. Overall, both employers of ICT and non-ICT firms predict that demand for ICT skills and occupations for their enterprises would increase in 2021 and 2022. Specifically, 72.0 percent of ICT firms reported an increase for 2021 compared to 33.3 percent of non-ICT firms. The average increase is estimated to be 41.0 percent for 2021 for ICT firms relative to the total number of employees at the time of survey (Figure 7). The percentage increase averages 20.0 percent for non-ICT firms. In terms of ICT occupations, the top five most required ICT occupations estimated by employers include ICT sales professionals, software and applications developers and analysts, database and network professionals, graphic and multimedia designers, information and communications technology operations, and user support technicians.

Figure 6: Future demand for ICT skills



Source: Authors' preparation using data from the firm survey

Figure 7: Percentage change in future ICT recruitment and ICT occupations



B. Future dedmand for ICT occupations

Occupation	ICT	Non ICT
1330 ICT Manager	8.7%	
2152 Electronics engineers	8.7%	9.5%
2153 Telecommunication engineers	1.9%	
2166 Graphic and multimedia designers	31.7%	9.5%
2356 Information technology trainers	6.7%	
2434 ICT sales professionals	33.7%	61.9%
251 Software developers	56.7%	4.8%
252 Database & network professional	31.7%	23.8%
351 ICT technicians	17.3%	4.8%
352 Telecommunication and broadcasting technicians	6.7%	14.3%
7422 ICT servicer	10.6%	

Source: Authors' preparation using data from the firm survey

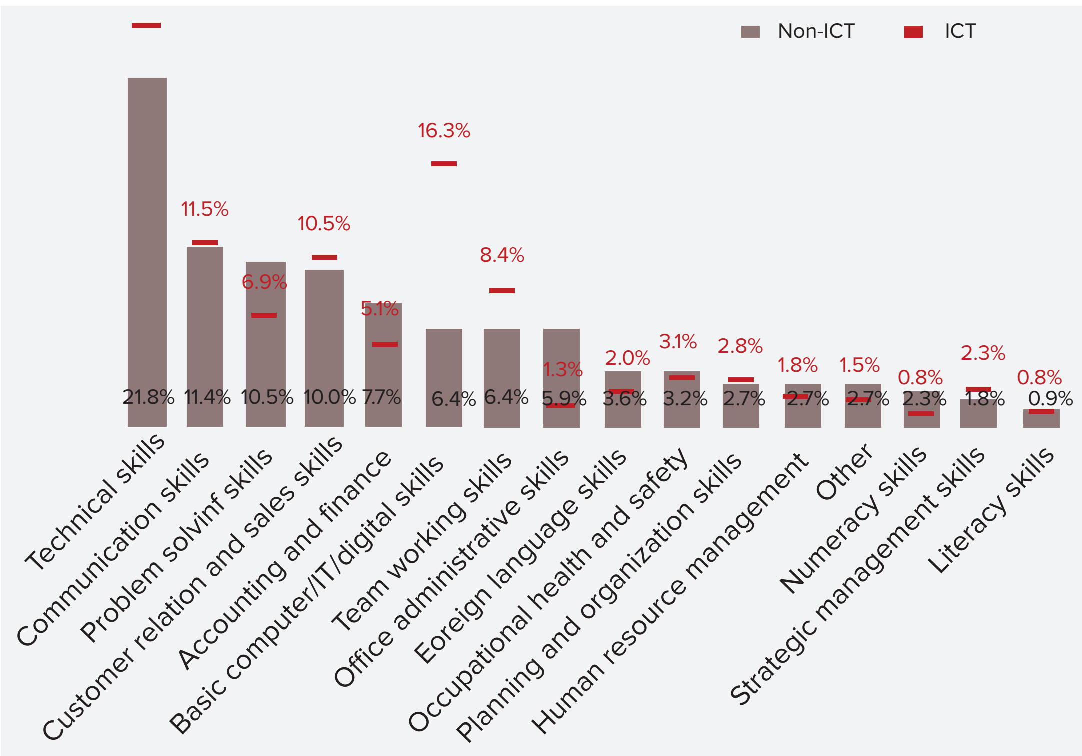
4.1.5 In-house Training Provision and Firm Perception on Quality of ICT Graduates

The results show that 93.0 percent of ICT firms provide on-the-job training to their employees (96.0 percent for non-ICT firms). The finding is consistent with that of Ven and Veung (2019), stating that on-the-job training is the main method for firms to reskill or upskill their workforce. According to the results of the key informant interviews, the reason may be that employers believe that new recruits do not have the skills required by the company. They state that:

> *"Once [employees are]hired, they have to do a lot of additional supplemental training in-house, that [the employees] did not get during the actual training programmes [or] accreditation certification programmes."*

Some common skills trainings that were provided by the surveyed firms included technical skills, communications, problem solving, customer relations and sales, accounting and finance, and basic computer literacy/IT/digital skills, and (Figure 8). Provision of technical skills accounted for 25.0 percent of the total number of trainings provided by ICT firms, and 22.0 percent of those provided by non-ICT firms. Technical skills constitute specialised tasks (e.g., coding, design, bookkeeping, etc.) that hired employees lack. Communication skills represented 11.0 percent of training in both sectors. Basic computer literacy/ IT/ digital skills accounted for 16.0 percent of training for the ICT sector, and 10 percent for the non-ICT sector. Problem solving comprised a further 7.0 percent of training for the ICT sector and 10.0 percent for the non-ICT sector.

Figure 8: On-the-job training provision by skill types



Source: Authors' preparation using data from the firm survey

Employers of sample firms were asked to rate hard and soft skills of ICT graduates on a scale of 1 to 5 (1 being the weakest and 5 the strongest). The results show that ICT firms rated most of the skills (technical, practical, language, and job hopping (reversing scaling) skills) of ICT graduates an average of 3 and an average of 4 for work attitude, suggesting that ICT graduates have medium levels of all skills, except for work attitude which was scored as being strong. The perceptions of non-ICT firms were similar to those of the ICT firms (3.5 for work attitude). Technical and language skills had a score of 3 (moderate skills) and practical skills had a score of 2.5 (almost moderate). Job hopping scored a 2, indicating that the ICT graduates in non-ICT firms were less likely to switch jobs frequently.

Most firms rated job performance of ICT graduates above moderate. It was rated by 56.8 percent of ICT firms as moderate, 31.8 percent as good, and only 11.4 percent as poor. For the non-ICT firms, 37.5 percent rated job performance as good and the same proportion rated it as moderate, while 25 percent rated it as poor.

The results also indicate that the majority of surveyed firms have minimal cooperation with ICT training providers, universities, or TVET institutions. That is, 96.9 percent of non-ICT firms reported not having any form of cooperation with training providers, compared to 77.6 percent of ICT firms, indicating that ICT firms have a relatively higher level of cooperation with training providers. The areas that the surveyed firms cooperated in included the provision of internships, collaboration that allows students to write about the companies in their theses, shared master trainers, and conference participation. Although most firms rarely had short and long-term partnerships with ICT training institutes, they were keen on participating in and deepening relationships with relevant stakeholders to improve ICT skills in Cambodia.

The study also quantified the effects of on-the-job training provided by companies to its workforce on firm productivity and sales. Productivity is the value of sales per employee. It should be noted that 34 percent of data points on company sales are missing. To avoid excluding the missing values, which could reduce the total sample size necessary to perform statistical tests and regression analysis, the authors imputed the missing values by replacing them with the mean obtained from available data (refer to Appendix G for the estimation strategy).

The results of the t-test show a positive association between on-the-job training provision and firm productivity and sales, for both ICT and non-ICT. This implies that ICT firms that provide on-the-job training to their employees have higher productivity and larger sales than those that do not provide such training. This also applies to the non-ICT firms that provide such training. The study further tested the relation using regression analysis as it enables additional controls for other factors which might affect firm productivity and sales. The regression results (Appendix G) indicate similar positive association between on-the-job training and firm productivity and sales among ICT firms that provide such training compared to those that do not. The results partly suggest that ICT firms require employees to have relatively high technical skills. Thus, if firms fail to train their workforce properly, production and sales could be negatively affected. It should be noted that the importance of on-the-job training (OJT) provision is not dependent on firm size, suggesting that OJT provision is crucial for MSMEs and large firms alike.

4.2. From the Student/ Graduate Survey

4.2.1 Profile of Sample Students

Table 13 illustrates characteristics of the sample and sub-samples of students and graduates. Nearly half of the surveyed respondents were students or graduates of ICT-related majors, although according to statistics by the Ministry of Education, Youth and Sport, ICT students represent only around 7 percent of the enrolment in higher education in the academic year 2018-2019. The oversampling of ICT-related major respondents was purposeful as this study has interests in ICT-related majors. About one-fourth of the respondents enrolled in the associate degree or higher diploma programmes. Similar proportions are found in both student and graduate samples.

Table 13: Characteristics of sampled students and graduates

	All	Student	Graduate
Major			
- Non-ICT	51.55%	50.85%	51.55%
- ICT-related	48.45%	49.15%	48.45%
Programme			
- Higher diploma	18.49%	18.73%	18.33%
- Bachelor's degree	81.51%	81.27%	81.67%
Gender			
- Female	32.19%	35.52%	29.95%
- Male	67.81%	64.48%	70.05%
Age Group			
- <=20 years	3.52%	8.27%	0.33%
- 21–25 years	70.45%	81.75%	62.85%
- 26–30 years	22.60%	8.03%	32.41%
-> 30 years	3.42%	1.95%	4.42%

Source: Authors' preparation using data from the student survey

Less than one-third of the sample was female, but the actual ratio of the female population in HEIs is much higher. The underrepresentation of females in this survey is a result of disproportional sampling of ICT-related majors and low female enrolment in those majors. The female ratio is even lower (10.14 percent) among graduates of ICT-related majors. On the positive side, the female ratio among ICT senior students is much higher at 17.82 percent, meaning that more females are now interested in ICT majors. Based on the MoEYS's Department of Higher Education statistics, over 10,000 students enrolled in IT majors (excluding communication-related majors) and around 15 percent of them were female. The respondents' ages are grouped into four distinct cohorts. More than 70 percent of the respondents fall into the second age cohort (21-25 years old), followed by the third age cohort (26-30 years old), consisting of more than 20 percent of respondents. An additional 3.4 percent were aged 30 or older. As expected, the mean age of graduates was around two years higher than that of students. More than 90 percent of the sampled students were under 25 years old.

The selection of higher education institutions to participate in the key informant interviews was based on sampling results of the first stage. The geographical coverage of the HEIs is scattered across four provinces and the capital: Svay Rieng, Battambang, Kompot, and Phnom Penh. The 18 interviewed HEIs are equally split into private and public institutions. All interviewed TVET institutions are public. The participants are members of the management teams, including vice presidents or (deputy) directors in charge of academic affairs, chief academic officers, ICT faculty/department deans, and IT specialists at universities or TVET institutes. They are well acknowledged/knowledgeable about the topics of interest in the study.

4.2.2 Current Workforce in ICT Occupations

The occupations of respondents were coded based on the Standard Classification of Occupations (ISCO-08) of the International Labour Organization (ILO). Two-level coding (major and sub-major) was applied for the occupations not related to ICT, while four-level coding was applied for the ICT-related occupations. More than 91.0 percent of the graduates were economically active in the last seven days, but the working ratio of ICT-related major graduates was slightly higher at 95.2 percent compared to 87.3 percent among non-ICT graduates.

Table 14 lists the percentage of employed respondents by the ISCO-08's occupation classification and average monthly wage by each classification. Nearly two in three ICT-related major graduates work in ICT-related occupations, while nearly all the non-ICT graduates work in the non-ICT sectors. Only 2.0 percent of respondents without an ICT educational background are economically active in the ICT sector. This relatively low employment ratio suggests hard skills acquired through formal education is a strong requirement in ICT-related occupations. In the ICT sector, most of the occupations are either at the professional or associate professional levels. Very few of the respondents in this sector work in management positions or lower tiers such as clerical or support workers.

A significant proportion of working respondents of non-ICT majors are economically active in a non-ICT occupation as shown in Panel B of Table 14. However, more than one third of graduates from ICT-related majors also work in non-ICT sectors. Business and administration associate professionals, business and administration professionals, and teaching professionals seem to be the most popular non-ICT occupations. The proportions of graduates working as managers, clerical support workers, and service and sales workers are also higher in the non-ICT sector.

The results also suggest that around one in four working graduates are over-overeducated for their jobs. Overeducation or vertical mismatch refers to those graduates who work in an occupation classified in ISCO-08's level 4 (clerks) or lower. The vertical mismatch is lower among ICT graduates (21.3 percent) compared to that of non-ICT graduates (29.8 percent). For ICT graduates, the horizontal mismatch is higher, as 38.4 percent of them are economically active in non-ICT sectors (see Panel B, Table 14).

Table 14: Percentage of graduate occupations by ISCO's classification and average monthly wage

		Percentage			Monthly Wage (in USD)		
		Total	ICT	Non ICT	Total	ICT	Non ICT
A. ICT-related		32.2%	61.6%	2.2%	443	443	442
1. Managers		*1.1%*	*1.8%*	*0.4%*	*867*	*980*	*300*
133	ICT service managers	1.1%	1.8%	0.4%	867	980	300
2. Professionals		*16.7%*	*32.4%*	*0.7%*	*493*	*493*	*525*
2514	Application programmer	1.4%	2.8%	0.0%	597	597	
2523	Computer network professionals	0.5%	1.1%	0.0%	483	483	
252	Database and network professionals	0.5%	0.7%	0.4%	493	385	600
2166	Graphic and multimedia designers	5.0%	10.0%	0.0%	427	427	
2356	Information technology trainers	1.1%	2.1%	0.0%	442	442	
2512	Software developers	3.8%	7.1%	0.4%	468	469	450
2522	Systems administrators 2	0.9%	1.8%	0.0%	488	488	
513	Web and multimedia developer	3.4%	6.8%	0.0%	598	598	
3. Technicians and associate professionals		*13.3%*	*25.3%*	*1.1%*	*363*	*360*	*433*
3521	Broadcasting and audio-visual technician	0.5%	1.1%	0.0%	470	470	
3513	Computer network and systems technicians	3.2%	6.4%	0.0%	378	378	
3511	ICT operations and technicians	3.4%	6.4%	0.4%	354	339	600
3512	ICT user support technicians	5.4%	10.0%	0.7%	367	368	350
3522	Telecommunications engineering technicians	0.2%	0.4%	0.0%	300	300	
3514	Web techinicians	0.5%	1.1%	0.0%	207	207	
7. Craft and related trades workers		*1.1%*	*2.1%*	*0.0%*	*292*	*292*	
B. Non-ICT		67.8%	38.4%	97.8%	417	421	416
0. Armed forces occupations		*0.9%*	*0.0%*	*1.8%*	*378*		*378*
1. Managers		*4.0%*	*2.1%*	*5.8%*	*1,256*	*652*	*1,488*
12	Administrative and commercial managers	3.6%	2.1%	5.1%	1,344	652	1,659
13	Production and specialized services managers	0.4%	0.0%	0.7%	550		550
2. Professionals		*21.4%*	*9.3%*	*33.8%*	*448*	*624*	*400*
21	Science and engineering professionals	1.4%	0.4%	2.5%	850	2,700	542
22	Health professionals	0.2%	0.4%	0.0%	700	700	
23	Teaching professionals	7.7%	2.5%	13.1%	311	352	303
24	Business and administration professionals	8.8%	4.3%	13.5%	496	597	466
26	Legal, social and cultural professionals	3.2%	1.8%	4.7%	504	625	454
3. Technicians and associate professionals		*18.0%*	*7.8%*	*28.4%*	*363*	*415*	*352*
31	Science and engineering associate professionals	3.6%	1.4%	5.8%	412	450	401
32	Health associate professionals	1.1%	0.4%	1.8%	318	300	322
33	Business and administration associate professionals	13.1%	5.7%	20.7%	347	378	341
34	Legal, social, cultural and related associate professionals	0.2%	0.4%	0.0%	800	800	
4. Clerical support workers		*14.9%*	*13.2%*	*16.7%*	*306*	*300*	*310*
44	Other clerical support workers	4.9%	3.2%	6.5%	262	252	268
41	General and keyboard clerks	2.7%	2.5%	2.9%	356	283	411
42	Customer services clerks	4.1%	4.3%	4.0%	314	325	302
43	Numerical and material recording clerks	3.2%	3.2%	3.3%	321	327	314
5. Service and sales workers		*7.0%*	*4.6%*	*9.5%*	*352*	*365*	*345*
7. Craft and related trades workers		*1.6%*	*1.4%*	*1.8%*	*238*	*258*	*222*
Grand Total		**100%**	**100%**	**100%**	**426**	**435**	**416**
Obs.		**556**	**281**	**275**	**556**	**281**	**275**

Source: Authors' calculations using data from the student survey

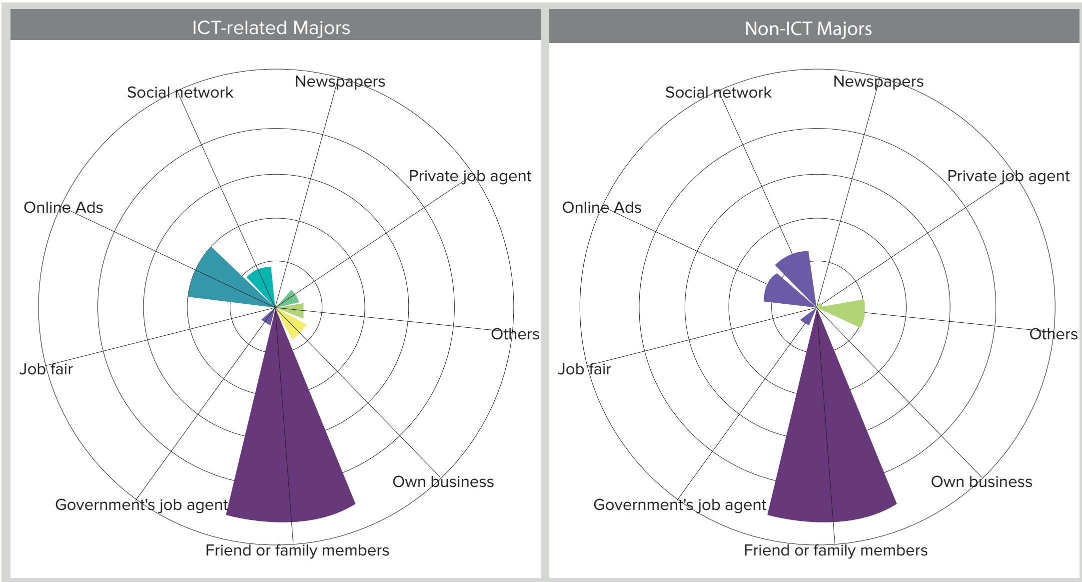
Regardless of educational backgrounds, the average monthly wage of working graduates is USD426, and employees in ICT sectors are paid slightly better than those in the non-ICT sectors at USD435 per month. Professionals in the ICT sector earn about 10 percent higher wages than their counterparts in the non-ICT sector. At the management levels, the average monthly earnings in the non-ICT sector are higher, while the monthly wages of the associate professionals in both sectors is roughly the same at around USD360. The highest paid occupation among the sampled graduates is administrative and commercial managers (ISCO 12), with an average monthly salary of USD1,344. Without controlling for any factor, on average students who graduated from ICT-related majors earn about four percent higher than their non-ICT peers.

Similar to the post-secondary enrolment in ICT-related programmes, the workforce in the ICT sector is dominated by males which represent over 90 percent of the labour force in the sector. Nevertheless, at the management and professional levels, female ratios are slightly higher at 16.7 percent and 13.2 percent, respectively. In other words, women are even less likely to work as associate professionals or in lower-tier occupations in ICT sectors. Over one third of economically active female graduates work as business and administrative associate professionals (ISCO 33) and teaching professionals (ISCO 23). The actual ratio could be even higher if ICT graduates were proportionally sampled in this study.

The wage premium of ICT-related majors is estimated to be around 11 percent among the surveyed graduates. Level of education (whether the participant graduated from a bachelor's degree or associate degree programme) and English language proficiency are also found to be strongly associated with monthly earnings in their early careers. Details on wage premium estimation can be found in Appendix B.

A majority of working graduates enter the world of work through friends and family members (Figure 9). As this study did not further ask how they obtained the job, it may be either that they were informed about vacancies or that they directly secured the job through their connections with friends or family members. The second and third most popular channels among surveyed graduates for job hunting are online advertisement platforms and social media platforms such as Facebook. ICT graduates are more likely to use online platforms to find job vacancies than social media, while non-ICT graduates utilise such networks less. Although the government has made efforts to promote job fairs through public job agents, only 0.4 percent and 3.9 percent of working graduates land their jobs through job fairs and government job agents, respectively.

Figure 9: Channels through which graduates obtain their jobs



Source: Authors' calculation using data from the student survey

4.2.3 Assessment of Digital Skills

4.2.3.1 Digital Skills of Students

The same 33 items used in the firm survey were used to assess the digital skills of the sampled students and graduates in the student survey. However, unlike the firm survey, the digital skills of students and graduates were assessed with a six-level Likert scale. Respondents were asked to self-evaluate the 33 digital skills items on a scale from 0 to 5, 0 being no skills and 5 being the highest level of skills.

The results (Table 15) indicate that students and graduates of ICT-related majors have a higher level of digital skills than their counterparts in all of the 33 skills items and the differences are statically different from zero. For the ICT group, the average score of basic digital skills that consist of 19 skills is 3.6, while the non-ICT group's average score is 3.21. The non-ICT group is particularly weak in the use of software or applications (such as installing, using, and updating software, and applying strong passwords) with an average score of 2.2, and in dealing with digital hardware skills (such as basic usage, electrical safety, backup provision, and deletion of data on hardware for disposal) with an average score of 2.4. However, they seem to be confident with their skills in sharing information and content through social networks (at 3.8), and digital communication skills (at 3.6). On the other hand, ICT students and graduates score no lower than 3.2 in the 19 basic digital skills. They seem to be the most competent in skills that include retrieving and storing information, sharing information and content, and managing digital identity.

Table 15: Digital skills assessment

	ICT Majors	Non ICT Majors	Difference
Basic Skills	**3.60**	**3.21**	**0.39 *** **
Lieracy	3.33	3.98	0.35 ***
Numeracy	3.46	3.27	0.18 ***
Writing	3.71	3.47	0.24 ***
Communication skills	3.82	3.63	0.19 ***
Understanding the basic laws and ethics applying to use ICTs	3.58	2.35	0.23 ***
Hardware	3.31	2.37	0.94 ***
Software skills	3.29	2.18	1.11 ***
Protecting personal data	3.65	2.95	0.70 ***
Health (e.g.ergonomics of ICT usage)	3.24	2.82	0.42 ***
Environment issues (e.g. relating to disposal of ICTs)	3.17	2.87	0.29 ***
Identifying, evaluating and procuring relevant ICTs (e.g. for disabilities	3.64	3.37	0.27 ***
Browsing, searching and filtering information	3.80	3.56	0.24 ***
Evaluting information	3.65	3.50	0.16 ***
Retrieving and storing information	3.97	3.62	0.35 ***
interacting and collaborating through ICTs	3.84	3.50	0.34 ***
Sharing information and content	3.96	3.85	0.11 ***
Engaging in online citizenship	3.78	3.52	0.25 ***
Netiquette	3.33	2.98	0.36 ***
Managing digital identity	3.89	3.22	0.67 ***
Workforce skills	**3.48**	**3.07**	**0.41 *** **
3.89	3.89	3.53	0.36 ***
3.61	3.61	3.20	0.41 ***
3.50	3.50	3.12	0.38 ***
3.93	3.93	2.42	0.51 ***
3.23	**3.23**	**3.39**	**0.85 *** **
Developing and re-purposing content	3.24	2.77	0.48 ***
Adopting appropriate good practice regarding copyright and licensing	3.28	2.92	0.35 ***
Application/programming skills	3.69	1.22	1.47 ***
Evaluating and using physical versus cloud-based ICT infrastrucures	3.44	2.31	1.13 ***
Solving information, software and technical (hardware) problems	3.20	1.80	1.40 ***
Creativity and innovation using technology	3.27	2.47	0.80 ***
Reviewing and evaluating ICT developments	3.11	2.39	0.72 ***
Protecting sensitive information	3.55	2.87	0.68 ***
Cybersecurity - Securing IT infrastructures	3.23	2.45	0.78 ***
Policies and practices for securing extended information infrastructures	3.32	2.68	0.64 ***
Average	**3,48**	**2,94**	**0,53 *** **

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation using data from the student/graduate survey

Workforce skills include being able to create documents with standard software such as word processors, spreadsheets, and presentations, using digital skills specific to changing workplace environments such as automation and 3-D printing, utilizing relevant information on digital formats, and understanding legal and ethical conditions in the workplace. Again, the non-ICT group on average score lower than their ICT counterparts on the four skills. The mean scores of both groups on the skills specific to changing workplace environments are less than 3.0. Professional skills at the highest level are made up of 10 skills. At the professional level, the digital skills gap is relatively high at 0.8 points, among which the skills gap in applications programming skills is the highest at 1.5 points. The non-ICT respondents' skills are also extremely limited when it comes to skills related to solving information, software and technical problems (at 1.8). The overall digital skills, measured by the average score of the 33 digital skills items, is 3.5 for the ICT group, or 0.5 points higher than their non-ICT peers.

4.2.3.2 Digital Readiness of Students

To measure digital readiness, the study used the Technology Readiness Index (TRI), first developed by Parasuraman (2000) and later refined by Parasuraman and Colby (2015). The TRI 2.0 consists of 16 questions divided into four dimensions, namely optimism, innovativeness, discomfort, and insecurity. The first two dimensions are positive, while the last two are negative statements.

The attributes of each dimension can be found in Appendix E. To estimate the overall technology readiness index score, negative dimensions (insecurity and discomfort) were first reversed by subtracting from 6 before the means of the four dimensions was calculated.

TRI 2.0 = (Innovative + Optimism + (6-Insecurity) + (6-Discomfort))/4

Table 16 reports the mean scores of each TRI dimension as well as the overall mean of technology readiness by respondents' majors and genders. The score differences between ICT and non-ICT groups were tested using the t-test to confirm statistical significance. The overall TRI score of the ICT group is relatively high at 3.4 out of 5, and 0.2 points higher than the non-ICT group. Males from the ICT-related majors score the highest at 3.4, while female non-ICT major respondents have the lowest score at 3.2. A relatively high Optimism score suggests that Cambodian postsecondary students and graduates are positive about technology and believe it offers flexibility, efficiency, and freedom in people's lives. The Innovation scores, which indicate a tendency to be a technology pioneer, are much lower at 3.3 for the ICT group and 3.1 for the non-ICT group. The statistical t-test results also suggest that non-ICT students and graduates feel more insecure or sceptical about technology, but it seems there is no difference in the level of Discomfort with technology between the two groups.

Table 16: TRI mean score

	All			Male			Female		
	ICT	Non-ICT	Dif	ICT	Non-ICT	Dif	ICT	Non-ICT	Dif
Optimism	4.11	3.99	0.11 ***	4.11	4.05	0.07 ***	4.06	3.94	0.12 *
Innovativeness	3.42	3.10	0.32 ***	3.45	3.22	0.24 ***	3.20	2.98	0.22 **
Discomfort	2.86	2.91	-0.05	2.86	2.94	-0.08 *	2.87	2.88	-0.01
Insecurity	3.17	3.40	-0.23 ***	3.16	3.36	-0.20 ***	3.22	3.44	-0.21 **
TRI	**3.28**	**3.20**	**0.18 *** **	**3.39**	**3.24**	**0.15 *** **	**3.29**	**3.15**	**0.14 *** **

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation using data from the student/graduate survey

4.2.4 Supply of ICT Workforce

In this section, the study examines the enrolment in ICT-related majors at HEIs and TVET technical training institutions, the process of ICT curriculum development, and skills that universities/TVET institutions offer to students and their challenges in delivering quality education/training. It also examines factors associated with students' decisions to enrol in ICT-related majors and the specialisations they choose.

4.2.4.1 Enrolment in ICT Majors

Table 17 indicates that post-secondary enrolment in Cambodia is concentrated in majors related to business, management, marketing, and related support services, which average over 40 percent of total enrolments. These majors are by far the most popular in both two-year associate degree/higher diploma programmes and four-year bachelor's degree programmes. Foreign languages and education are the second and third most popular majors.

Table 17: Enrolment in post-secondary level by major

	Associal degree/ Higher diploma	Bachelor's degree
Business, management, marketing, and related services	43.6%	42.7%
Foreign languages, liteature, and Linguistics	8.5%	10.7%
Education	0.5%	9.8%
Engineering	16.9%	6.8%
Computer and information sciences and related services	8.5%	6.4%
Legal professions and studies	4.5%	6.5%
Engineering	2.0%	4.9%
Social sciences	0.6%	4.0%
Health professions and related programs	3.4%	2.4%
Public administration and social service professtions	0.5%	2.6%
Architecture and related services	1.8%	2.1%
Agriculture, agriculture operations, and related sciences	2.3%	0.9%
Mechanic and repair technologies/technicians	6.6%	0.0%
Others	0.3%	0.2%

Source: Authors' calculations using data from MoEYS and MLVT for the 2018-19 academic year

Enrolment in majors related to computer and information sciences and support services accounted for less than 7 percent in the 2018-19 academic year (8.5 percent in associate degree/higher diploma programmes and 6.4 percent in bachelor's degree programmes). Enrolment in these majors is still dominated by males, as females accounted for about 16 percent of the total enrolment. As shown in Table 18, the enrolment trends in the past four years based on student-cohort analysis show moderate and steady increases in both STEM and IT enrolment. In the four-year period, the share of undergraduate students majoring in IT increased nearly 20 percent, from 6.3 percent to 7.7 percent. Although females accounted for more than half of higher education enrolments in the academic year 2018-19, only 32.7 percent of STEM undergraduate freshmen are female, and the female ratio is much lower still in the IT field at 15.9 percent, although this number is on an upward trend.

Table 18: STEM and IT enrolment trends (%)

	Year 1	Year 2	Year 3	Year 4
Share of STEM enrolment	25.5	24.4	23.1	22.4
Share of IT enrolment	7.7	6.8	6.5	6.3
STEM enrolment (female)	32.7	32.8	34.6	32.8
IT enrolment, (female)	15.9	12.9	12.2	12.2

Source: Authors' calculation based on MoEYS's statistics for the 2018-19 academic year

In the 2018-19 academic year, MoEYS's Department of Higher Education and MLVT's Directorate General of Technical and Vocational Education and Training recorded over 16,000 ICT-major enrolments at 88 HEIs and TVET providers. The enrolment is expected to be higher as enrolment from the private and NGO TVET providers are not available in the DGTVET annual statistics and not all HEIs report to DHE. Annually, about 4,500 ICT-major students (about three-fourths of them are from bachelor's degree programmes) graduate from post-secondary education and training programmes in Cambodia. However, the vast majority of ICT enrolment is concentrated in Phnom Penh (Table 19).

Table 19: Enrolment in ICT majors by programme and province

Province	Associate degree/ Higher diploma		Bachelor's degree		Total	
	Enrolment	Provider	Enrolment	Provider	Enrolment	Provider
Phnom Penh	1,461	17	10,873	35	12,334	36
Battambang	143	5	649	6	792	7
Siem Reap	77	3	706	5	783	7
Kampong Speu	72	2	233	2	305	3
Svay Rieng	78	1	200	2	278	2
Banteay Meanchey	90	3	148	3	238	4
Kampong Cham	88	3	120	4	208	5
Kampot	35	3	162	2	197	4
Takeo	16	2	141	3	157	4
Koh Kong	0	1	155	1	155	1
Kratie	44	2	104	1	148	3
Pheah Sihanouk	7	1	116	2	123	3
Tbong Khmum	-	-	84	1	84	1
Pursat	48	1	26	2	74	2
Kampong Thom	55	2	-	-	55	2
Kandal	45	1	-	-	45	1
Sihanoukville	6	1	16	1	22	1
Kampong Chhang	14	1	-	-	14	1
Prey Veng	-	-	9	1	9	1
Total	**2,279**	**49**	**13,742**	**71**	**16,021**	**88**

Source: Authors' calculation based on MoEYS and MLVT's statistics for the 2018-2019 academic year

Findings from school principals and management indicate that all surveyed HEIs do not offer specific specialisations, as students need to take all required courses with no or limited elective courses regardless of the adoption of the credit system. However, in the student survey, respondents were asked about the specialisations they think they are in. As shown in Table 20, network administration has the highest share among the graduated ICT students, while web development is the most popular among senior students. Although only 3 percent of graduates chose mobile application development as their specialisation, there is a noticeable increase two years later among senior students. There is also a sharp decline in students (from 5.4 percent to 1.5 percent) who are interested in system engineering.

Table 20: Specialisations in ICT majors

Network administration	34.1%	28.3%
Web development	26.7%	33.8%
Database management	8.4%	6.6%
Media and Communication	7.1%	7.1%
System design	5.4%	4.5%
System engineering	5.4%	1.5%
Computer Hardware	3.4%	3.0%
Mobile development	3.0%	8.1%
Others	6.4%	7.1%

Source: Authors' calculation using data from the student survey

4.2.4.2 ICT Curriculum Design and Development

This section examines the process of curriculum design and development. The approaches and perspectives are elicited as to the level of academic freedom the institution is entitled to construct the curriculum and to what extent ICT-related courses are incorporated. It is evident that the post-secondary learning institutions under the jurisdiction of MoEYS and MoLVT have been presented with autonomy in terms of curriculum design and development, with the exception that Higher Education Institutions (HEIs) are requested to submit their curricular to their respective ministries to review and assess the contents of the programmes prior to their implementation. The selection of learning materials and the control of all teaching and learning activities are decentralized at the school level, unlike for general education. This argument was agreed on by both HEIs and TVET institutions during the KIIs.

In addition, it is obvious that universities and TVET institutions have considered the ICT integration into their curricular to be a project priority and strategic direction for promoting pedagogical innovations and strengthening the quality of teaching and learning delivery methods. When asked how a curriculum is designed, both private and public institutions emphasized that their institutions consist of a curriculum development office, and their stakeholders are inclusive of student alumni and private sector actors related to their degree programmes. Moreover, they also acknowledged that they have expanded their focus on the linkage with industry to mobilize labour market information that enables them to identify the skills shortages, skills in high demand, and cutting-edge technologies that all institutions should consider incorporating into their curricular. One management staff member narrates their experience in approaching the industry, as follows:

> “*I believe, for the Faculty of Information Technology, this falls under my [the Dean's] responsibility. My faculty does not only provide technical support at the university. We also pay a visit every year to companies, one of which is Angkor Beer. I meet with the companies' management teams to discuss in-demand skills. As a result, we have our action plan, which is annually updated. We do the report every three to six months about our action plan.*”

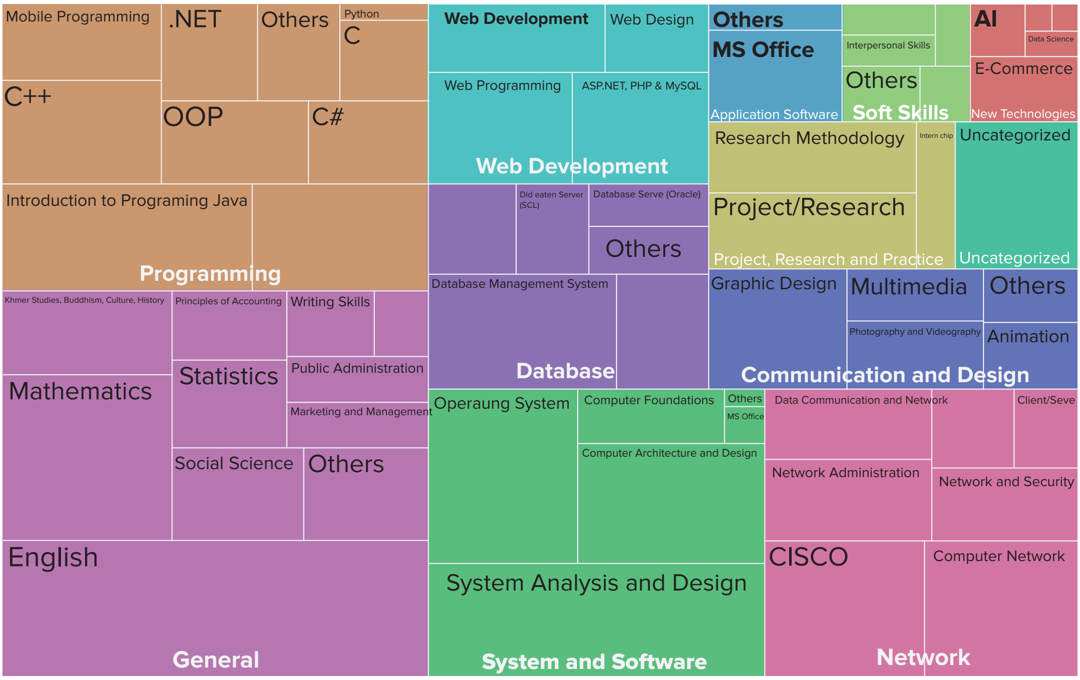
Information on how cooperation between the institutions and the private sector are initiated was also collected. One of the approaches is through the establishment of a Memorandum of Understanding (MoU), which is a useful resource that proves advantageous for institutions to collect labour market information. The results from key informants show that all institutions have an office that holds responsibility for public relations. Their priority is to develop and maintain the (existing) networks. The primary intent might be collecting market information, but in practice, it is to share employment opportunities with students. One university with sufficient financial resources highlights that:

> “*My university invites firms to conduct presentations at my institution, aiming to get them to share their experiences and employment opportunities. Moreover, my university can help budget each faculty to host a meeting with stakeholders to discuss the needs and demands for skills in the labour market and thereby revise their curriculum upon receiving the inputs from the stakeholders.*”

What is more interesting to note is that when it comes to their stakeholders, the most important source that enables institutions to keep up with the fast-changing trends in the labour market and in technological advancement is their student alumni, and their active engagement with the institutions. In alignment with MoEYS's higher education policy, many interviewed HEIs have conducted tracer studies to examine their alumni employment outcomes after graduation. It can also serve as a tool to receive feedback from graduates and to assess whether skills acquired at schools well respond to the demands in the market.

The process to construct the curriculum and its contents are barely distinguishable between HEIs and TVET institutes. However, what this study is aware of is that TVET institutions stress the importance of occupation-specific components in their curricular. Having obtained information from all stakeholders, the institutions have substantial evidence that can be conclusively proven effective for a curriculum design that is applicable to all geographic and demographic variation. This is why HEIs and TVET institutions have the complete ability to embrace the pace of major development in the market and fast-changing technology, and thereby incorporate ICT-related courses into curricular either in ICT or non-ICT curriculum. These ICT courses can serve as a bridge to smooth the transition from high school to higher education.

Figure 10: ICT-relation curricula at HEIs



Source: Authors' calculation using data from sample HEIs

Curriculum analysis based on subjects taught at HEIs in Cambodia is shown in Figure 10. The study collected the most recent ICT-related major curricular of the target HEIs from their websites or directly from the schools during the interviews. About one-fourth of the curricular was found to be dedicated to general subjects including English, mathematics, and statistics in the foundation year as recommended by the Accreditation Committee of Cambodia (ACC). The ACC is tasked with quality assurance for higher education. Subjects related to programming accounted for 17 percent of the total subjects, followed by systems and software (14 percent), and network (12 percent). It is worth noting that although all the interviewed HEIs have adopted the credit system, there were no or very limited elective subjects from which students can choose their subjects of interest. The results of the key informant interviews indicated that most sample HEIs offer a basic computer course(s), mainly on MS Office and the use of internet and e-mails, in the first year to all students including non-ICT students.

The World Economic Forum has updated its prediction on future jobs, which includes the growing demands for new emerging skills including data analysis and science, AI and machine learning, big data, robotics engineering, and process automation (WEF, 2020). Most of the leading professions in the future are related to new technologies. However, only a fraction of HEIs offer subjects related to emerging technologies such as cloud computing, data science, machine learning, AI, and fintech. Among all interviewed HEIs, only two schools have introduced Python, a popular programming language in data science. Many interviewed HEI managements believe that soft skills are well integrated into their regular courses and that it is effective enough to equip their students with the soft skills needed in the workplaces. But this study's firm survey suggests that Cambodian general education and higher education fail to adequately equip students with sufficient soft skills that are highly appreciated at work. From the employer perspective, soft skills such as general attitude to work, communication skills, and problem-solving skills are the skills that both ICT and non-ICT firms in Cambodia need the most. As shown in Figure 10, very few HEIs include soft skill subjects in their curricular, probably due to the lack of information on these skills gaps at the management level of the institutes.

4.2.4.3 Determinants of ICT Major Choice

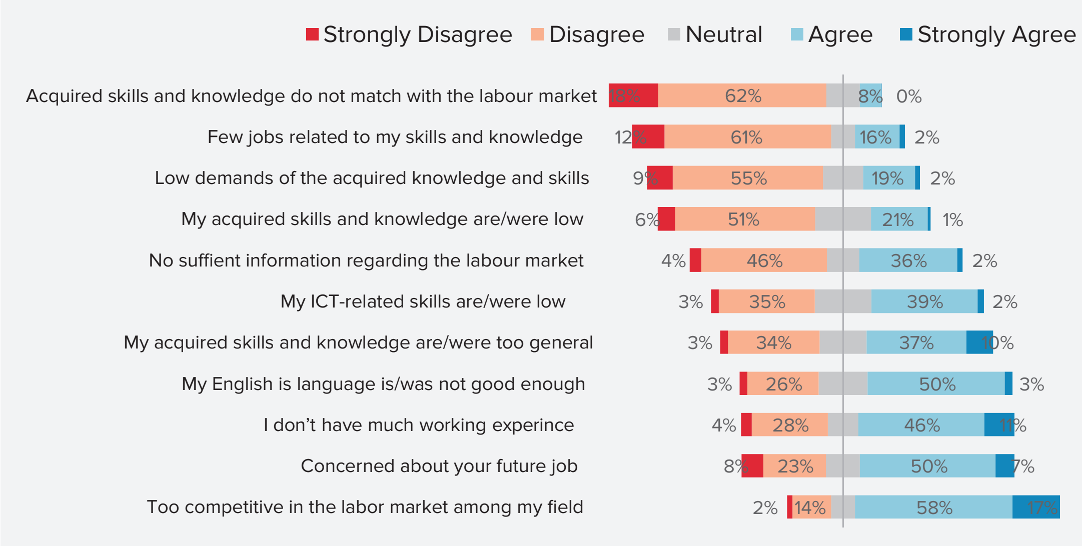
This section presents factors associated with students' decisions to enrol in ICT-related majors. The Probit regression results (Appendix C) suggest that gender is the strongest predictor of the examined factors of ICT-related major choice. Male students are 41.7 percent more likely to enrol in majors related to ICT, although a smaller coefficient in the student sub-sample analysis in comparison to the graduate sub-sample indicates that the gender factor is less predominant in recent years. Student age is negatively correlated with enrolment in ICT-related majors. In other words, enrolment in ICT majors is higher in younger students. Other factors positively associated with ICT-related major choice include social-economic status and self-efficacy in mathematics. Students from better-off households seem to be less likely to choose ICT-related majors in comparison to those from the middle class. Also, students who reported that they are good at mathematics when there were in grade 12 have a higher chance of enrolling in ICT-related majors. Although it is not consistent across the sub-group, mother's education appears to positively influence the decision of females in selecting ICT-related majors for their postsecondary education and training. A student's high school stream in social science or the science track appears to have no significant influence on enrolment in ICT-related majors. Most students (nearly 85 percent of the study's sampled students) chose the science stream, but very few decided to enrol in STEM majors in higher education. The weak association between high school stream and choice of an ICT major can be partially explained by the fact that the study treats students of other STEM majors (engineering, agriculture, basic science, and health) as the control group.

4.2.5 Student Concerns and School Support

Students were asked to rate their concerns on their career prospects using a five-level Likert scale based on eleven items, as shown in Figure 11. More than half of them appeared to worry about their future jobs when they were students. Competitiveness in the labour market, followed by lack of working experience and English proficiency seemed to be at the forefront of students' concerns. However, from their perspective, the mismatch between acquired skills and the labour market was not seen as a major issue. Only 8 percent of respondents expressed their concern on this issue and 18 percent thought there were few jobs related to their skills and knowledge. A significant proportion of them (over 40 percent) considered their ICT skills to be rather low.

Overall, ICT students were slightly less concerned about their career prospects. They were also worried less about the lack of jobs related to their skills and insufficient information about the job market. However, around half of them, slightly higher than that of non-ICT students, thought their acquired skills and knowledge were still too general. Nearly 80 percent of them agreed or strongly agreed that the job market in their field is too competitive.

Figure 11: Concerns expressed by students



Source: Authors' calculation using data from the student/graduate survey

As mentioned, lack of working experience is one of the major concerns students have when seeking a job. As a way to enter the world of work before graduation, students seek internship opportunities and information on job vacancies through their schools, teachers, or by themselves. Most of the interviewed HEIs have an office to help connect students with companies that offer internship programmes. Of the sampled students and graduates, 53.3 percent acknowledged the existence of their school's career support office, 33.5 percent did not think there was any such office, and the other 13.2 percent were not sure. However, less than 40 percent of those who knew about the career support office had sought support from the office. Since an internship is a requirement for some majors, it is too much of a burden for schools to find internship positions for all students. In many cases, students need to look for internship positions by themselves. Based on the survey, 34.5 percent of students who conducted internships obtained the positions through their school networks. Among students who solicited assistance from their school's career support office, more than half of them sought internship opportunities.

Nearly 40 percent of the 1,022 students and graduates conducted an internship programme at least at one workplace. Two out of five students participated in at least one internship programme as a school requirement. ICT students were more proactive in seeking internship programmes, as more than half of them had participated in such a programme. Internship providers included Cambodia enterprises (50.7 percent), foreign enterprises (20.3 percent), and government institutions (14.2 percent). Nearly two-thirds of the internship positions were paid. The duration of internship could be as short as one week and as long as three years, but on average, the internship duration was 5.3 months. Although legally internship programmes should not be longer than six months, the results of this survey indicated that more than 15 percent of the internship programmes exceed this threshold.

4.2.6 Educational Technologies Adoption During COVID-19

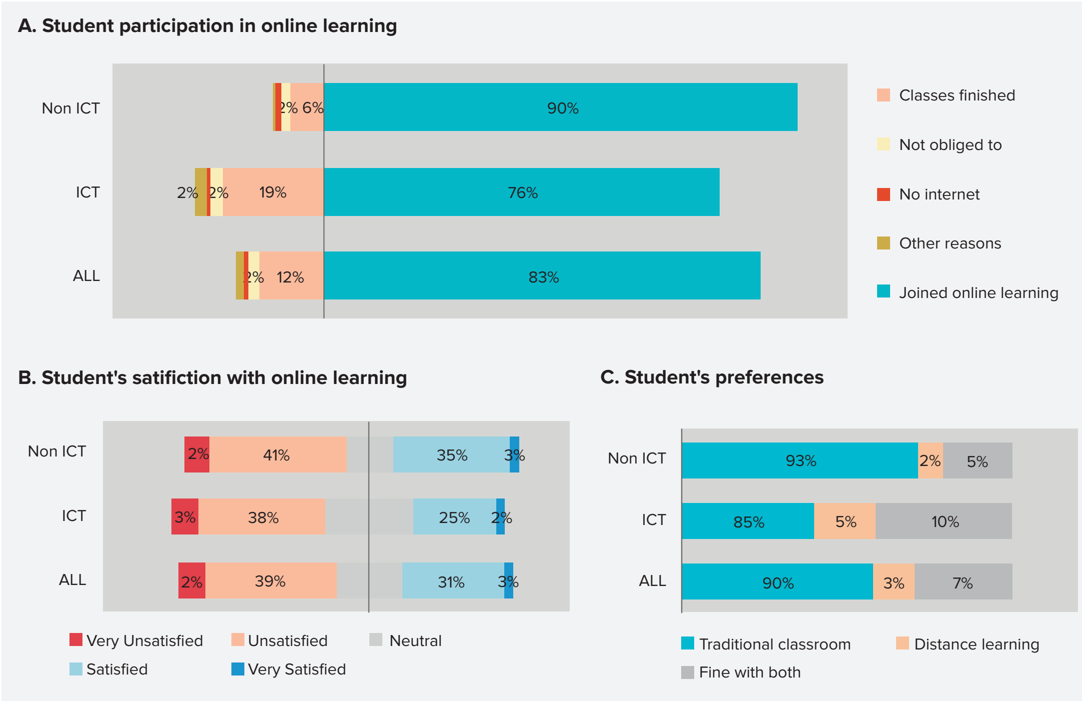
This section illustrates how learning institutions responded to the COVID-19 pandemic by switching to distance learning and adopting educational technologies, as well as the challenges and opportunities brought by the pandemic.

Higher education in Cambodia has faced immense challenges during the COVID-19 pandemic. In March 2020, the Ministry of Education, Youth and Sport directed all learning institutions, including HEIs, to temporarily close their campuses, and in May 2020, all schools were requested to provide distance learning. HEIs had no option but to embrace educational technology to keep learning opportunities available regardless of their limited human resources and infrastructure, and to move all their classroom activities online. Despite the MoEYS guidelines for general education such as initiatives to televise lessons and deliver live lectures on social media, higher education learning was left to the decision of each HEI (UNESCO, 2020).

However, less well-off HEIs, especially those outside of Phnom Penh, found themselves constrained with few tools or guidelines for them to move forward. Some HEIs suspended teaching for several months before being able to start distance learning programmes. According to the KIIs with HEI management, only eight HEIs had started offering some form of online learning by the MoEYS' directive in May, which requested schools to move to virtual classrooms. The remaining HEIs commenced distance learning after mid-May, two months after school closures. The student survey also confirms the late adoption of education technology, as over 20 percent of the final-year students did not start their online learning until June 2020. The online learning platforms also vary across HEIs. While most schools either use Microsoft Teams or Google G Suite for Education to deliver their online learning, a few schools only share learning materials with students through Telegram to continue their learning. Two HEIs out of 18 interviewed schools had developed their learning management system (LMS) using the open-source system Moodle.

Figure 12 presents students' participation in online learning, their satisfaction and preferences of learning approaches. According to the student survey, more than 80 percent of the final-year students participated in online learning by the time the survey was conducted between mid-July and the end of August. The participation rate is lower among ICT students, however, a large proportion of students did not join the online learning because they had completed all the required courses. Only a small proportion of students did not join online learning due to access to the internet or other reasons. Nearly half of the surveyed students were unsatisfied or very unsatisfied with the online learning implemented by their respective schools, and only one-third of them were happy with virtual learning. Asking what their preferred learning approaches were, more than 90 percent of them were in favour of traditional classrooms. ICT students were more positive about the new learning approach, with around 15 percent of them preferring online learning or reporting that they were fine with either face-to-face or remote learning.

Figure 12: Students' online participation, satisfaction, and learning preference



Source: Authors' calculation using data from student/graduate survey

It is not without challenges that learning and training institutions are suddenly forced to adopt new technologies to replace the traditional classrooms. The results of KIIs indicate some key challenges including poor internet connection (particularly in rural areas), difficulty in assessing student performance, unreadiness of some teachers and students (older teachers and freshmen) in adopting new technologies. Although the results of the student survey indicate that nearly all final-year students have access to a computer or smartphone at home, the access to computers at home among non-ICT freshmen appears to be much lower, according to the KIIs with HEI management. Many interviewed management teams also indicated the failure of the ICT programme in secondary education as a reason for students' limited ICT knowledge. For this reason, most HEIs include basic computer courses such as MS Office in their curricular for the foundation year.

Nevertheless, the interviewed school principals also acknowledged the opportunities brought by the pandemic. Most of them were positive about the possibilities of introducing blended learning or of continuing to offer online courses even after the situation returns to normal. It was also a good opportunity for both teaching staff members and students to learn new things and technologies, and to acquire new digital skills.

05. Discussion

This section discusses the main findings of the firm and student/graduate surveys. These discussion points have relevant policy and programme implications. Particularly, the study substantiates future demand for ICT and digital skills, geographical and gender disparities in STEM enrolment and pay, modernisation of STEM curriculum and subjects, public-private partnership, skills mismatch and shortage, and adoption of new technologies, specifically in the context of COVID-19.

As shown, ICT and non-ICT firms surveyed are optimistic that their demand for ICT and digital skills and occupations will increase in the next two years. ICT firms are more positive in their future hiring of ICT occupations at an average rate of 40 percent between 2021 and 2022, compared to 20 percent of non-ICT firms. Occupations that interviewed employers and representatives of business associations expected to hire in the future include ICT sales professionals, software and application developers, e-marketing professionals, web developers, and programmers. Although it is not directly evident from the results of the firm survey that there are future demands for emerging new skills such as data science, big data, artificial intelligence, machine learning, robotics engineering, and process automation, demand for such skills was raised, to some extent, by the key informants. At the current stage of Cambodia's development, although these skills are crucial to support the realisation of the framework for a digital economy and society, this would require significant investment in soft and hard infrastructure that needs public-private partnership. The results of the key informant interviews also indicate that data privacy and security need to be considered with the new skills given that analyses are data driven.

Gender differences in STEM major enrolment in tertiary education remains uniform though several initiatives have been launched and some advances have been made. A large proportion of Cambodian STEM-major students enrolled in ICT-related majors. Nonetheless, only 13.2 percent of sampled graduates and students in this area were female. On a positive side, the gender gap is narrowing given a higher female ratio of ICT senior students of the 2019-2020 academic year (17.8 percent), in comparison to the female ratio of students that graduated in the 2017-2018 academic year (10.1 percent). Gender-related stereotypes and personal interests appear to be major factors associated with low female enrolment in STEM majors. The gender-based stereotype has its root in socio-cultural factors, including the beliefs and expectations of the society on the perceived abilities of each gender. Men, for instance, are perceived to be more rational and analytical, while women are perceived to be more expressive in terms of emotions and lack of self-control over emotions (Wang and Degol, 2017). Although the grade 12 national examination results in 2019 suggest that males performed better in mathematics, the difference is not noticeable, and females slightly outperformed males in physics. In other words, cognitive abilities seem not to be a pronounced constraint for female students to pursue STEM majors in higher education.

The analysis of curriculum suggests that Cambodia's HEIs could have put more effort into introducing courses related to cutting-edge technologies such as data science, blockchain technologies, cloud computing, and fintech, and at the same time equip students with 21st century skills, such as critical thinking, problem solving, communication, creativity, and collaboration. The lack of courses related to new technologies is potentially due to insufficient human resources and HEIs' investment budgets. It is worth noting that due to school competition for students, there was a small increase in tuition fees in higher education over the last decade. The incremental rate is much lower than the inflation rate. Nevertheless, for higher education to be able to produce competent human resources, general education also needs to help equip students with better skills and knowledge. Most HEIs still dedicate the first semester or year (mostly known as the foundation year) to preparing their freshmen by teaching basic computer literacy and the English language as many students failed to acquire these skills and knowledge even after completing upper secondary school.

Evidence from the firm and student surveys further indicates linkages between universities/TVET institutions and companies (ICT and non-ICT), either through formal MoUs or periodic consultations/conferences with relevant stakeholders. Although current collaboration with universities/TVET institutions remains limited and periodic, owners/managers of the surveyed firms are keen to deepen cooperation to help narrow general and digital skills gaps and to enhance technology adoption in response to the Fourth Industrial Revolution. This is consistent with the study's framework of the Fourth Industrial Revolution, which stresses the importance of public-private partnership. In addition to the usual channels of collaboration (e.g., MoUs, consultations, participation in conferences, and internship opportunities), there is a possibility to establish a sector skills council for ICT, which would help define occupations in this sector and determine required skills and qualifications to inform curriculum development and programme delivery at TVET institutions and universities. With their strong network and knowledge of the ICT industry, the council would also help place students for internship opportunities and tap industrial resources for education and training. Joint research collaboration could be another avenue to explore, in which private firms work with universities/TVET institutions on research projects aiming to solve specific problems the firms face.

Moreover, findings from the study suggest that skills mismatch is less severe in comparison to what was found by Sam (2019) using data of graduates collected in 2011. ICT graduates are more likely to work as associate professionals or at a higher level that is suitable to the education level they obtained. In other words, they are less likely to be overeducated for their jobs in comparison to their non-ICT peers. Still, more than one-third of ICT graduates do not work in ICT-related sectors. Nearly 30 percent of sampled ICT students and graduates expressed their concern about job prospects due to their low ICT skills, while only 14.1 percent thought there were few jobs related to their skills. This implies that rather than the lack of demands in the ICT job market, the issues may lie in the knowledge and skills students acquired from school. This is also reflected by employers of sample firms. Specifically, the results from the study's key informant interviews indicate that Cambodia continues to face skills gaps and shortages, implying that there is not a sufficiently qualified ICT workforce and the qualification of the current workforce does not meet the needs of employers. For example, an interviewed employer stated that:

> *"It applies to both the quantity and skill. As for quantity, the number does not meet the demand. As for skill, they do not have the practical knowledge after their graduation. For example, while they graduated as a code developer, they have no experience relating to that kind of work. The kind of knowledge and experience needed requires a lot of trainings. Based on what I know, the Japanese investors need specific skills in workers. For example, if they need a code developer, the person must have advanced knowledge and experience in the field."*

Another respondent noted that:

> *"I think we have higher demand in regard to supply. As the result, why do you have so many foreigners filling all of those roles? Because if you talk to the business community, they really struggle because people who are supposed to be trained in this area are not getting sufficient training, certification and (ac)creditation."*

In addition, soft skills are considered one of the skills gaps. In the words of a respondent:

> *"From what I have seen, and also from what I heard from private sector companies, the number one skill is soft skills. Just to know how to work, to be in the office or to be able to say 'I don't understand the instruction'. Those things are not unique to only Cambodia."*

The results of skills gaps imply that ICT firms are more likely to report more digital skills gaps among their ICT employees than among non-ICT employees. Nonetheless, non-ICT firms report more digital skills gaps in their non-ICT employees than ICT employees. This might mean that ICT firms require more digital skills for their ICT employees than the non-ICT firms. On the other hand, non-ICT firms are satisfied with the digital skills of their ICT employees but expect that their non-ICT staff have more digital skills.

The results of the key informant interviews further indicate that the required skills in this digital era include adapted learning skills, creativity and critical/logical thinking skills, digital literacy, understanding how computers and the internet work, and foreign languages. Adapted learning is necessary for learning new digital skills, as shared by several key informants:

> *"All the software we are using are already quite different or very different from five years ago and it will change again and keep changing. So, more than being taught how to use some very specific system, it is actually much more about having the adapted learning skills."*

> *"Especially in the IT space, it's constantly evolving and changing, and you have to be able to continuously learn to learn and adjust and adapt and adopt new technologies, new ways, new processes."*

> *"I would not be so favourable of teaching people in detail how to do some specific ICT applications while in school because by the time they finish school and try to work, the technology probably would have changed. Suppose you teach your students in great detail how to use word processors, Microsoft Word, Office 365 [...], yes, it could be useful up to a point. But as I said, you know, 10 years later when they join the workforce, the whole thing will be different."*

With respect to critical thinking skills, a respondent further noted:

> *You won't need many detailed technical skills. So, for ICT skills again, the core skill that people need is some basic digital literacy such as how devices work and networks work. But more than that, [the skills needed] are critical thinking and problem solving.*

A lack of soft skills has been an issue for at least the last decade. It is not uncommon to encounter research findings that point to the problem (NEA, 2018; Bruni, Luch and Kuoch, 2013). For instance, analysing data of 500 establishments in six sectors (food and beverages; garments, apparel, and footwear; rubber and plastics; finance and insurance; and accommodation), Bruni et al. (2013) highlight soft skills in oral communication and foreign language as the two skills gaps which need improvement. This might suggest new thinking on the part of educational pedagogies and teaching methodologies adopting a more collaborative and project-based approach to teaching and learning. This would enable students to interact with their peers and to increase exposure to real-world applications.

Technology has changed the ways businesses are modelled and operated, the ways teachers teach, and the ways students learn and later search for jobs. For example, finding jobs through newspapers has become obsolete, and a growing number of students now look for jobs online or via social networks. In addition, under the 4IR framework, the adoption of new and relevant technologies is crucial. The results from the firm survey show a certain level of technological adoption by firms even though the types of technologies adopted remain at the basic stage. Using digitalised data and cloud storage is common. There was also optimism on the side of educators that opportunities exist that were brought by the COVID-19 pandemic. The majority of the interviewed school principals and teachers are positive about the possibilities of introducing blended learning or of continuing to offer online courses even after the situation returns to normal. It is also a good opportunity for both teaching staff and students to learn new technologies and to acquire new digital skills. This, however, is not without challenges. The results of the study's key informant interviews indicate that poor internet connection (particularly in rural areas), difficulty in assessing student performance, and unreadiness of some teachers and students (older teachers and freshmen) in adopting new technologies are some of the challenges that the government and school management need to address.

06 Concluding Remarks and Policy Implications

This report employs the Fourth Industrial Revolution framework to: (1) study demand for and supply of ICT and digital occupations and skills; (2) identify the ICT-related subjects and skills that universities/TVET institutions offer to students, and skills students acquired during the programmes; and (3) identify support and challenges faced by universities/TVET institutions to produce qualified ICT students and how the management teams of these institutions tackle these challenges. To address these objectives, the study combines quantitative analysis of firm and student survey data with qualitative analysis of key informant interviews with employers of ICT and non-ICT firms and principals/teachers of higher education institutions and TVET institutions.

The firm survey results show that there has been a growing trend of ICT-related businesses for the last decade, the majority of which are micro and small. The demand for ICT and digital skills and occupations by ICT and non-ICT firms is expected to increase in the coming years (2021-2022), averaging 40 percent for ICT firms and 20 percent for non-ICT firms. This implies that higher education and TVET institutions should be ready to supply qualified graduates to meet the demand. In doing so, higher education and TVET institutions would need to close skills mismatch and shortage—a remaining issue in the ICT job market.

The study also observes an increasing trend in STEM enrolment. However, STEM education remains male dominated despite continued efforts by the government and other stakeholders to increase the share of female students and graduates in the sphere. In addition, access to ICT and digital education and infrastructure continues to be an urban phenomenon, leaving a significant number of educational institutions in rural areas with limited resources to adapt and adopt to new technologies. This demands for gender and geographically sensitive approaches to STEM policy and programmes. It is also important that the government, together with development partners, continue initiatives such as Sisters of Code, STEM Sisters Cambodia, and Technovation Girls, to name a few, to provide female students opportunities in science and technology.

Although the current level of technology adoption among firms remains relatively low and at the initial stage, adoption is expected to increase. This, however, requires an inclusive and conducive ecosystem and a strong public and private partnership to ensure a healthy and continued adoption. Support is particularly needed for micro, small, and medium-sized enterprises as they lack necessary financial and human resources to absorb and to operationalise new technologies. The study also concurs that industry-university linkage is necessary to reduce skills mismatch and shortage and to enhance adoption, and that the collaboration should be done more systematically.

This study is not without weaknesses. First, given limited information on unregistered firms constraining efforts to establish a comprehensive sampling frame, the firm survey covers registered firms. Future research should aim to include informal firms as their challenges and, thus, solutions to demand for skills and technology adoption might be different. Also, about 93 percent of the surveyed firms are micro, small, and medium. Large firms account for 7.5 percent of the total. Future studies on similar topics might seek specific insights from large firms given their extensive experience in technology adoption and challenges in obtaining the right ICT and digital skills. Second, occupational and skills classification should have included emerging new occupations or skills particularly under the 4IR framework. Future studies might want to include occupational classification such as the O*NET database. Third, comparison of wage premium between graduates of ICT majors and those of non-ICT majors is carried out within a two-year period which is considered short term. Efforts should be made to examine labour market performance of graduates in these two classes of major over a longer time horizon.

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APPENDIX A: DETAILED SAMPLING DESIGN

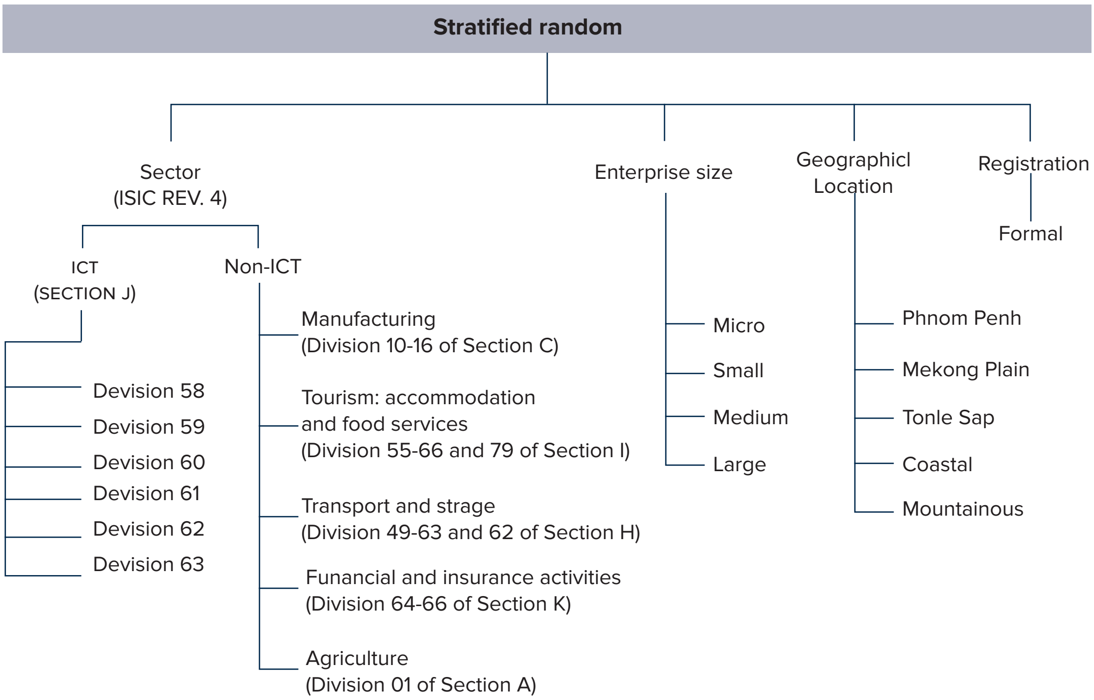
Firm Survey

The qualitative information is complemented by a survey of 202 firms operating in the country. A stratified random sample is used to select the desired sample size. The sampling method is chosen in lieu of a simple random sample for several reasons:

- To obtain unbiased estimates for different subdivisions of the population with some known level of precision.
- To ensure that the final total sample includes establishments from all different sectors and other desired criteria, and that it is not concentrated in one or two industries, sizes and/or regions.
- To exploit the benefits of stratified sampling where population estimates, in most cases, will be more precise than using a simple random sampling method (i.e., lower standard errors, other things being fixed).
- Stratification may produce a smaller bound on the error of estimation than would be produced by a simple random sample of the same size.
- The cost per observation in the survey may be reduced by stratification of the population elements into groupings than the simple random sample.

Figure A.1 illustrates various stages of the sampling procedure used in the data collection. The proposed stratification is to ensure a nationally representative data of formal IT and non-IT firms operating in the country. The four levels of stratification are: industries, enterprise size, geographical location, and firm formality. Industrial Standard Classification Code (Rev. 4) is used to categorize firms. IT sector covers enterprises in Division 62 of Section H. This includes computer programming activities (6201), computer consultancy and computer facilities management activities (6202), other information technology and computer service activities (6209), data processing, hosting and related activities (6311), and web portals (6312). Manufacturing covers divisions 10-16 of Section C; tourism: accommodation and food services activities (divisions 55-56 and 79, Section I); transportation and storage (divisions 49-53, 62 of Section H); education (division 85, Section P); financial and insurance activities (divisions 64-66, Section K); and agriculture (Division 01 of Section A).

Figure A.1: Sampling design



The sample firms cover micro, small, and medium enterprises and large enterprises with the following definition.

Table A.1: SME Definition

	Total asset	Number of employees
Micro	< $50,000	1-10
Small	$50,000 – $250,000	11-50
Medium	$250,000 – $500,000	51-100
Large	> $500,000	>100

Source: SME Development Framework (unpublished 2017), MISTI

As shown in Table A.1, assets and number of employees are used for enterprise classification. Since data on assets is, to our knowledge, not reliable, we use number of employees. The inclusion of micro firms is that certain IT companies have less than 10 employees but hold more assets. Table A.2 provides detailed criteria used in the sampling procedure.

Table A.2: Sectors and other criteria covered by the survey

Excluded	Included
Sectors	**Sectors**
Fishing	Agriculture
Mining	Manufacturing
Public utilities	Hotels, guesthouses and restaurants
Public administration	Transportation and storage
Public and private education (secondary or lower)	ICT
Gambling	Financial intermediation and insurance
Other criteria	**Other criteria**
Partial or 100 percent state-owned enterprises	All firm sizes
	Geographical location (Phnom Penh, Mekong Plain, Tonle Sap, Coastal and Mountainous)
	Formal (registered with Ministry of Commerce or Ministry of Posts and Telecommunications or both)

Source: Authors' preparation

A combination of sampling frame of companies from the Ministry of Posts and Telecommunications (MPTC) and Ministry of Commerce (MoC) is utilised. A list of firms registered with MPTC was given, whereas those registered with MoC was compiled by the research team.

The power calculation indicates that a sample size of 202 ICT and non-ICT firms would be representative of the sample frame used in the study with a 90-95 confidence level. Nonetheless, due to several reasons, we could interview 202 (67.3 percent of the total number). This would also reduce the confidence level to 90-93 percent, which remains statistically acceptable.

Student/Graduate Survey

The population of the student survey is the final-year postsecondary students enrolling in either higher diploma/associate degree or bachelor's degree programmes. Statistics of the MoEYS and MLVT recorded more than 1,100 second-year students enrolling in the higher diploma/ associate degree programme and approximately 40,000 senior students in the academic year 2019-2020. For the purpose of this analysis, we conduct a power calculation to identify the optimal sample size required to detect statistically significant differences of outcomes of interest. That is, whether examined labour market performance of ICT-major graduates are significantly different from those of non-ICT-major graduates. The outcomes of interest are the difference in employability and monthly wage earnings of graduates in the two groups. The power calculation indicates that a sample size of 618 individuals is required to detect the minimum impact on the outcome variables at a 10 percent confidence interval. Therefore, our initial plan to collect a sample of 1,000 of which 600 are graduates is statistically sufficient. Table A.3 illustrates the results of power calculations.

Table A.3: Results of the power calculation

Impact	Alpha	Power	N	Delta	μ_0	μ_1	s.d
5%	0.05	0.8	2395	0.05728	178.6	187.5	155.7
10%	0.05	0.8	618	0.1129	178.6	196.1	155.7

Source: Authors' calculation

A two-stage random sampling design is used to select a national representative of students and graduates of higher education institutions (HEIs). The first stage involves selecting HEIs as primary sampling units (PSUs). According to the latest Education Congress Report, in 2020 there were 124 HEIs in Cambodia under 16 different ministries and agencies, of which 101 (81.4 percent) were under the Ministry of Education, Youth and Sport (MoEYS) and the Ministry of Labour and Vocational Training (MLVT) (MoEYS, 2020). Only main campuses of HEIs under these two ministries providing at least one ICT major with student enrollment higher than 500 are included in the sampling frame for the first stage, which is sampled based on probability proportional to size (PPS). The number of total students enrolled is used as probability weight to ensure that major HEIs are more likely to be selected as PSUs. Lists of HEIs and student enrolment statistics are obtained from MoEYS and MLVT. However, the list from MLVT does not include private HEIs. NIPTICT is later added to the list of the selected HEIs. Amongst those selected, students and former students from 22 HEIs participated in the survey.

At the second stage, respondents are randomly selected by student status stratum (student vs. graduate) and major stratum (ICT-related or non-ICT related). Lists of final-year students (second year for the associate degree or higher diploma, and senior year for the bachelor's degree programme) and students who graduated in the 2017-2018 academic year are obtained individually from the selected HEIs.

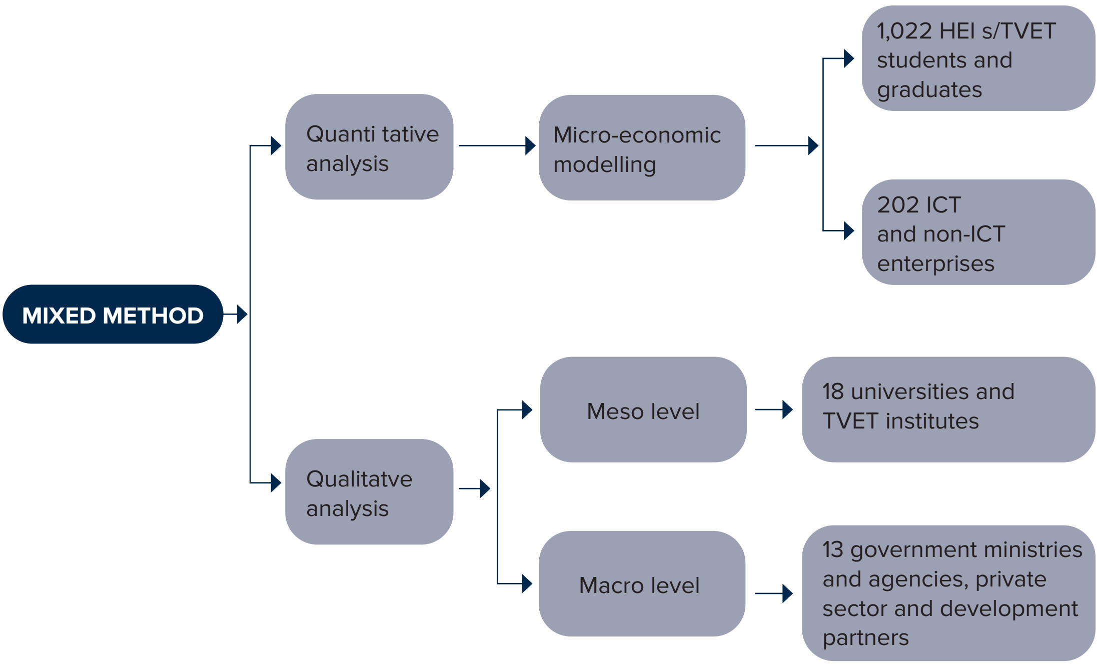
1,022 respondents (411 students and 611 graduates) participated in the student survey. Of the 411 students, 202 enrolled in majors related to ICT, while the remaining enrolled in non-ICT majors. For the graduate sample, 296 respondents are in ICT-related majors, and 315 in non-ICT majors. As recommended by Cohen (1988), the power level is set at 0.8 and the significance level, the probability that we commit the type I error (false positive) is set at 0.05. This means that we are 80 percent certain that our sample can detect the impact if it exists. There is also a five percent probability that we can wrongly detect an impact when in reality there is no impact (Type II errors).

The survey was administered through face-to-face interviews between 15 July and 31 August 2020. Since all HEIs were physically closed after mid-March due to the COVID-19 pandemic, enumerators contacted students via phone and met the respondents at the place designated by them. The data collection took place in Phnom Penh, Kandal, Takeo, Kampot, Svay Rieng, Prey Veng, Kampong Cham, Kampong Speu, Kampong Chhnang, Battambang, Banteay Meanchey, and Siem Reap.

APPENDIX B: EMPIRICAL METHODS

Figure B.1 outlines the identification strategy in accordance with the research objectives and theoretical framework proposed in the study. The study adopts a mixed method of quantitative and qualitative analyses, utilising information from the latter approach to complement and to contextualise estimated results from micro-econometric estimates.

Figure B.1: Estimation strategy



Source: Authors' preparation

Micro-econometric Modelling: Student/graduate Level

The student/graduate level analysis examines how ICT skills and knowledge affect market outcomes of graduates. We estimate the following equation:

$$Y_i=\beta_0+ \beta_1 ICT_i+ \beta_2 Edu_i+\beta_3 Exp_i+ \beta_3 X_i+ \mu_i$$

where Y_i is a set of labour outcomes (log of monthly wage, duration of the transition from school to work, and type of employment) of individual i; ICT_i is the dummy variable taking the value 1 if individual i majored in ICT otherwise 0; Edu_i is the dummy variable taking the value 1 if individual i graduated from bachelor programme otherwise 0; Exp_i is a continuous variable of individual i's working experience in month; X_i is a vector of other covariates, such as sex, age, ability (using examination score as the proxy), marital status and characteristics of their alma maters; and μ_i is the error term. A shortfall of the Mincerian earning function is the concern of endogeneity of education variable or ability bias, that individual ability is likely to positively correlate with both educational attainment and earnings (Heckman, Lochner, and Todd, 2006).

Another concern is the selection bias issue. Individuals who chose ICT-related majors are likely to have different characteristics from those who decided to study non-ICT majors. Randomized Controlled Trial (RCT) is the gold standard for measuring the causal effect that can address this kind of issue. However, for some obvious reasons, it is not always ethical to conduct experimental studies using the RCT approach. For instance, we cannot randomly select two groups of individuals and assign them as a treatment group (to study ICT-related majors) and a control group (to study non-ICT-related majors) to evaluate the impact of the major choices. Besides, it very costly to conduct an experimental study. When RCT data is not available, there are some quasi-experiment methods to address the selection bias issue, although they are less rigorous in comparison to the randomized controlled trial (RCT). The common methods include regression discontinuity design (RDD), instrument variable (IV), Difference in Difference (DiD), and Propensity Score Matching (PSM) (Angrist and Pischke, 2008). In this study, we will use the inverse-probability weighted regression adjustment (IPWRA), an improved matching method using the PSM concept, to estimate the effects of our interest.

Propensity Score Matching

Two critical assumptions are required to yield suitable comparison groups. First, the conditional independence assumption that the outcomes Y are independent of treatment assignment D conditional on observable covariate X. This means that the outcome variables must be independent of the treatment conditional on the propensity scores. If Y_1 and Y_0 are the outcomes for treatment and control groups respectively, conditional independence can be expressed by $(Y_1,Y_0 \perp D_i | X_i)$. Secondly, we need a good balancing and strong common support to ensure that there are enough matches to make the comparison (Khandker, Koolwal, and Samad, 2009). The average treatment effect, $ATE=E[Y_1-Y_0]$, is the expected effect on the outcome.

As the treatment is binary, a probit model will be used for the propensity score estimation. Choosing variables to include in the estimation to ensure the conditional independence is a crucial part, as excluding important variables can increase the biased estimation of the scores. We need to collect baseline information prior to their enrolment (using recall method) to estimate the probability of the major choices (ICT-related and non-ICT-related). The baseline information is used as observed factors to construct the propensity score, $P(X)=Pr(D=1|X)$ for the matching.

There are several methods to match the participants to the non-participants based on the propensity scores, such as nearest-neighbour matching (with or without replacement), radius matching and kernel matching. In this study, the inverse-probability weighted regression adjustment (IPWRA) is used for the estimation of programme effects. It is a two-stage regression that models both the outcome and the treatment, to account for the non-random treatment assignment. The treatment model (inverse-probability weighted estimators) in the first stage predicts the probability that students are likely to choose the ICT-related majors based on our observable covariates. The outcome model (regression adjustment estimators) computes the labour market outcome by controlling factors that can influence the outcomes. An advantage of IPWRA estimators, unlike classical propensity score matching methods, is that the

IPWRA can control for the factors that influence the outcomes in the second stage regression adjustment. By evaluating the results of different types of the matching method using data from a job training programme and comparing them to the experimental data, Heckman, Ichimura, & Todd (1997), conclude that the regression-adjusted matching method shows the least bias because it provides the closest results to the experimental data. The estimates using inverse-probability weighting are also more efficient than the traditional propensity score matching in evaluating the average treatment effect of programme participation (Hirano, Imbiens, and Geert, 2003).

Post-estimation Strategy

Post-estimation strategy (PSM) estimates are internally valid and unbiased if and only if the above-mentioned assumptions are satisfied. Nonetheless, the conditional independence assumption is hard to test empirically even though we are able to control for a number of unobserved factors. To address that, we conduct a number of post-estimation tests to understand the extent to which unobserved factors could potentially affect validity and unbiasedness of the estimates. We propose the bound methods proposed by Rosenbaum (2002), and implemented by an mhbounds Stata command given by Becker and Caliendo (2007). The Mantel-Haenszel statistics given by mhbounds is only applicable for categorical variables. Thus, we employ rbounds Stata command with continuous outcome variables. Besides, we also re-estimate propensity score on the matched sample of treated and controls to test whether characteristics of beneficiaries and non-beneficiaries remain significantly different after matching. Roth and Tiberti (2017) and Bertoli and Marchetta (2014) state that pseudo-R2 after matching should be small, indicating no systematic and statistical differences in characteristics between programme beneficiaries and non-beneficiaries. Another important consideration is the influence of specification on the average treatment effects on the treated. There is no conclusive evidence in the literature, but Zhao (2008) finds that specifications of the PSM selection equation do not significantly affect (downward or upward bias) the ATET when the conditional independence assumption holds. Nonetheless, ATET would be sensitive to specifications if the CIA fails. Caliendo, Mahlstedt, and Mitnik (2017) concur the findings, stating that potential unobservables might influence selection equations, but not the average treatment effects on the treated. Other authors, nonetheless, find that specifications might have negative impact on estimated results (Biewen et al. 2014). Given the inconclusiveness, we propose to conduct a number of specification tests.

Defining ICT-related Majors

The study follows the two and four-digit Classification of Instructional Program (CIP) developed by the U.S. Department of Education and the Institute of Education Sciences for the academic programme classification. ICT-related majors are those falling under the CIP code 09, 10, and 11[2].

[2]The full list of the code is available at https://nces.ed.gov/ipeds/cipcode/browse.aspx?y=56.

Table B.1: Educational major classification

Code	Sub-Code	Program
09	Communication, Journalism, and Related Programs	
09	09.01	Communication and Media Studies.
09	09.04	Journalism.
09	09.07	Radio, Television, and Digital Communication.
09	09.09	Public Relations, Advertising, and Applied Communication.
09	09.10	Publishing.
09	09.99	Communication, Journalism, and Related Programs, Other.
10		Communication Technologies/technicians and support services; and
10	10.01	Communications Technology/Technician.
10	10.02	Audiovisual Communications Technologies/Technicians.
10	10.03	Graphic Communications.
10	10.99	Communications Technologies/Technicians and Support Services, Other.
11	Computer and Information Science and Support Service	
11	11.01	Computer and Information Sciences, General.
11	11.02	Computer Programming.
11	11.03	Data Processing.
11	11.04	Information Science/Studies.
11	11.05	Computer Systems Analysis.
11	11.06	Data Entry/Microcomputer Applications.
11	11.07	Computer Science.
11	11.08	Computer Software and Media Applications.
11	11.09	Computer Systems Networking and Telecommunications.
11	11.10	Computer/Information Technology Administration and Management.
11	11.99	Computer and Information Sciences and Support Services, Other.

Source: Authors' compilation

APPENDIX C: MARGINAL EFFECT RESULTS ON ICT-RELATED MAJOR ENROLMENT

	(1) All	(2) Males	(3) Females	(4) Graduates	(5) Students
Male	0.417***			0.453***	0.369***
	(0.038)			(0.036)	(0.056)
Age	-0.018**	-0.015	-0.034**	-0.022*	-0.007
	(0.008)	(0.010)	(0.014)	(0.012)	(0.011)
Region (Base Group is Rural)					
-Phnom Penh	0.071	0.033	0.092*	0.140**	-0.044
	(0.053)	(0.059)	(0.055)	(0.071)	(0.069)
-Provincial	0.071*	0.058	0.060	0.054	0.085
	(0.041)	(0.076)	(0.056)	(0.039)	(0.086)
-District	-0.028	-0.043	0.011	-0.018	-0.038
	(0.039)	(0.059)	(0.043)	(0.045)	(0.046)
Father Education	0.001	0.002	0.000	0.001	-0.001
	(0.003)	(0.005)	(0.004)	(0.005)	(0.005)
Mother Education	0.004	-0.001	0.012***	0.006	0.002
	(0.004)	(0.005)	(0.004)	(0.005)	(0.009)
Socioeconomic Status (Base group is Middle)					
-Poor	0.053	0.044	0.076	0.082*	-0.016
	(0.036)	(0.064)	(0.089)	(0.043)	(0.074)
-Rich	-0.280***	-0.296**		-0.377***	-0.133

	(0.090)	(0.126)		(0.096)	(0.154)
Household Size	-0.004	-0.006	-0.005	-0.006	-0.002
	(0.010)	(0.013)	(0.012)	(0.013)	(0.015)
Public High School	0.088	0.083	0.116*	0.168	0.019
	(0.062)	(0.076)	(0.065)	(0.127)	(0.070)
Science Stream	0.047	0.059	0.056	0.050	0.057
	(0.041)	(0.057)	(0.066)	(0.055)	(0.056)
Good at Math	0.101***	0.151***	0.002	0.097***	0.075
	(0.034)	(0.038)	(0.059)	(0.034)	(0.059)
English Proficiency					
-Good	0.008	0.012	0.029	0.006	0.048
	(0.050)	(0.076)	(0.062)	(0.051)	(0.073)
-Poor	-0.002	0.057	-0.093	0.038	-0.043
	(0.048)	(0.054)	(0.059)	(0.053)	(0.074)
Grade 12 Exam Performance (Base Group is E and Fail)					
-Grade A or B	0.025	-0.033	0.014	0.004	-0.061
	(0.064)	(0.090)	(0.119)	(0.080)	(0.107)
-Grade C	0.014	0.007	-0.024	0.021	-0.082
	(0.048)	(0.063)	(0.093)	(0.057)	(0.090)
-Grade D	0.002	-0.018	0.027	-0.028	0.039
	(0.037)	(0.046)	(0.070)	(0.052)	(0.056)
Grade 12 Math Performance (Base Group is E and Fail)					
-Grade A or B	-0.034	-0.056	0.030	-0.040	0.085
	(0.082)	(0.085)	(0.098)	(0.095)	(0.117)
-Grade C	-0.095	-0.111	-0.047	-0.146*	0.086
	(0.058)	(0.068)	(0.091)	(0.075)	(0.120)
-Grade D	-0.001	-0.043	0.099	-0.065	0.142
	(0.058)	(0.059)	(0.148)	(0.062)	(0.116)
Observations	1,022	693	323	611	411

Source: Authors' calculation
Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

APPENDIX D: WAGE PREMIUM ESTIMATION

To estimate the wage premium of ICT-related majors, this study begins with a simple OLS method using modified Mincerian model to examine the correlation between earnings and ICT major. The sample is restricted to economically active graduates in this estimation. Table D.1 reports the OLS results on logged monthly wage. Being a graduate of an ICT-related major is associated with an 11.5 percent increase in monthly wage, but the correlation is weaker when the sample is disaggregated by gender. As seen in column (3), the coefficient in the female sub-sample is positive but not statistically significant. Graduates from bachelor's degree programmes (in comparison to those from associate or higher diploma degree programmes) is a strong predictor of higher income. This factor is even more important among female graduates. English proficiency is also found to be another important determinant of earnings in the early career stage of graduates.

As discussed in the methodology section, to address the issue of non-random bias, this study employs the IPWRI method to estimate the effect of ICT major on monthly earnings. In the first stage of the IPWRA, the probabilities of being a treatment (or in other words, choosing an ICT-related major for their post-secondary education) are estimated with the probit regression model. The marginal effect of a treatment can be found in Appendix A. Figure D.1 illustrates the distributions of predicted probabilities of being a treatment (ICT major) and control (non-ICT major) group. Since the areas are well overlapped, we do not apply the trimming approach for the second stage adjusted regression. However, we noticed that the common support is rather weak in the female sub-group. In addition to the IPWRA approach, the study also employs the nearest-neighbour matching approach for robustness check.

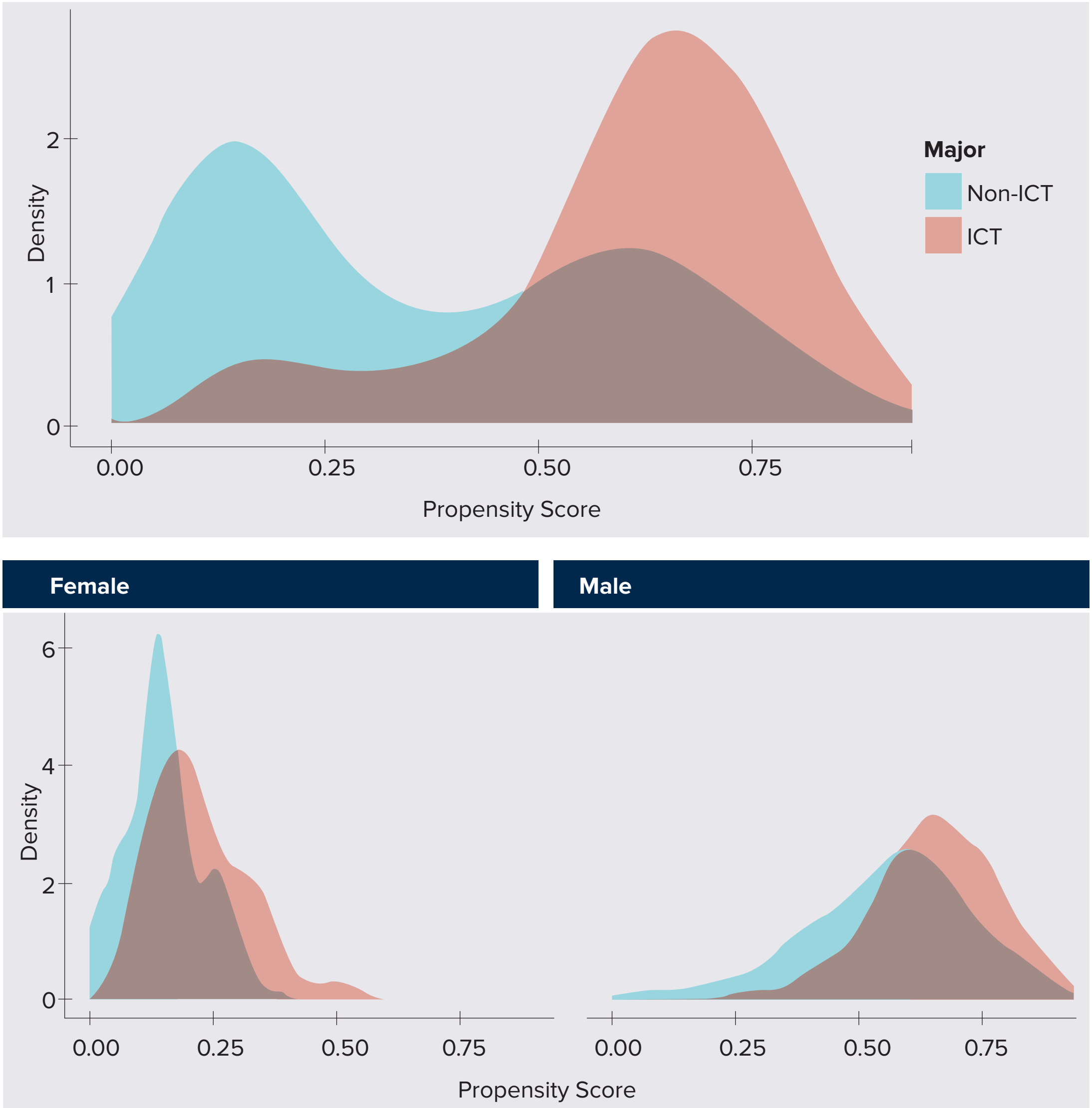
Table D.1: OLS results on logged monthly wage

	(1)	(2)	(3)
VARIABLES	**All**	**Male**	**Female**
ICT Major	0.115**	0.097*	0.179
	(0.049)	(0.053)	(0.138)
Experience	0.034*	-0.013	0.060
	(0.020)	(0.040)	(0.038)
Experience Square	-0.000	0.004	-0.001
	(0.001)	(0.003)	(0.001)
Male	0.075		

	(0.056)		
Internship	0.036	0.027	0.047
	(0.045)	(0.057)	(0.079)
Grade 12 Exam Score (Base group: Fail or not complete grade 12)			
- Grade A or B	0.212	0.221	0.064
	(0.139)	(0.144)	(0.390)
- Grade C	0.245**	0.282**	0.089
	(0.111)	(0.120)	(0.353)
- Grade D	0.099	0.159	-0.142
	(0.109)	(0.119)	(0.355)
- Grade E	-0.005	0.023	-0.167
	(0.104)	(0.113)	(0.341)
English Language (Base group: Low confident)			
- Confident	0.144***	0.129**	0.186*
	(0.046)	(0.056)	(0.096)
- Intermediate	-0.032	-0.052	0.022
	(0.062)	(0.071)	(0.126)
Bachelor programme	0.219***	0.145*	0.433***
	(0.070)	(0.080)	(0.158)
Constant	5.379***	5.588***	5.274***
	(0.120)	(0.136)	(0.340)
Observations	519	369	150
R-squared	0.152	0.132	0.204

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculation

Figure D.1: Distribution of predicted probabilities of treatment



Source: Authors' calculation

Table D.2 reports the covariate balance summary of standardized mean difference and variance ratio before and after implementing propensity score weighting. The weighted standardized differences and variance ratios are closer to 0 and 1 respectively, suggesting the after matching the covariates between the two group are now more balanced.

The IPWRA and classical matching using nearest neighbour matching produce similar results found in the OLS estimation. However, we could not performance estimations for the female sub-group due to the small sample size and lack of common supports. The positive treatment effect with the IPWRA approach turns insignificant in the male sub-group estimation.

Table D.2: Covariate balance summary before and after propensity score weighting

Covariates	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
Male	0.969	0.030	0.334	0.970
Age	-0.199	-0.050	0.395	0.600
Region				
-Urban	0.136	0.009	1.261	1.013
-Provincial Town	0.121	-0.012	1.250	0.978
-District	-0.168	0.018	0.915	1.010
Father Education	0.080	-0.021	1.106	0.972
Mother Education	0.143	-0.021	1.031	1.063
Social Economic Status				
-Middle	0.064	0.029	0.905	0.956
-Rich	-0.243	-0.049	0.102	0.695
Household Size	0.057	-0.018	0.831	0.842
Public High School	0.136	0.068	0.460	0.629
Science Stream	0.129	0.022	0.831	0.968
Good at Math	0.263	-0.013	1.424	0.983
Grade 12 Exam				
-Grade A or B	-0.039	-0.004	0.844	0.982
-Grade C	-0.037	0.032	0.934	1.059
-Grade D	-0.122	0.049	0.829	1.079
-Grade E	0.096	-0.071	0.991	1.005
Grade 12 Math Score				
-Grade A or B	0.043	0.006	1.107	1.015
-Grade C	-0.155	0.047	0.663	1.126
-Grade D	-0.055	0.017	0.863	1.046
-Grade E	0.197	-0.016	1.249	0.982

Source: Authors' calculations.

Table D.3. IPWRA and PSM estimation results

ATE	(1) All	(2) Male	(3) Female
IPWRA	0.113** (0.050)	0.0708 (0.051)	N/A+
PSM (nn=5)	0.100** (0.046)	0.126** (0.062)	N/A+

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
+ Due to the lack of common support of propensity score.
Source: Authors' calculation

APPENDIX E: 16-ITEM TECHNOLOGY READINESS INDEX 2.0

Optimism: A positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives.

1 New technologies contribute to a better quality of life

2 Technology gives me more freedom of mobility

3 Technology gives people more control over their daily lives

4 Technology makes me more productive in my personal life

Innovativeness: A tendency to be a technology pioneer and thought leader.

1 Other people come to me for advice on new technologies

2 In general, I am among the first in my circle of friends to acquire new technology when it appears

3 I can usually figure out new high-tech products and services without help from others

4 I keep up with the latest technological developments in my areas of interest

Discomfort: A perceived lack of control over technology and a feeling of being overwhelmed by it.

1 When I get technical support from a provider of a high-tech product or service, I sometimes feel as if I am being taken advantage of by someone who knows more than I do

2 Technical support lines are not helpful because they don't explain things in terms of my understand

3 Sometimes, I think that technology systems are not designed for use by ordinary people

4 There is no such thing as a manual for a high-tech product or service that's written in plain language

Insecurity: Distrust of technology, stemming from scepticism about its ability to work properly and concerns about its potential harmful consequences.

1 People are too dependent on technology to do things for them

2 Too much technology distracts people to a point that is harmful

3 Technology lowers the quality of relationships by reducing personal interaction

4 I do not feel confident doing business with a place that can only be reached online

APPENDIX F: DEFINITIONS OF NEW TECHNOLOGY TERMS

No.	Term	Definition
1	Augmented reality (AR)	is a highly visual, interactive method of presenting relevant digital information in the context of the physical environment—connecting employees and improving business outcomes.
2	Automated guided vehicles (AGVs)	are material handling systems or load carriers that travel autonomously throughout a warehouse, distribution centre, or manufacturing facility, without an onboard operator or driver.
3	Machine learning (ML)	is a method of data analysis that automates analytical model building. It is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns, and make decisions with minimal human intervention.
4	Machine vision (MV)	is the capability of a computer to perceive the environment. One or more video cameras are used with analog-to-digital conversion and digital signal processing. The image data is sent to a computer or robot controller.
5	Natural language processing (NLP)	is a branch of artificial intelligence that deals with the interaction between computers and humans using the natural language.
6	Radio Frequency Identification (RFI)	refers to a wireless system comprised of two components: tags and readers. The reader is a device that has one or more antennas that emit radio waves and receive signals back from the RFID tag. Tags, which use radio waves to communicate their identity and other information to nearby readers, can be passive or active. Passive RFID tags are powered by the reader and do not have a battery. Active RFID tags are powered by batteries.

7	Robotics	is the intersection of science, engineering and technology that produces machines, called robots, that substitute for (or replicate) human actions.
8	Touchscreens	is a computer display screen that serves as an input device. When a touch screen is touched by a finger or stylus, it registers the event and sends it to a controller for processing.
9	Voice recognition	is the technology by which sounds, words or phrases spoken by humans are converted into electrical signals, and these signals are transformed into coding patterns to which meaning has been assigned.
10	Face recognition	Is a type of biometric identification system that relies on pattern recognition to match faces in a given data set. In other words, digitized information about a person's body (in this case, the face) is extracted from images or video and linked to other images of faces or to additional biographical information.
11	Fingerprint recognition	refers to the automated method of identifying or confirming the identity of an individual based on the comparison of two fingerprints. Fingerprint recognition is one of the most well-known biometrics, and it is by far the most used biometric solution for authentication on computerized systems.
12	QR code	is a type of barcode that can be read easily by a digital device and which stores information as a series of pixels in a square-shaped grid. Quick response (QR) codes are square-shaped matrices of dark or light pixels used to encode and quickly retrieve data using computer devices.

Source: Authors' compilation

APPENDIX G: MULTIPLE REGRESSION ANALYSIS

We examine the association between provision of on-the-job training and firms' productivity and sales using the following multiple regression.

$Y_i=\beta_0+\beta_1 OJT_i+\beta_2 (OJT_i \times Size)+\beta_k X_{ki}+\varepsilon_i$
(1)

where y_i represents productivity and sales of firm i; OJT_i is a dummy variable taking a value of 1 if company i provides on-the-job training to its workforce, 0 otherwise; X_i is a set of other firm characteristics might affect firm performance; ε_i is an error term indicating possible unobserved factors which might affect productivity and sales. The error term is assumed to be normally distributed and has zero conditional mean. β_1 is the parameter of interest.

The multiple regression is also applied to the sub-sample of ICT and non-ICT firms with.

$y_i^{ICT}=\beta_0+\beta_1 OJT_i+\beta\_2 (OJT_i \times Size)+\beta_k X_{ki}+\varepsilon_i$ (2)

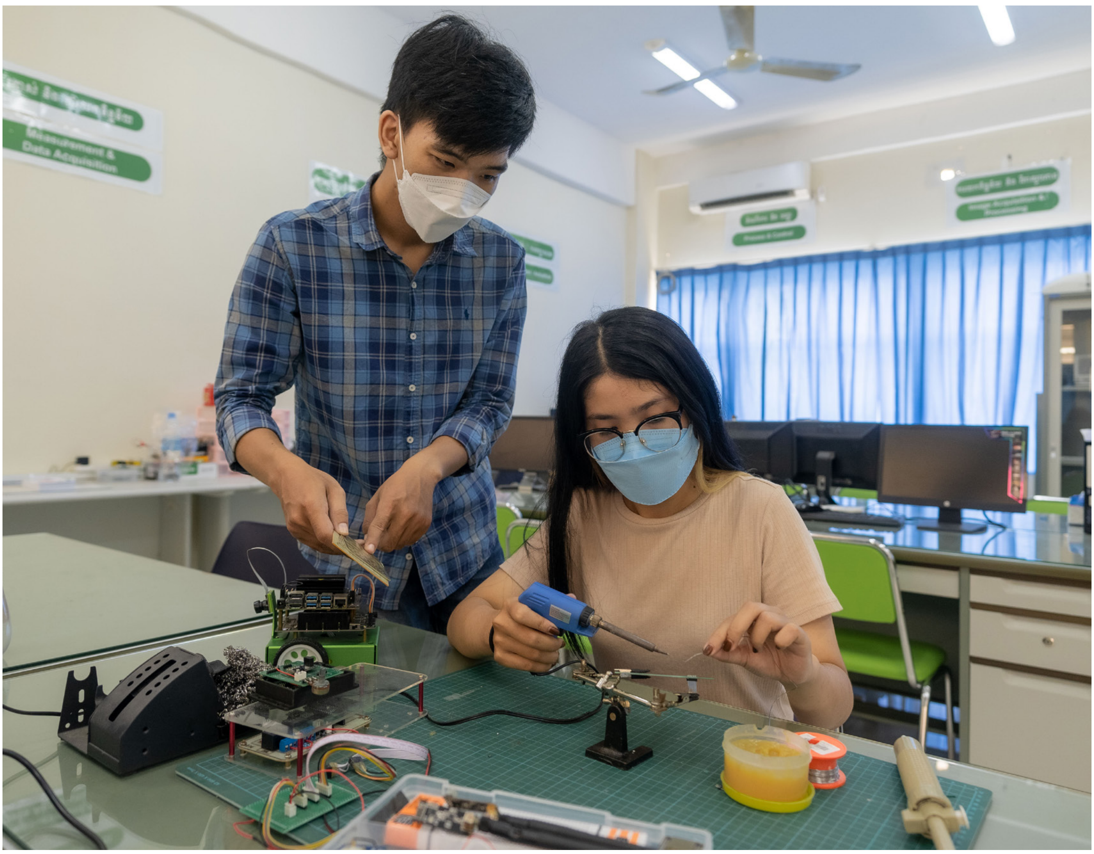
$y_i^{Non\text{-}ICT}=\beta_0+\beta_1 OJT_i+\beta_2(OJT_i \times Size)+\beta_k X_{ki}+\varepsilon_i$ (3)

Table G.1: Regression results

	All	ICT	Non-ICT
Provision of on-the-job training	116.620 (147.879)	58.637** (25.788)	91.701 (663.221)
Domestically owned	-2.356*** (0.892)	-0.076 (0.152)	-6.379** (2.612)
Start date	5.863 (6.144)	0.596 (1.146)	12.595 (17.049
Value of domestic sales	0.991 (1.123)	0.344 (0.248)	1.798 (2.650)
Investment in new technology	-339.612 (339.846)	-131.837 (50.966)	-1069.327 (1408.263)
Sector	-101.081 (69.288)	-	-

Final product	118.217 (137.003)	7.597 (29.172)	143.584 (326.747)
Firm size	-0.149 (4.024)	2.573 (2.369)	-0.997 (9.479)
Interaction (OJT and firm size)	-0.013 (4.030)	-2.849 (2.369)	0.722 (9.503)
Obs.	202	135	67
R^2	0.058	0.118	0.114
Log likelihood	-1502.052	-731.300	-532.390

Note: standard errors are in the parentheses. *, **, *** represents 1%, 5% and 10% significant level, respectively.
Source: Authors' calculation using the firm survey data



បណ្ឌិត្យសភាបច្ចេកវិទ្យាឌីជីថលកម្ពុជា
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