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EduTech Roadmap

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FOREWORD

The Royal Government of Cambodia has set an ambitious vision to become an upper middle income country by 2030 and high income country by 2050. Strategic manpower development is the core of the Rectangular Strategy IV and one of the pillars of Cambodia's Science, Technology & Innovation (STI) Roadmap 2030. The COVID-19 pandemic prevented normal classroom operations, but resulted in the acceleration of online teaching and learning. As such, in the post-COVID era, the integration of education technology has becoming increasingly important in curriculum implementation and delivery. This approach calls for acute and forced innovation in the education sector. Therefore, the development and deployment of digital tools for teaching and learning is now essential, if not vital. The adoption of education technology should be a top priority. Establishing a robust Education Technology Roadmap will be crucial for laying out strategic policies to address these emerging educational challenges.

This roadmap aims to provide a detailed outline for technology adoption and to support strategic and long-term growth of the education sector in Cambodia.

I hope that this Education Technology Roadmap will serve as a strategic and effective guide for a wide range of stakeholders including policymakers, academia, private sectors, general public, and development partners, in their mission to develop quality manpower for Cambodia.

I wish to take this opportunity to commend and thank the Education Technology Roadmap steering and technical committees, the research team of the Cambodia University of Technology and Science (CamTech), policy makers of the General Department of STI at Ministry of Industry, Science, Technology & Innovation (MISTI) and the Science and Technology Policy Institute (STEPI) of Republic of Korea for their contributions in drafting the roadmap.

Finally, I would like to encourage active participation from all stakeholders to contribute to the full deployment of this new policy. The ultimate goal will be to assist Cambodia in her efforts to develop highly-qualified manpower, to meet the targeted economic development goals for the nation.

Phnom Penh, 22 June 2022

Senior Minister
Minister of Industry, Science, Technology & Innovation
and Chair of National Council of Science, Technology & Innovation

***Kitti Settha Pandita* CHAM Prasidh**

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This roadmap would not be possible without the significant contributions from many individuals and relevant institutions who should be acknowledged for their strong commitment and involvement. The roadmap was initially developed in October 2021 by a research team from the Cambodia University of Technology and Science (CamTech), who worked with very close coordination and supports from the Ministry of Industry, Science, Technology & Innovation (MISTI) of Cambodia and Science and Technology Policy Institute (STEPI) of South Korea. The contributions of many national and international participants who shared their insights during the in-depth interviews, panel discussions, and consultation workshops are also acknowledged.

ABBREVIATION

AI	Artificial Intelligence
AR	Augmented Reality
CamTech	Cambodia University of Technology and Science
ECCD	Early Childhood Care and Development
EMIS	Education Management Information System
GDP	Gross Domestic Product
HRMS	Human Resource Management System
ICT	Information and Communication Technology
IDP	Industrial Development Policy
LMS	Learning Management System
MISTI	Ministry of Industry, Science, Technology & Innovation
MoEYS	Ministry of Education, Youth, and Sport
NGS	New Generation School
NSDP	National Strategic Development Plan
OECD	Organization for Economic Cooperation and Development
PISA-D	Program for International Student Assessment for Development
R&D	Research & Development
RGC	Royal Government of Cambodia
S&T	Science & Technology
SME	Small and Medium Enterprise
SMS	School Management System
STEM	Science, Technology, Engineering, and Mathematics
STEEP	Society, Technology, Economy, Ecology, and Politics
STI	Science, Technology & Innovation
UNICEF	United Nations Children's Fund
VR	Virtual Reality

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Section 1: Executive Summary

Cambodia has made tremendous efforts in encouraging universal enrollment for general education and undertaken several significant initiatives related to quality, infrastructure upgrading, and facilities for education. However, there is still room for further improvement, especially in terms of promoting the use of technology in education. Indeed, digital and independent learning is still limited among Cambodian students who have been largely used to the traditional physical classroom style. Regrettably, their situation tends to exacerbate since the COVID-19 pandemic first struck the country. It is estimated that the current cohort of Cambodian students, on average, lose about 1.5 years of learning adjusted for both quantity and quality of schooling. This is due to a direct loss of quality of learning, discontinuity of teaching activities, and an increase in school dropout because households now face more financial burdens.

The Royal Government of Cambodia's aspiration to bring the country into the upper-middle-income and high-income groups by 2030 and 2050, respectively, also means that Cambodia will need to persistently build a knowledge-based society and generate more skilled labor to meet the demand from industries and market which are also favored by technological changes. Therefore, investment in education in general as well as the use of technology in teaching and learning in particular to improve skills of the Cambodian population have never been more important to achieve goals and visions set in not only the Rectangular Strategy and National Strategic Development Plan but also other national policies, including the National Industrial Policy 2015 – 2025; National Policy on Science, Technology and Innovation 2020 – 2030; Cambodia's Science Technology & Innovation Roadmap 2030; Cambodia Digital Economy and Society Policy Framework 2021 – 2035; and Cambodian Sustainable Development Goals.

This roadmap's vision is to build the next-generation technology-enhanced learning ecosystem focusing on improving innovation and entrepreneurship skills. Its main objective is to infuse technology rapidly in teaching and learning at home and school to support students acquiring skills and knowledge that they will need for a successful education, life, and career in the modern workplace and society. In this regard, this EduTech roadmap objective is also in line with that of the Cambodia's Science, Technology & Innovation Roadmap 2030. In particular, the EduTech roadmap aims to promote overall learning outcome, digital literacy, entrepreneurship skills, and technological readiness of the Cambodian population, starting from the very young age when children begin their formal general education. This in turn will help contribute to building students' capacity for STEM majors at university. In addition, the roadmap seeks to encourage multidisciplinary and multi-stakeholder collaboration between the government, industries, academia, and community also known as the Quadruple Helix Model. Such collaboration is essential to facilitate innovation, exchange of ideas, and incubation of tech SMEs.

From the STEEP and SWOT analyses which were done by desk review method and the data that the research team collected through in-depth interviews and roundtable panel discussions and the consensus among EduTech committee members and participants during the consultation and validation workshops, four pillars/areas of products/services have been identified, namely the Essentials, Management System, Courseware, and Capacity Building. Appraisal of importance of each product or service is also based on a few factors, including economic impacts, current and future market potentials, and overall national development agenda.

First, strategic products/services that are classified in the Essentials pillar are considered as indispensable because they provide fundamental tools for other products/services to operate, and that is the reason why they are put in the first pillar, which comprises electricity, computer, and the internet. Second, the management system here refers to computer software and/or mobile applications which are employed for administrative and logistic supports. Such system, including LMS, SMS, EMIS, and HRMS, is also introduced with the purpose to digitalize schools, making them paperless institutions. In addition, there is plenty of research evidence which suggests that such software also facilitates the interaction between students and teachers and school leadership. Having said that, such a concept is made largely possible only through the system monitoring and management of a central authority which should be the ministry in charge of education. Third, courseware consists of computer software used mainly for educational purposes, computer-assisted instruction software, digital resources, and online materials, such as journal articles, books, and e-learning platforms. Courseware offers many advantages. It supports personalized learning and allows for flexible and self-directed learning. Nevertheless, courseware should be used as an auxiliary tool, according to its advantages and features to provide support for student learning. It should not be employed to substitute teachers. Rather, it ought to assist teachers in instruction because without much physical interaction and socialization, students might lose their communication and collaboration skills when they reach adulthood. Finally, capacity building on digital literacy and hybrid learning pedagogy is neither a strategic product or service nor technology in itself. However, it is indispensable because technological products and services are merely tools or instruments to help users who must have a certain level of knowledge or skills to operate or take advantages of them.

Key technologies that should be used to develop strategic products and services have also been discussed and prioritized by the technical experts. Prioritization is in turn based on the technologies' strategic importance, economic and environmental impacts, affordability, technical practicality, and whether or not such technologies can be adapted in Cambodia, given its geographical and socio-economic contexts. More importantly, the experts also consider if the technologies are likely to be replaced in the very near future. It is also worthwhile to note that some technologies can be utilized to develop multiple products and services. For instance, we can use blockchain and cloud technology to develop all the management systems and digital learning platforms. Ultimately, this roadmap also discusses when one should acquire, develop, and/or import what technology/products/services, and given that the technology is at one's disposal, it tells what one should do next to realize the goals of the roadmap. Bear in mind that charting the technology by timeframe has to align with the government's major development directions and existing key performance indicators or expectations.

As a concluding remark, this roadmap is an attempt to outline a solid framework to incorporate educational technology into teaching and learning, but alone it will not entirely solve learning crisis without strong participation and commitment from the academia, private sector, and community. But why does one need the private sector and academia? To answer the question, one has to understand that while the government does make policies and national development agendas, private-sector entrepreneurs know more about their markets and consumers; and R&D which leads to innovation generally originates at universities or research institutes etc. Therefore, all parties involved have to be able to sit and work together through solidarity building for the benefits of students and society, industrial development, and thereby socio-economic growth of the country.

Section 2: Introduction

2.1. Background and Objective

At a time when the global economy is facing serious issues, livelihood is threatened, and the public health is in crisis due to the COVID-19 pandemic, it would be easy to overlook looming challenges in education because discussion about or investment in education can generally be delayed to another time. This is also the reason why education is one of the first things to suffer when everything else falls apart. However, one can also argue that education should be considered as an important solution for a variety of economic and social problems and thus deserves a large investment during the time of peace, for it will help tackling challenges in the time of disarray. This is because education can play a substantial role in economic recovery, as it can improve resilience, promote social cohesion, complement physical capital, and foster social capital, such as trust and tolerance of others. Therefore, this is when one can emphasize the primacy of education, which requires a concerted effort now more than ever since the world is experiencing an unprecedented global learning crisis due to not only the pandemic but also generally low investment in schooling which is a result of undervaluing the return to education (World Bank, 2018). While many countries have thrived to provide their populations with educational access, the World Bank asserts that a large number of children in developing countries have reached adulthood without even necessary skills in reading and arithmetic operation despite having spent many years in school.

Cambodia has also made tremendous efforts in encouraging universal enrollment for general education and undertaken several significant initiatives related to quality, infrastructure upgrading, and facilities for education. However, there is still room for further improvement, especially in terms of promoting the use of technology in education as only one fifth of the students who took the Program for International Student Assessment for Development (PISA-D) test in 2017 indicated that they have computers at home. Moreover, about 45 percent said that they had internet access (MoEYS, 2018). In addition, approximately 22 percent of all the schools have computers that are in good condition and can be used. Nevertheless, 69 percent of K-12 students had access to mobile phones for online learning in 2020 (World Bank, 2021a). Interestingly, online learning through smartphones is not as effective as using computers since mobile phones are not designed for such purpose. Not to mention, many students reported difficulties in accessing online-learning materials on account of poor connectivity and a lack of financial resources to buy top-up cards.

Indeed, digital and independent learning is still limited among Cambodian students who are largely used to the traditional physical classroom style, and their situation tends to exacerbate due to the government's prolonged school closure to contain the spread of the coronavirus. It is estimated that the current cohort of Cambodian students, on average, lose about 1.5 years of learning adjusted for both quantity and quality of schooling (ibid). This is due to the direct loss of quality of learning, discontinuity of teaching activities which lower teachers' performance, and increase in school dropout because households now face more financial burdens that require more contributions from all family members to handle. It is worth highlighting that when the pandemic first struck and schools were closed, only 13% of all teachers at the general education level believed that they had enough capacity to deliver online learning. This is according to the World Bank's household survey (World Bank, 2021a).
With that said, technology has at least two main advantages in improving learning outcomes. First, it allows for personalized learning anytime and anywhere to complement in-person

education, and second, it improves students' digital learning experience and peer communication, especially during the time of crisis. Evidently, there are quite a large number of research studies which show positive impacts of technology on education (Bulman & Fairlie, 2016). Therefore, to improve the quality of education, it is also essential to improve the use of technology in teaching and learning, and only when quality teaching and learning are delivered adequately, will education help individuals build a fulfilling life and pull a country out of economic misery.

The Royal Government of Cambodia's (RGC) aspiration to bring the country into the upper-middle-income and high-income groups by 2030 and 2050, respectively, also means that Cambodia will need to persistently build a knowledge-based society and generate more skilled labor to meet the demand from industries and market which are also favored by technological changes. That is, private firms continue to reallocate their resources towards investing in technology to increase their productivity, and manual work gradually becomes obsolete as firms tend to prefer workers who have adequate competency to operate or work with machines. Therefore, investment in education in general as well as the use of technology in teaching and learning in particular to improve skills of the Cambodian population have never been more important to achieve goals and visions set in not only the Rectangular Strategy and National Strategic Development Plan (NSDP) but also other national policies, including the National Industrial Policy 2015 – 2025; National Policy on Science, Technology and Innovation 2020 – 2030; Cambodia's Science Technology & Innovation Roadmap 2030, Cambodia Digital Economy and Society Policy Framework 2021 – 2035, and Cambodian Sustainable Development Goals.

To help address the learning challenges and contribute to the government's efforts in developing human capital and boosting welfare of the Cambodian population, this roadmap's main objective is to infuse technology rapidly in teaching and learning at home and school to support students in acquiring skills and knowledge that they will need for a successful education, life, and career in the modern workplace and society. For that, they will need non-cognitive skills, such as grit, conscientiousness, and goal orientation. However, the most crucial constellation of non-cognitive skills that would help individuals overcome challenges and succeed in a variety of settings is entrepreneurial mindset. Entrepreneurship skills are a set of skills that drive actions, and a person with such skills would think and act like an entrepreneur who recognizes opportunities, learns from failures, and is innovative, flexible, decisive, solution-oriented, and willing to take risks. In this regard, this EduTech roadmap's objective is also in line with that of the Cambodia's Science, Technology & Innovation Roadmap 2030, pillar 2 (building human capital in STI) and pillar 4 (increasing collaboration and networking between different actors). In particular, this roadmap aims to promote digital literacy, entrepreneurship skills, and technological readiness of the Cambodian population, starting from the very young age when children begin their formal general education. This in turn will help contribute to building students' capacity for STEM majors at university. In addition, the roadmap seeks to encourage multidisciplinary and multi-stakeholder collaboration between the government, industries, academia, and community also known as the Quadruple Helix Model. Such collaboration is essential to facilitate innovation, exchange of ideas, and incubation of tech SMEs (Small and Medium Enterprises).

Besides, the roadmap serves three other purposes, including:

- To encourage the high-stakes technology usage in education in order to achieve the long-term visions of the RGC

- To provide a strategic direction to address challenges pertinent to educational technology and human resources
- To build a stepping stone for EduTech development in a systematic way.

2.2. Cambodia's Educational Context

To help achieve the goal of delivering internationally-recognized quality of education for Cambodian students, the Ministry of Education, Youth, and Sport (MoEYS) joined PISA-D of the Organization for Economic Cooperation and Development (OECD), which evaluates the level of students' knowledge and skills proficiency in relation to international standards. In December 2017, 5,162 Cambodian students aged between fifteen years and three months and sixteen years and two months and studying at the secondary level of education (grade 7-12) in 170 schools were randomly selected across the country to take a two-hour test in reading, mathematics, and science. It is worth noting that the test does not assess whether or not students can memorize very well but their ability to apply the knowledge that they have learned to solve practical problems in unfamiliar settings in and outside of school. Such test also reflects the reality of the modern workplace in which employers value not what employees know or how smart a student they were but what they can do with what they have learned.

Results show limited abilities among the Cambodian students on average in all of the three domains, and girls outperformed boys in reading by 5.4% and science by 1.2%. For math, they performed similarly (Ministry of Education Youth and Sport, 2018). In addition, boys are also more likely to repeat a grade. Regardless of that, the findings provide MoEYS solid evidence to understand what skills Cambodian students are lacking and factors that are hindering their progress to reach their full potential, and that the government can effectively eliminate them and improve the educational system. In fact, at least 15 educational reform agendas have been passed (MoEYS, 2018) to propel Cambodia towards excellence in educational delivery and realization of its long-term visions and goals of becoming a highly developed and prosperous nation. The agendas are intended to tackle the root causes of students' underperformance, including obsolete teaching methods, teachers' qualifications and career pathways, and curriculum development. However, such efforts alone cannot fully remove the barriers to quality education without parental and community engagement and contribution because, as most research studies suggest, children's families or households predominantly explain the variation in students' success in adulthood (Carneiro & Heckman, 2002).

Having said that, it is perhaps appropriate to recall a bit of the history so that the current educational context and challenges in Cambodia can be better understood. It is worth noting that the education system was completely laid waste by the Khmer Rouge regime, which prohibited schooling, teaching, or studying. Around 90 percent of the educational infrastructure after the revolution was destroyed or left in ruins. In addition, 70 percent of primary and secondary school teachers and pupils as well as 90 percent of university lecturers and students were either massacred or died of forced labor, diseases, and starvation (Clayton, 1998; Hang, 2016). Following the collapse of the regime, the education system was promptly resurrected from scratch, but it was a very arduous task due to a lack of studying materials, personnel, and school buildings. Moreover, many intelligentsias who survived fled Cambodia. The early wave of teaching staff was enlisted regardless of their qualifications as long as they were able to read and write and willing to teach with very low salary. Because of their disadvantages, some senior teachers who are still teaching have been slow to adopt new cutting-edge curriculum or modern teaching technology.

After 1993, Cambodia has embarked on a reconstruction of the education system and undertaken several significant developments in educational curriculum and overall relevant infrastructure and facilities. The last major reformation in the education system has been initiated since 2014, focusing on improving quality of teaching and learning. In addition, MoEYS has also put an emphasis on directing more national budget towards human capital development, and contribution from relevant stakeholders, including households and the private sector. As a result, there was a remarkable increase in the government expenditure on public education from 1.5 percent in 2010 to 2.2 percent of the country's gross domestic product (GDP) in 2018 (World Bank Databank, 2021). To put it into perspective, the funding for schooling in 2018 has increased threefold compared to that in 2013 because the executive branch has kept pouring an incremental large pool of budget into educational expansion annually. In recent years, RGC has distributed about 18-19 percent of the total government budget expenditure to education and is committed to increasing the budget allocation in the near future (MoEYS, 2019b). However, the budget is still insufficient as the ministry in charge of education continues to stipulate at least 20 percent of the national budget to modernize the infirm government teaching system. Therefore, it is expected that we will soon see more investment in education.

Nevertheless, the Cambodian education system has also faced several common challenges and limitations experienced by most developing countries, and that should be properly recognized. Firstly, while the country has almost achieved the universal primary school enrollment, which is a significantly remarkable achievement, there is still a lingering dropout issue at the secondary level. Since 1996, the general education requires 12 years consisting of primary school for 6 years, lower secondary for 3 years, and upper secondary for another 3 years, and the first 9 years are compulsory. The general education at public schools is provided for the Cambodian population, starting at the age of 70 months, free of charge, and subsidized by the government, yet not all teenagers are in school, especially boys who are more likely than girls to have never attended school and dropped out.

Figure 2.1 below demonstrates the dropout rate in the academic year 2017 – 2018 by grade and gender. As can be clearly seen, the dropout rate was relatively high for the secondary level (grade 7 onward), and the peak was at grade 12 when students have to take the strictly-proctored National Baccalaureate Exam. In addition, boys were more likely than girls to drop out of school for all grades. While it is true that many factors contribute to students' decision to leave school, including financial circumstance, other major determinants of dropout are actually a lack of enthusiasm to learn and students' poor performance (National Institute of Statistics, 2020b). Another significant factor influencing the high dropout rates during the transition to lower and upper secondary education is youth's early engagement in the labor market and late enrollment. The latter imposes a financial loss and high opportunity cost for households as those who are much older than six years old when they enroll in grade 1 will be entering secondary school at the same time that they become legally employable. Together with an immediate financial gain, it is thus more compelling for rural youth to drop out of school at grade 7 or 8 and find jobs in the low-skilled sector than to wait until they finish university which they are not entitled free of charge. In fact, it is found that labor force participation of the Cambodian youth aged between 15 – 19 years old is at 54 percent which mainly comprises those living in rural areas (Chea et al., 2021). Household undervaluing the return to education and skills training has been an influential factor contributing to young people's early participation in the labor market (Chea & Wongboonsin, 2020). This is accompanied by an abundance of informal jobs and the current labor-market characteristics of developing

countries, such as Cambodia, where there is a high demand for low-skilled workers as aggregate wage is still lower relative to investment in technology. However, this will be a big challenge in the future because as Cambodia continues to grow and the labor market condition is slowly transformed toward skill-based, unskilled workers will find themselves in a difficult position to find suitable jobs which require higher skills and the ability to work with machines.

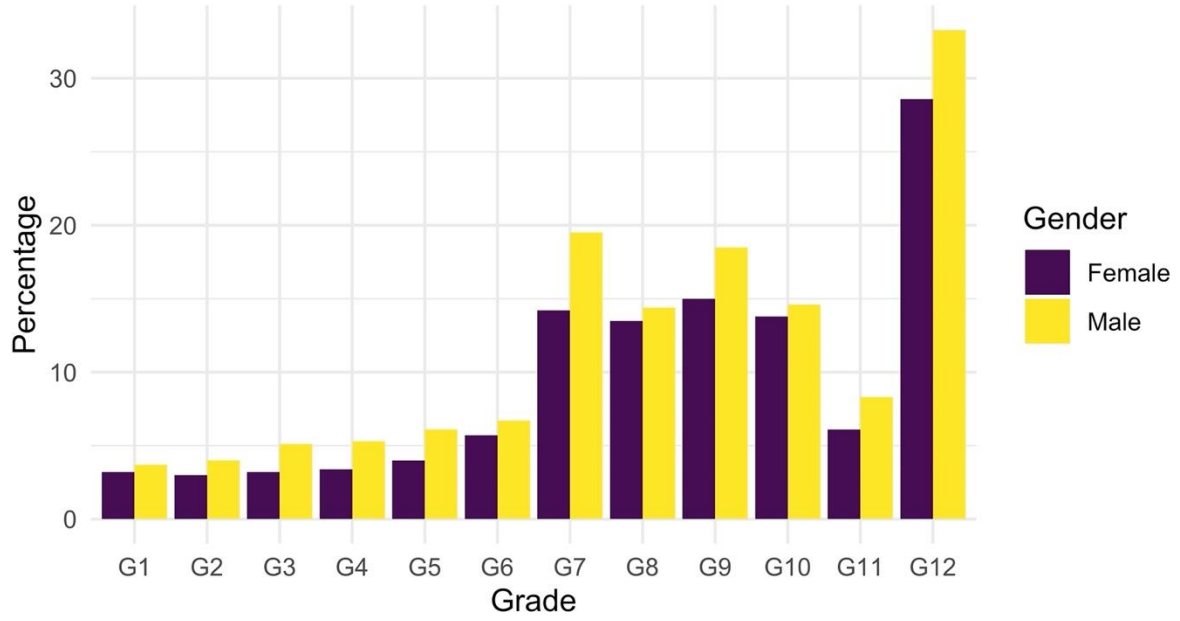


Figure 2. 1: Dropout Rate in the Academic Year 2017 - 18 at Public School by Grade and Gender

Source: Department of Education Management Information System (2019).

Secondly, young children have also been found to have low readiness to learn which is another important challenge being addressed by the government currently. Even though it is generally agreed upon by empirical research evidence that children who entered preschool at the age between 3 and 5 years old are more likely to be ready to learn with better performance, development, and social skills, and thereby will remain in school for a longer period than those who did not. Only about 43 percent of Cambodian children did actually enroll in early childhood education in the academic year of 2017 – 2018 (UNICEF Cambodia, 2019). This figure also comprised mainly children living in urban areas even though urban children account for a much smaller fraction of the total number of children between 3 and 5 years old.

Thirdly, individual's perceptions, conservative mindset, and attitudes towards technology due to a lack of digital literacy also present a big problem for the incorporation of educational technology into teaching and learning. Many Cambodian individuals are still skeptical about technology or unable to make a good use of it properly although some technology or technological products are critical for education; for example, computers. Moreover, most of them are accustomed to the traditional pedagogical methods, and hence are reluctant to prepare the ground for a successful integration of educational technology into the education system. Another possible reason of some senior teachers' disapproval attitude toward the use of technology in curriculum and instruction is that they fear technology would distract students who would also depend too much on it (Qing, 2007). Furthermore, some of them are also concerned about the possibility that their teaching role would be substituted by technology. Such a low confidence in the utilization of technology or so-called techno-phobia perhaps

arises from individual's low digital literacy and skills. It is worth noting that only about 30 percent of the Cambodian population has basic digital literacy, including the ability to utilize digital systems and internet for searching, communicating, and sharing information (RGC, 2021). However, it should be highlighted that MoEYS has indeed made every effort to address computer illiteracy among students by incorporating computer literacy into the curriculum framework for the general education. Starting from grade 4, students will have to learn how to use computers for daily activities, including office work, graphic design, and presentation (Department of Curriculum Development, 2015).

Nevertheless, the government through MoEYS has also attempted to tackle the dropout-rate issue using various mechanisms over the years, and some improvement has been observed. These financially-incentivized methods include, inter alia, conditional cash transfer, school breakfast program, and government scholarships which have been widely utilized in this new millennium to directly support student livelihood (Chea & Chen, 2021). In addition, RGC gives a special attention to the demand for supplemental reforms in the education sector to enhance quality of teaching and learning at the primary and secondary school levels via improving the national curriculum, learning materials, and teachers' knowledge and skills. The ministry has also introduced a significant and innovative educational reform, namely the New Generation School (NGS), that moves away from the old-school model, with plans for expansion to 100 of such schools across Cambodia by 2022 (MoEYS, 2020). The government has also built dormitories for teachers in rural regions whose houses are far from the schools that they teach. Some other indirect aids through government partnerships with development partners to improve household agricultural production and reduce pressure on children's economic contribution have also been developed. However, family and surrounding environment which force students to leave education in the first place continue to be a main concern. As a result, contribution from and engagement with households and community to change their mindset is indispensable to make more significant enhancement in the quality of education delivered.

In a similar manner to grapple with early education and prepare young children for primary school, an international program called the Early Childhood Care and Education (ECCE) or known locally in Cambodia as the Early Childhood Care and Development (ECCD) has been introduced in the country. The government has made this program a national policy in 2003 after it adopted the 2000 Education for All Dakar Framework for Action. This plan targets children under 6 years old and supports caregivers in relation to parenting, care, health, nutrition, and sanitation in order to safeguard and promote cognitive and non-cognitive development of the Cambodian children. Additionally, RGC endorses three major models of ECCE programs, namely state preschool funded by the government, community preschool mainly subsidized by UNICEF but to be financed by the local community in the long run, and home-based care program supported by groups of mothers organized at the commune level to foster protective environment. Empirical evidence deriving from an appraisal of the program's impacts indicates that ECCD greatly helps tackle the issue of high dropout rate at the secondary level, improves student performance in class, and fosters their learning process and appreciation of education (Rao et al., 2012). As a result, MoEYS, in its Education Strategic Plan 2014 – 2018 and again in 2019 – 2023, is committed to expand community preschool, preschool within primary school, private preschool, and home-based care programs with the goals targeting preschool children so that they will be very well established and their parents can take full-time employment.

2.3. Scope and Approach

The research team carried out a multi-stage multi-level qualitative method, bearing in mind the objectives of the roadmap which will lay out a national strategic direction with inputs from the academia, industries, and government as well as students who are the direct beneficiaries. In particular, the method involved multiple phases (stages) of data gathering, using different qualitative data collection techniques, namely in-depth interviews, focus group discussions, and observations. In each phase, many people from different levels were also included. The levels were individual, industrial (firm level), and government (national level).

The initial stage of the study began with a desk review and an internal group discussion to build knowledge, identify all relevant stakeholders, and design an open-ended semi-structured questionnaire for each individual. After the questionnaire was finalized, the team started to conduct face-to-face in-depth interviews with multiple individuals consisting of high school students, EduTech committee members, government officials, representatives from industries, including some Chief Executive Officers of tech companies or solutions whose scopes of businesses also cover educational materials, and the academia. This was done to achieve "triangulation" in research to increase both reliability and validity of research findings, and to put together an all-inclusive standpoint of different actors in a particular topic. The total number of participants at this stage was 10 individuals. Apart from individual interviews, the research team also carried out a focus group discussion in the form of a roundtable panel discussion, using Zoom with six participants such as teachers, researchers, practitioners, NGO workers, and government officials as panelists in order to gather several perspectives and comprehensive information on the intention to use, practicality, and challenges for educational technology at school. A total of 20 individuals (students and the general public) were the audience, but while they were not questioned, they were allowed to ask questions during the last 20 minutes before the discussion ended.

After the end of the interviews and focus group discussion, the conversations were transcribed from the voice recordings and summarized for a coding process which is the first step of qualitative data analysis. All the data were then coded and compared with the notes to find common patterns and issues which in turn allowed the research team to generate themes. The themes in our case are the four pillars, which we will discuss below, and they are ranked according to the prevailing views of the interviewees.

It should be highlighted that our initial data collection process, which included the in-depth interview and panel discussion, also provided us some ideas on the strategic products and services to be included in each pillar. In particular, many participants and interviewees, especially students, teachers, and those with leadership positions at school/university indeed mentioned specific products, services, and technologies that they believed would improve education. These generated and suggested pillars, products/services, and technologies were then put forward for discussion during a consultation workshop. The consultation workshop involved many relevant stakeholders from various backgrounds and sectors, including members of the EduTech Committee and National Council of Science, Technology, and Innovation (NCSTI), representatives from research institutes, schools, universities, and the private sector, innovators, entrepreneurs, practitioners, government officials, and students. The purpose of the workshop was to identify and gather more technical inputs for vision, goals, strategic products and services, and key advanced technologies to support the diffusion of technology in the Cambodian education sector.

Besides the products and technologies that have been proposed in advance, during the focus group discussion, the workshop participants also raised up some others and rated them and proposed for them to be included in this roadmap. A few of the early proposed products were removed from the list eventually, and some more products or technologies were also identified. However, while many new products were technically incorporated, some were not considered as pragmatic or of the top priority for the time being by most members, including the government officials. Only strategic products and services that the participants consensually agreed that they would help enrich teaching and learning experience were used for the roadmap. In sum, vision, goals, strategic products and services, and key technologies that will be presented in section 5 of the roadmap are primarily the results and findings generated from the in-depth interviews, panel discussion, and technical consultation workshop with participations from the government, academia, industry, and the general public.

Then, an early draft roadmap was sent for a technical review which was done simultaneously by the General Department of Science, Technology, and Innovation (GDSTI) and two other external experts in the fields of technology roadmap and educational technology to obtain more comments and suggestions for further improvement. The draft was then revised accordingly to meet the highest standard possible. The first revision was then sent to members of the EduTech Committee for their final comments and consultations which were done during a consultation workshop before the final draft was reviewed again by technical experts at MISTI and then forwarded to NCSTI for discussion and endorsement. The entire method for drafting this roadmap can be best understood using figure 2.2 below.

It should be highlighted that this roadmap is drafted targeting the formal general education (grade 1 to 12). However, to a certain degree, it is also appropriate for higher learning as some products, services, and/or technologies that are used at the general education level can also be used at the university. With that said, there are also limitations deriving from the method itself. First, qualitative method is for exploring and explaining phenomenon. It is not intended for generalization purpose as sample size is rather limited. However, qualitative technique is the only method to gather comprehensive perspectives from relevant stakeholders at all levels. Secondly, some statistics necessary for the roadmap is not available. For example, it is unsure how many teachers are digitally literate or well-equipped with information and communication technology (ICT) skills or for STEM education. A carefully-designed household survey is indispensable if one is to implement this roadmap effectively as one will need many baseline indicators.

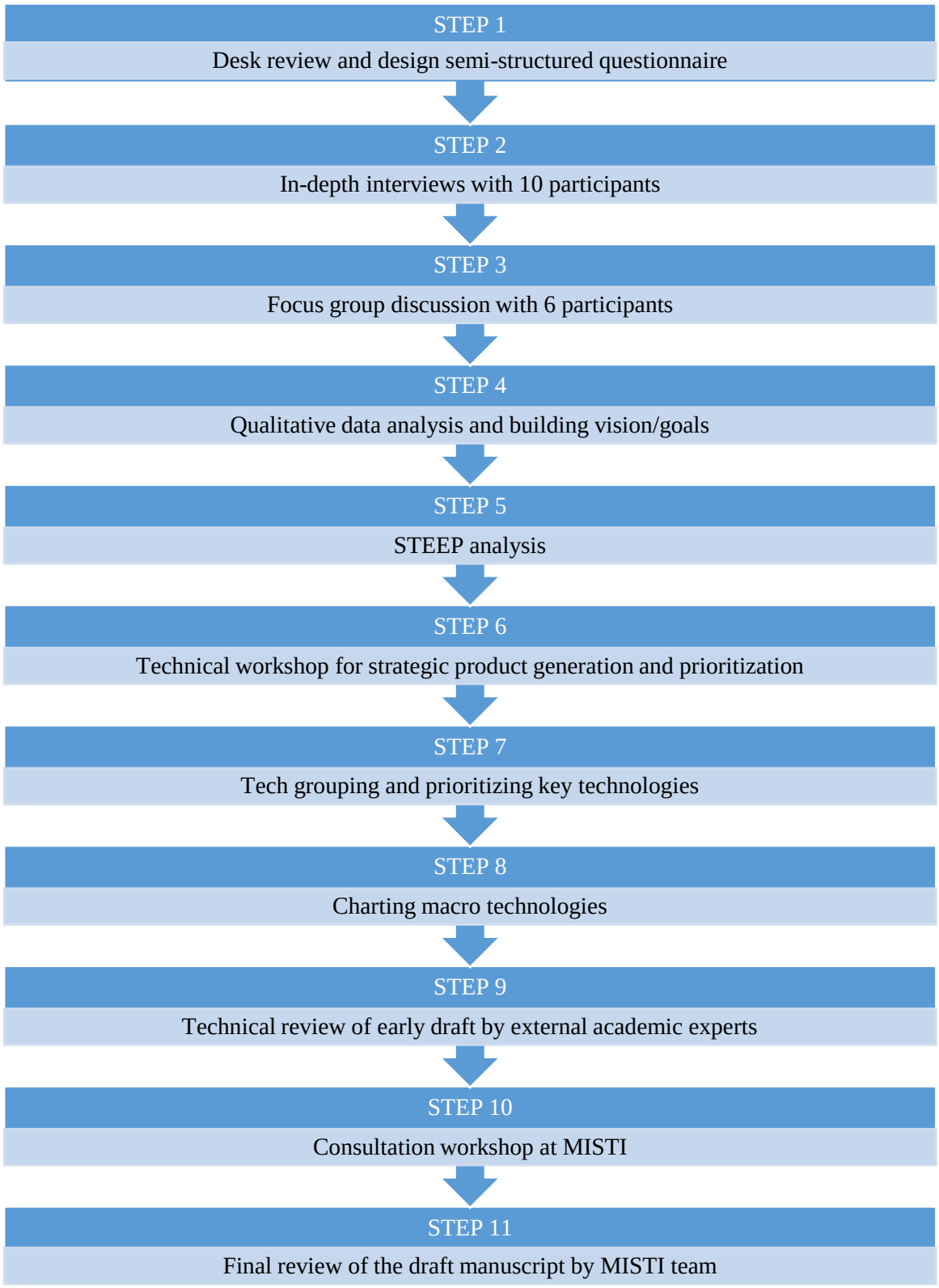


Figure 2. 2: Technology Roadmapping Method

Source: Authors.

2.4. Structure of the Roadmap

Following this introduction part, which is Section 2, Section 3 provides an overview of market demand for and supply of education. This will help give some understanding about the patterns and trends that have characterized the education system and context in Cambodia in recent years. Section 4 offers a more detailed account of the policy perspectives towards education sector development in the country, including its growth directions. Section 5, which is the momentous part of this roadmap, introduces the vision, goals, STEEP analysis, technology roadmap, strategies, targets, and action plans. Finally, section 6 comes with a conclusion and recommendations for further actions.

Section 3: Demand for and Supply of Education

3.1. Demand for Education

Individual students, in our case children and teenagers, and households are generally considered as the demanders for education. However, in this section, we will only look at the macro level to provide an overview of the market demand for education in Cambodia. First, it should be noted that Cambodia is a young-population country and technically still in the period of demographic dividend in which most of the population is in the working age group (Chea & Kobjaiklang, 2017). We will discuss this demographic topic in detail later, but for now it is perhaps worthwhile to go through it a little bit to understand the situation of the demanders first.

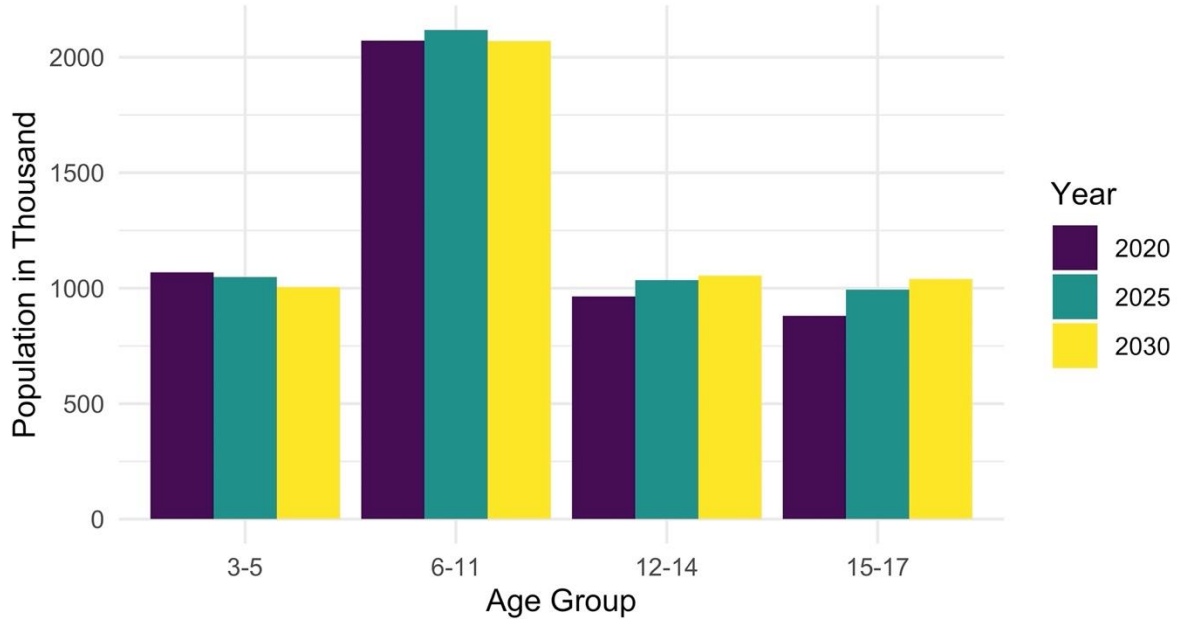


Figure 3. 1: Cambodia Population Projection by Year and Broad Age Group

Source: United Nations World Population Prospect (2021).

Figure 3.1 illustrates the population projection for Cambodia by year and broad age group. This graphic only presents the number of population aged between 3 and 17 years old because these are the age groups of people who conventionally go to school for the general education. In addition, it should be noted that the number of individuals aged between 6 and 11 years old is a lot higher than that of the other age groups simply due to the fact that the interval is larger being in line with the primary level in Cambodia, which consists of 6 grades starting at the age of 6 whereas the other levels comprise only 3 grades. Regarding the interpretation of the figure, the number of children under 6 years old will go down in the future, reflecting the decreasing fertility rate in Cambodia during this new millennium. Notably, the number of population aged between 12 and 17 years old will increase from now until 2030, and it means that the demand for secondary education will continue to rise in the near future, and at the same time, the market needs for primary education will steadily decline. However, in terms of per capita educational

expenses, we are likely to see an increase because even though the number of population decrease, per capita consumption can increase due to growth in household wealth and shrinking number of consumers to share the available resources. In other words, households tend to invest more in education of each individual children when they earn more money and when the total number of children decreases. In fact, an analysis of the available financial data of Preah Sisovath High School suggests that over the last several years, the cost of running the school ranging between USD 400,000 and USD 500,000 has been slowly shifted to parents who make voluntary contributions to sustain the operation (Ministry of Education Youth and Sport, 2021).

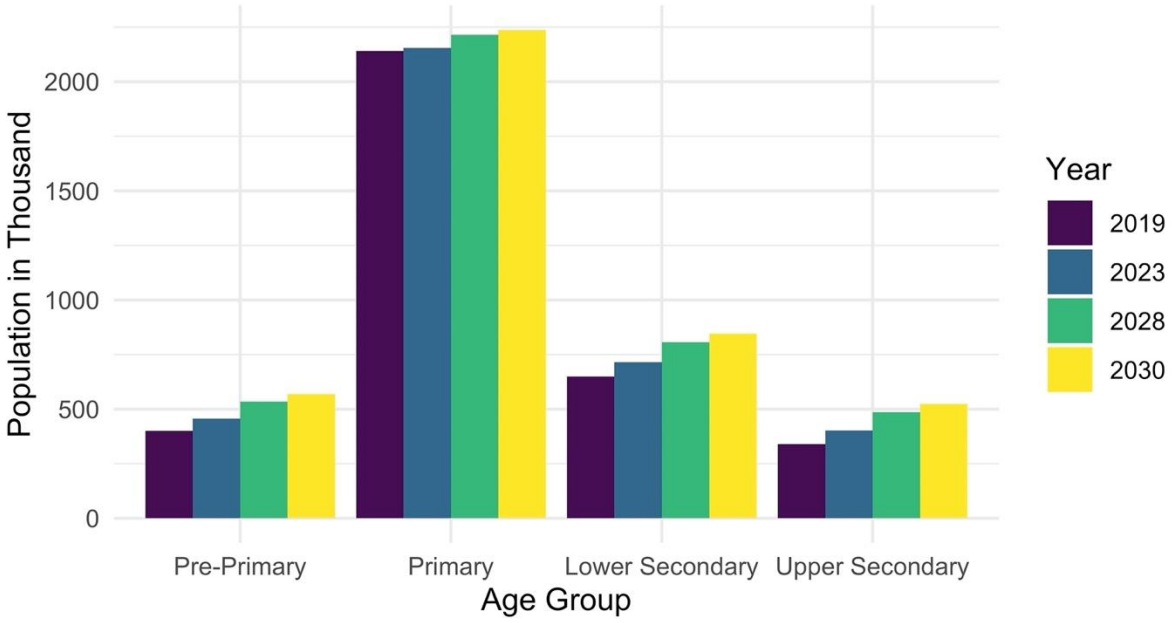


Figure 3. 2: Enrollment Projection by Year and Education Level

Source: Ministry of Education Youth and Sport (2019a).

Figure 3.2 shows projected number of enrollment by year and education level. The projection suggests that the enrollment will continue to increase for all levels of education, including the primary one, especially between 2023 and 2028, probably because it is a 5-year interval. Based on figure 3.1 and 3.2, it can be assumed that the enrollment for the primary education is almost 100 percent, meaning Cambodia will achieve its universal enrollment for children by 2030. It should be highlighted as well that while the number of enrollment should not be much larger than the number of population because Cambodia is not conventionally a destination for immigrants or expats, the method for population projection used by the United Nations in figure 3.1 and for the enrollment projection used by MoEYS are not exactly the same. Therefore, they do not necessarily give similar values although they should be approximate. Having said that, it is clear that the local market of educational services in general educational technology in particular, is quite significant for any investment targeting primary-education students in the short-term and students at the other three levels, including secondary in the medium- and long-term when those at the primary level enter high school ten years from now. Every effort must also be made to reduce the high dropout rate at the secondary level, which mainly explains the big gap between the population at the primary level and that at the secondary level as seen in the graphic above.

3.2. Supply of Education

When talking about the demand for education, it is imperative that one should also understand the supply side because without both the supply and demand curves, the market cannot basically reach an equilibrium. To begin with, it should be noted that the general education is available for free at public schools for all Cambodian students across the country. However, there are still challenges in terms of access to education for the remote rural population, who has little to no mean to travel to school. To cope with such an issue, the Cambodian government, through its NSDP, which will be discussed in more details below, continues to make a large investment in the construction of educational infrastructure. Particularly, the policy aims to expand the number of kindergarten classes and build at least one primary school in every village and one secondary school at the commune level. Additionally, there are more than 14,500 villages and over 1,400 communes in the country.

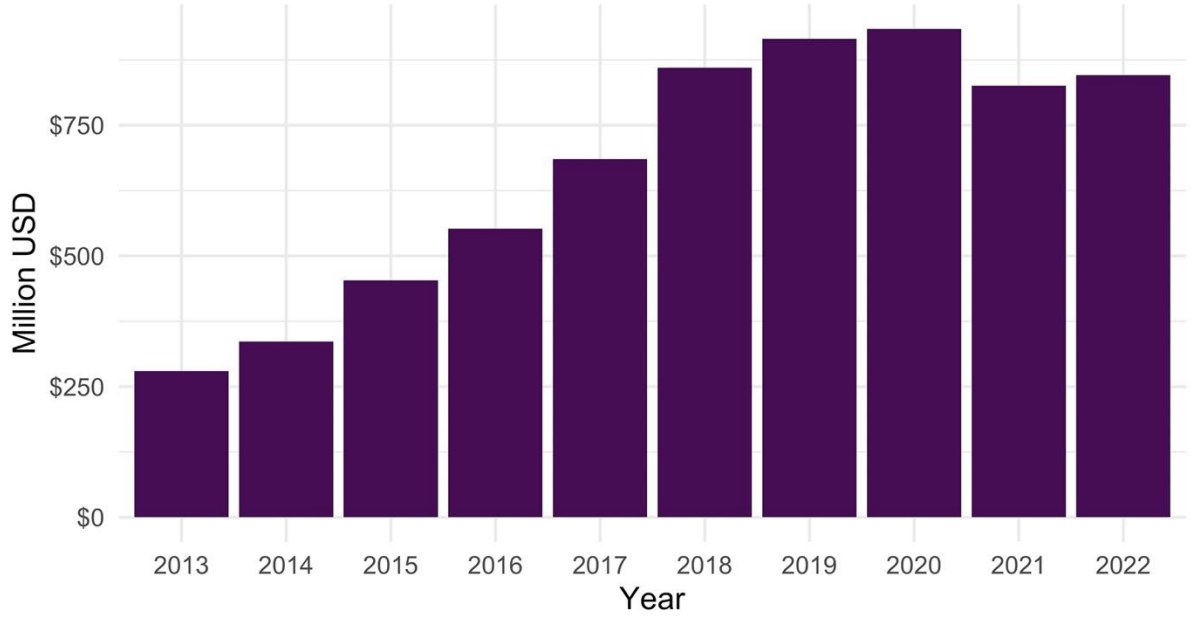


Figure 3. 3: Proposed Annual National Budget for the Ministry of Education, Youth, and Sport

Source: Law on Financial Management between 2013 and 2022.

Showing in figure 3.3 is the proposed annual national budget allocated to MoEYS. Since 2013, the government has continued to increase and redirect funding toward MoEYS to improve the quality of educational infrastructure and teaching and learning experience. In 2021, it leveled off due to the COVID-19 pandemic, which required a huge investment in public health. However, it is expected that the amount of budget will steadily rise in the upcoming years since RGC has still set education as a top priority in its development agenda. In addition, there has also been a plan to expand the number of NGS from 11 to 26 by 2027, using a funding of USD 30 million (MoEYS, 2021). Bear in mind that, as of 2020, RGC had already invested approximately USD 6.62 million in 10 NGSs and one pedagogical research center serving 5,722 students in four provinces and Phnom Penh, with a plan to establish a Social Equity Fund to mobilize more financial resources to help children from disadvantageous households to be able to afford any direct or associated cost of education (Chea & Chen, 2021).

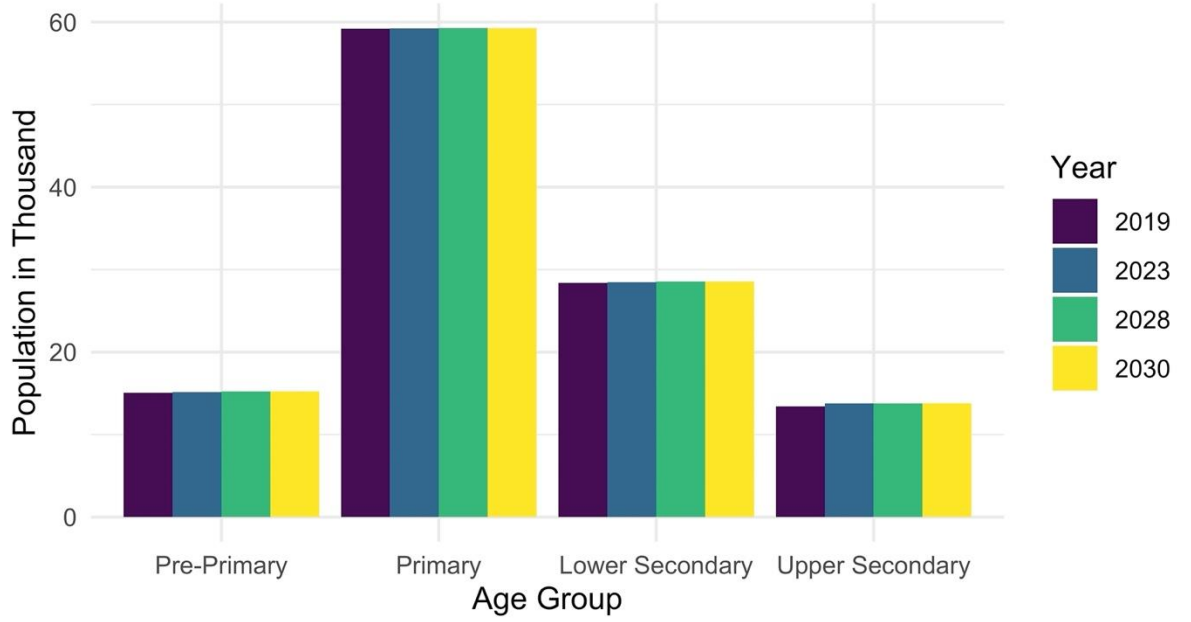


Figure 3. 4: Number of Teachers Required by Year and Education Level

Source: Ministry of Education Youth and Sport (2019a).

Figure 3.4 demonstrates the total number of teachers required by year and education level. From the graph, it can be clearly seen that the number is expected to increase although the magnitude is rather small. This very small growth can perhaps be best explained by the growing number of private schools in the country which would play a more significant role in delivering educational services and household ability to afford private educational system which is in turned suggested by the proliferation of private schools itself (Brehm, 2017). Simply put, the growing number of private schools suggests that there is certainly a more demand for private educational services, and that of public schools has been relatively constant. Therefore, while the number of schools might increase remarkably to reduce the traveling cost and time and to improve access, the number of teaching personnel might not do so at a similar pace.

Regarding the private sector, it is important to note that there also exists private educational institutions in Cambodia (and most countries) which provide parents a choice for their children's education for a fee alongside with public schools. The fee is not really cheap, ranging from USD 1,200 to USD 20,000 per year (Brehm, 2017). However, many parents find private schools more gratified, and that has led to a rapid increase in the number of enrollment in private schools from 168,287 students in 2016-17 academic year to 253,569 students in 2019-20 (Department of Education Management Information System, 2018, 2020) while the number of private schools jumped from 1,076 in 2017 to 1,307 in 2020 (Department of Education Management Information System, 2018, 2021). A study also finds that the increasing urban middle class population is sending their children to attend private-paid schools while public institutions are losing enrollment between 30-50% as a result (Kampuchean Action to Promote Education, 2013). In some urban cities, the drop is as high as 75%. This is one of many challenges that the Cambodian government is trying to address when MoEYS introduces the NGS model, which is the Cambodian equivalent of Charter School in the United States.

Section 4: Existing Educational Vision, Policies, and Strategies

With regards to policy environment, RGC acknowledges the significance and benefits of science & technology (S&T) and is striving to integrate it into all sectors and segments of the society. Consistent and coherent efforts of line ministries and government agencies in promoting the S&T sector are reflected in a number of policy frameworks, such as the NSDP 2019 – 2023, Industrial Development Policy 2015 – 2025, the National Policy on Science, Technology and Innovation 2020 – 2030, the Cambodia's Science Technology & Innovation Roadmap 2030, the Cambodia Digital Economy and Society Policy Framework 2021 – 2035, Cambodia ICT Master Plan, Policy on Higher Education Vision 2030, and Policy on STEM Education etc. In addition, there are specific policies and plans which indicate the utilization of science and technology in education including Education Strategic Plan 2019 – 2023, Cambodia's Education 2030 Roadmap, and National Technical Vocational Education and Training Policy 2017-2025 etc.

It should be noted that all of these policy frameworks place a strong emphasis on building soft and hard ICT infrastructure, human resources, and regulatory frameworks that support Cambodia's socio-economic development, which has generally continued to focus on four broad areas, namely people, roads, energy, and water. The former one revolves around human capital building through strengthening the quality of education, science and technology, expanding technical and vocational training, improving healthcare delivery and nutrition. This section will discuss recent major national policies that largely play a role in laying foundation in science and technology, education, and educational technology.

4.1. National Strategic Development Plan

This section discusses a series of NSDP from 2006 to 2023 and its sectoral foci. It should be highlighted that NSDP is one of the top national-level overarching social and economic development policies. Prior to NSDP, there was indeed other socio-economic development plans in place, two of which were quickly produced in 1994 after the newly elected and stable government was established. These two documents were the *National Program to Rehabilitate and Develop Cambodia 1994-1996* and the *Cambodia, from Rehabilitation to Reconstruction*. Between 1996 and 2006, two more medium-term development strategies known as the First and the Second Socio-Economic Development Plan were passed. It should be highlighted that during this time a set of Cambodia Millennium Development Goals was additionally outlined following the Millennium Declaration of the United Nations Summit in 2000. And as an act in furtherance of the CMDGs, the government has decided to adopt a more holistic, cogent, and coherent scheme called the Rectangular Strategy in 2004 to tackle both socio-economic development challenges and governance issues. As a result of the change in such decision on overall focus and strategic goals, the first National Strategic Development Plan 2006-2010, which operationalizes the Rectangular Strategy, has also been given birth (Royal Government of Cambodia, 2006).

Unlike any previous development policies set out by the Cambodia government, NSDP is a single and comprehensive document, spelling out in more detailed priorities and goals to be reached, measures to be taken to achieve them, and amount of investment needed to execute such plan. However, before NSDP 2006-2010 could be successfully implemented, the country was dragged into the Global Financial Crisis in 2008 and 2009. The depression faced by

advanced economies presented Cambodia a new and external challenge, and to pull the country out of the crisis, the government then was required to re-examine, re-prioritize, and update the Plan and pass NSDP 2009-2013. Through concerted efforts, Cambodia has remarkably achieved the Cambodian Millennium Developments Goals promised to the United Nations by the end of 2013. Besides the results, there was also a big lesson learned in assigning different tasks to specific institutions. As a result, the principals and mechanism which were used for the preparation of NSDP 2009-2013, were once again employed for the next 5-year plan known as NSDP 2014-2018, a further refinement to the previous one. Similar to what had been laid out in the NSDP 2009-2013, apart from outlining the goals and objectives to succeed, the new Plan identified which ministries or government agencies would do what (Royal Government of Cambodia, 2014). However, it should be noted that the overall goals of NSDP 2014-2018 were to prepare the country for the first step for ASEAN Economic Community in 2015 and in sustaining its economic growth under the circumstance that Cambodia would be increasingly less eligible for further grant and soft loan.

The latest version of this national development policy, which is NSDP 2019 – 2023, was passed by the Sixth Legislature of the National Assembly in 2019. The central themes of the plan are Growth, Employment, Equity, and Efficiency which should be linked together. To achieve such goals, RGC focuses its development on quality and inclusive education concentrating on science, technology and innovation and labor market orientation. It is in this regard that the Cambodian government has continuously modernized its educational system and integrated STEM into the national curriculum and textbooks. Other reform priorities include increasing the salaries and bonuses for teaching staff, capacity building for teachers, building career pathway for educators, expanding the New Generation School model, and intensifying the involvements from parents and communities in which students live. From academic perspective, these factors are essential, but what truly evince the government's commitment to translate its development aspirations into reality and improve quality of schooling through educational technology is their intention to promote the development of information technology to reform education management and monitor students' performance at school so that they can intervenes at a timely manner to lower the perpetual issue of dropout.

At the school level, reviewing and strengthening the role of quality assurance approaches at general education level also receive the government's attention. RGC intends to strengthen its inspection capacity to ensure that all schools are following the national curriculum and agenda. It is in this sense that technology can also play a role in helping the school leadership manage its administrative and logistic tasks better to enhance its governance and organization, boost quality of education delivery, and provide an effective response or solution to tackle various problems including teacher absenteeism.

It should be highlighted that NSDP 2019 – 2023 also emphasizes entrepreneurship, STEM, leadership, and innovation skills as important prowess that should be enhanced not only at the general education level but also at the tertiary education, namely university as well as technical and vocational education and training (TVET). Indeed, the Ministry of Education, Youth, and Sport has passed the Policy on STEM Education in 2016 and prepared a more comprehensive curriculum framework for university education to respond to the Fourth Industrial Revolution and that includes STEM and some major social science subjects based on market demand for skills. In addition, it is suggested in the latest NSDP that the government would found more education and science centers which are in line with the Cambodia STI Policy 2030 indicates the government's political dedication toward building an economy based on heavy industries driven by marketable technologies which are in turn a result of scientific advancement. Such

progression is possible only through a large investment in research, research and development (R&D), and innovative-focused solutions. And as we would normally expect, such a national policy indeed aims to build capacity and resources for research personnel and scholars via research funding mechanism.

4.2. Educational Strategic Plan 2019 – 2023

The Educational Strategic Plan (ESP) 2019 – 2023 of Cambodia was passed by MoEYS and is the thorough and comprehensive version of the National Strategic Development Plan 2019 – 2023 that elaborates on human resource development. In particular, it adds detail to the first goal of NSDP of improving the quality of education, science, technology and to goal 4 of the Cambodia Sustainable Development Goals. It should be highlighted also that the priorities of development areas for the ministry between 2019 and 2023 is sevenfold namely teachers, expansion of schools at all levels including kindergarten, improvement of comprehensive inspection of school management and administration, promotion of technical education at upper secondary level, market-oriented skills enhancement, development of comprehensive national curriculum and textbook, and preparation for the Southeast Asian Games which will be held in 2023. But while the ESP talks about K-12, university, non-formal, and sport education, our focus of discussion here would be general education, in particular secondary and technical education which pinpoints the expansion of STEM subjects in the national curriculum to meet the 21st century skills framework. In addition, the ESP aims to improve access to secondary education for all Cambodian youth and lower the high dropout rate in response to the implementation of the Industrial Development Policy 2015 – 2025 which is also reviewed in the next sub-section. Specific action plan includes increasing the use of computer, workshop, and laboratories and modern teaching methods which would demand for a substantial investment in educational technology.

It is worthwhile to indicate that MoEYS also approved the Cambodia's Education 2030 Roadmap in February 2019 to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. The 2030 roadmap outlines five policy priorities:

- All children regardless of gender have access to early childhood care and education with international standard, as well as to pre-primary education, and completely free, equitable and quality mandatory education (grade 1 – 9).
- All teenagers should complete upper-secondary education (grade 10 – 12) and have certain level of competency in market-oriented skills.
- A notable number of youths both male and female should have accessed to affordable and quality technical and vocational and tertiary education.
- All youths and adults achieve literacy including digital and financial literacy and numeracy, and all individuals have increased life-long learning opportunities.
- Educational governance and management should be refined.

All of these priorities, especially the last one, can largely be achieved with the contribution from the exponential use of educational technology, including management system software.

4.3. Cambodia's Science, Technology & Innovation Roadmap 2030

Before the Prime Minister of Cambodia approved the National Policy on Science, Technology & Innovation 2020 – 2030, the government had also passed its Industrial Development Policy (IDP) 2015 – 2025 in March 2015 in a plenary meeting. IDP aimed to industrialize the country and maintain sustainable economic growth of 7% through connecting Cambodia to the global value chains, diversifying the economic sectors, and improving competitiveness in terms of quality and productivity rather than low labor cost. The latter can only be achieved by encouraging industries to move to use modern technology in production line. At the same time, the country needs to equip its labor with competency necessarily to work alongside machines which is also a strategy mentioned in the IDP. However, many Cambodian industrial sectors remain weak, and vast majority of them are family-based SMEs with limited ability to compete in the international market. While large industries also have a very simple structure of manufacturing and mostly concentrate on garment and food processing with limited use of technology (Royal Government of Cambodia, 2015).

Being aware of these challenges and aspired by the country's 2050 Vision, RGC decided to establish MISTI in March 2020 to promote STI as a driving force for rapid economic growth and social development. The first National Policy on STI 2020 – 2030 was also passed by the government to strengthen the STI foundation, improve the enabling ecosystem, develop an STI environment for sustainable development, and enhance the quality of people's lives at all levels and in all sectors. Remarkably, the National Policy on STI 2020 – 2030 pays its STI priorities attention to five scientific and technological domains namely agriculture and agro-processing, modern production and engineering, health and biomedical science, material science and engineering, services and digital economy, including artificial intelligence (AI), space and spatial technology. In order to smooth the development process, the National Policy on STI was accompanied by the Cambodia's STI Roadmap 2030 which is endorsed to assist the implementation of the Policy and intended as a short and medium-term guideline for government institutions and relevant agencies or authorities that are playing a part in the development of national STI ecosystem in Cambodia. The roadmap has five main pillars of focus including:

- Governance: enhancing the governance of the STI system
- Education: build human capital in STI
- Research: strengthening research capacity and quality
- Collaboration: increasing collaboration and networking between different actors
- Ecosystem: fostering an enabling ecosystem for building absorptive capacities in firms and attracting investments in STI

It is worth highlighting again that this EduTech roadmap aims to contribute to achieve pillar 2 and 4 of the Cambodia's STI Roadmap 2030, and therefore, it is perhaps useful to note that the government attempts to get at least 50% of the university students to choose STEM major by 2030. This section is concluded with a final remark that even though Cambodia has continuously developed national policies on STI with impressive efforts, legal and institutional framework that govern technology development and cyberspace remain insufficient. Technology is advancing at a rapid pace, in terms of scope and magnitude, which calls for dynamic legal framework that are responsive to the emerging opportunities and risks. It is vital to ensure protection and security for consumers in order to encourage widespread usage of technology in general, educational technology in particular.

Section 5: National Education Technology Roadmap Development

5.1. Building Vision and Goals

Vision

Building the next-generation technology-enhanced learning ecosystem focusing on improving innovation and entrepreneurship skills.

Goals

- Offer an open educational resource platform by creating a central repository to manage and deliver freely accessible learning resources
- Increase time spent on personalized learning which complements physical classroom
- Increase access to internet at school and at home through computer
- Improve learning outcome
- Improve innovation and entrepreneurship skills.

Monitoring and Evaluation

The consultation workshop participants have also reached an agreement that a mechanism for monitoring and evaluation of the implementation of the National Educational Technology Roadmap is indispensable to ensure that the execution is within the timeframe and guarantee effective policies, and that the roadmap will not be a speech but a tool to achieve a desired outcome. For that, each goal of the roadmap should be set with specific indicators for benchmark and 2030 targets. To do so, a baseline survey such as a National Student Survey, College Student Survey, and/or Labor Force Survey must be conducted in early 2023 to be used as a point of reference and an end-line survey must be done in late 2030 to compare the indicators and evaluate the entire implementation process. There can also be two interim small-scale surveys and qualitative data collection (E.g., in-depth interview) to be done in 2025 and 2027 as monitoring mechanism and to identify bottleneck if there is any. Furthermore, it is suggested that three 3-year action plans should be additionally developed between now and 2030 to lay out specific actions, roles of individuals and institutions, and responsible personnel.

5.2. STEEP Analysis

In order to identify the prospects of adoption and adaptation of educational technology in the context of Cambodia, it is crucial to analyze various macro-level factors that create strengths, weaknesses, trends, opportunities, and threats for the incorporation of educational technology. Besides the educational context mentioned above, there are other five main aspects of the macro-environment situation, STEEP, namely social, technological, economic, ecological, and political, which will be examined in this subsection to provide a clearer picture about Cambodia.

5.2.1. Social Environment

The Kingdom of Cambodia lies between Vietnam and Thailand with its north-eastern border shared with Lao PDR and a total area of 181,035 squared kilometers divided geographically into four different regions: Plain, Tonle Sap, Coastal, and Plateau/Mountainous areas or administratively into 24 provinces, excluding Phnom Penh, the largest city and home to about 14.7 percent of the country's total population (National Institute of Statistics, 2020a). The Cambodian socio-economic context today owes much to its recent tragic history, which was filled with long periods of anguish, turmoil, and despair. As a result, it is probably impossible to understand Cambodian demography now without basic knowledge of the Khmer Rouge's legacy and three decades civil war after a coup d'état in March 1970 to remove Prince Norodom Sihanouk from power. However, since the beginning of this new millennium, Cambodia has experienced peace and political stability which provides an essential environment for the society and economy to grow. When a census was conducted in 2008, it was shown that the population of the country was roughly 1 million (National Institute of Statistics, 2009), but the number has increased to 15.5 million in 2019 (National Institute of Statistics, 2020a) with a median age of 25.6 years (United Nations Department of Economic and Social Affairs, 2019). Therefore, it is understood that a large proportion of the Cambodian population is dominated by children and youth bulge, and it is in this sense that Cambodia needs to capitalize on its demographic window of opportunity. That is, taking advantages of its young population and labor force to boost economic growth. Moreover, young population also means high demand for quality education, as at young age, people would spend most of their time at school to accumulate human capital.

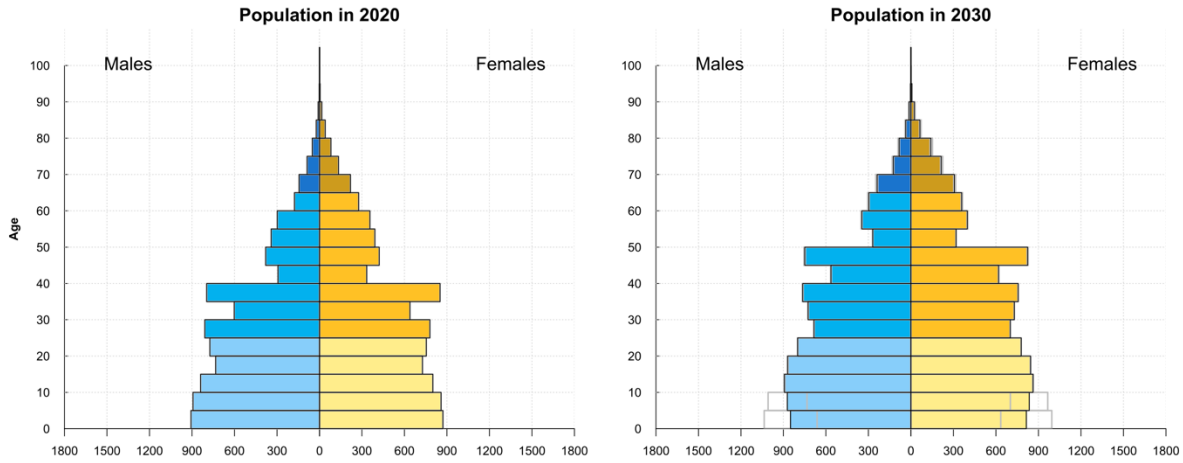


Figure 5. 1: Population Pyramid of Cambodia 2020 and 2030

Source: Adapted from United Nations Department of Economic and Social Affairs (2019). Medium variant projection.

Figure 5.1. illustrates the population pyramid of Cambodia between 2020 and 2030. The effects of political turmoil and the Khmer Rouge's genocide exhibit a small proportion of the population at the upper half in 2020, a crystal-clear indentation. During the Khmer Rouge regime, it was estimated that about 2 – 3 million or one-third of the total Cambodian population at that time perished of execution or succumbed to diseases (Gellman, 2010). With that said, the baby boom that occurred in the late 1980s and 1990s has also, to a large extent, influenced the age structure making Cambodia a young labor country with approximately 300,000 workers

entering the market every year (Ministry of Labour & ILO, 2014). Nevertheless, this figure comprises mostly rural youth with low skills and productivity, and as a consequently they tend to work in the informal and blue-collar sectors (Chea et al., 2021). By 2030, a vast majority of the Cambodian population will be still in the labor market, but the Generation Z and Alpha have begun to dominate the labor force participation rate. These generations are highly familiar with technology, and Artificial Intelligence (AI) and Virtual Reality (VR) are also their reality. In addition, their learning style is very much personalized. What it signifies is that the future human resource of Cambodia who are the potential students, educators and leaders would be quick adopters of technology. They also tend to be open-minded, keen to explore new ideas, full of curiosity, and therefore they are likely to develop interests in technological development and embrace adoption of technology and innovative concepts. Compare to other stages of life, youth is the phase that people can absorb new experience better and change their mindset.

5.2.2. Technological Environment

Cambodia is one of the least developed countries that has the highest number of internet users in the world. According to the World Bank, approximately 80 percent of the Cambodian population has access to the internet through some types of devices (World Bank Databank, 2021). Intense competition among mobile network operators and internet service providers has brought down the cost per megabyte of internet data from USD 4.56 in 2013 to one of the lowest in the world at USD 0.13 in 2019, and that has led to a substantial increase in the consumption of internet data to 6.9 gigabyte per capita per month which is the highest among low and lower-middle-income countries (World Bank, 2021c). This is possible due to a combination of multiple approaches including migrating spectrum and users to 4G, moving software to the cloud, and outsourcing construction work (ibid). In addition, the RGC active efforts in promoting industrialization across all aspects of the country provide a supportive political environment for implementing digital transformation in general, educational technology in particular. Having a key enabling digital infrastructure, such as the National Data Center and the National Internet Gateway, has also played a pivotal role in fostering a favorable technological environment for digital transformation of education sector. But there is still plenty of room for improvement particularly regarding of cybersecurity, legal framework, and the use of technology for educational purpose at household and school level.

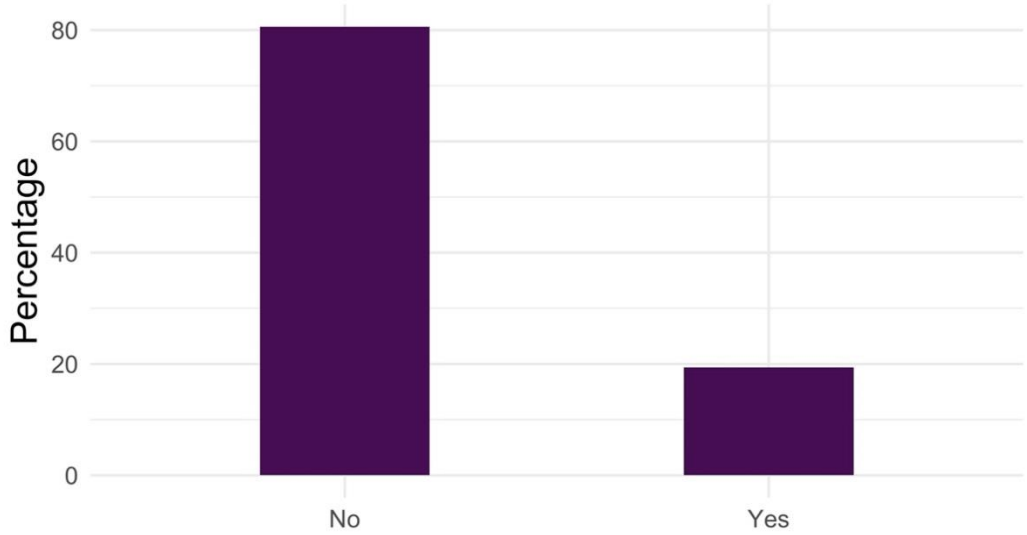


Figure 5. 2: Percentage of Students Who Have Computers at Home that Can Be Used for Schoolwork

Source: Ministry of Education, Youth, and Sport (2018).

Presenting in figure 5.2 is the percentage of students who have a computer at home which can be used for schoolwork. The graphics derives from the PISA-D survey, which asks students who are exactly 15 years old and studying at the secondary level. The figure also indicates that only about 20 percent of Cambodian students actually have a computer, either laptop or desktop, at home for studying or doing homework. It is worth noting that even though they might have a computer at home, it can belong to their parents or family members, and that they are not allowed to use such devices. But according to an unpublished College Student Survey 2020 conducted by the Cambodia Development Resource Institute (CDRI), the number of students at tertiary level who own a computer is much higher at more than 70%. However, it is probably because Cambodian universities are populated mainly by students from the middle and high-income families who are also more likely to be able to afford such technological devices. When asked, teacher samples in PISA-D survey also revealed that only a bit more than 20 percent of the schools has computer in good condition and can be used by students.

Figure 5.3 below shows the percentage of students who have internet access. Approximately, 43% of the students aged 15 years old have access to the internet. As the internet allows for access to digital resources and online materials and encourages personalized learning, lack of internet access is very much likely to prevent students to reach their full potential and affect their labor market consequence. In fact, there are empirical evidence that computer-assisted instruction and digital resources do have a positive impact on student's learning outcome in developing countries (Bulman & Fairlie, 2016). In addition, because only a small number of them have a computer, it can be concluded that they are likely to surf the internet using mobile phones which is difficult for studying. This might also have a negative impact on their performance and learning outcome during the COVID-19 pandemic when all classes have to be moved to online platform, and that they have to use mobile phones to attend classes and do the homework.

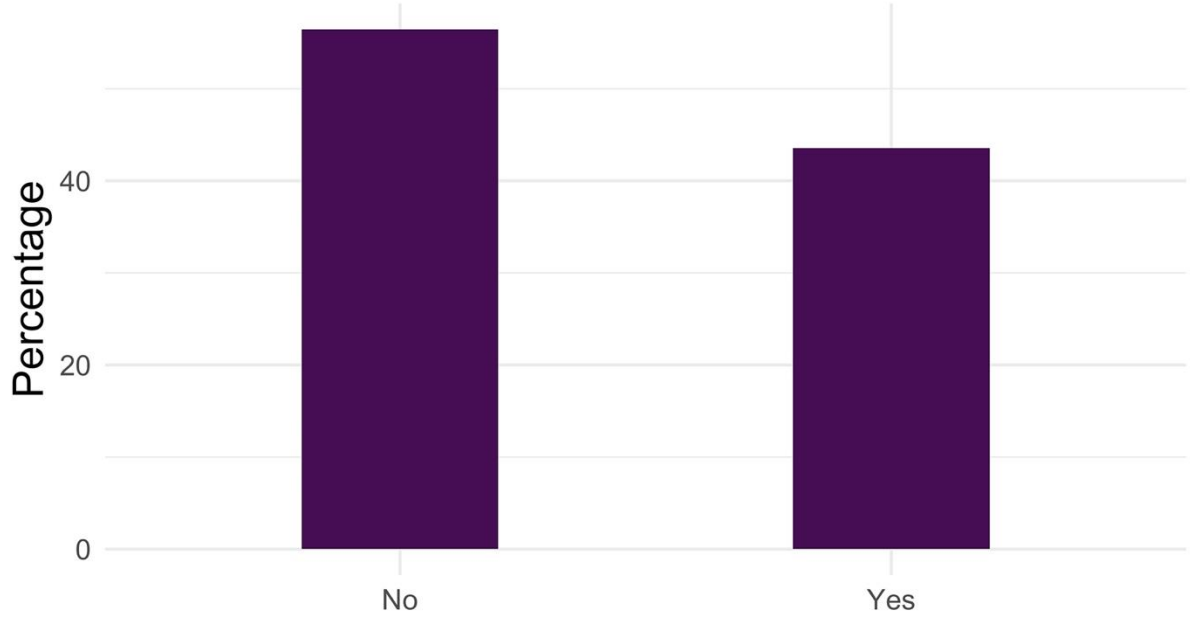


Figure 5. 3: Percentage of Students Who Have Access to the Internet

Source: Ministry of Education, Youth, and Sport (2018).

Overall, the digital readiness of the Cambodian population is also unfavorable albeit growing steadily. Technology adoption among the general public, government, and industries is also lower relative to other countries in the region (RGC, 2021). There are also concerns about high risks as a result of vulnerable digital infrastructure and inadequate legal framework for cyberspace which lead to low levels of trust in reliability of technology and in turn slow down the growth of technology adoption (Rahamathulla, 2021). Human resources in Information and Communication Technology (ICT) are also another factor hampering the development of digital and technological infrastructure in the country. In a recent estimate, Cambodia has approximately 50,000 individuals with ICT capacities, but most of them have just intermediate level of skills and are not specialists. In a report drafted by the Cambodia Development Resource Institute (CDRI), it was indicated that while the number of enrollments at higher education have been increasing rapidly, only 20 percent of about 220,000 bachelor degree students actually chose STEM (Science, Technology, Engineering, and Mathematics) major at the university in 2016 even though CDRI also suggested that to maintain a strong economic growth of 7% per year, Cambodia will need to generate about 35,000 engineers and 46,000 technicians between 2015 and 2020 (Kao, 2020). These figures altogether showed that Cambodia is lacking capable individuals to build a strong and enabling digital and technological environment.

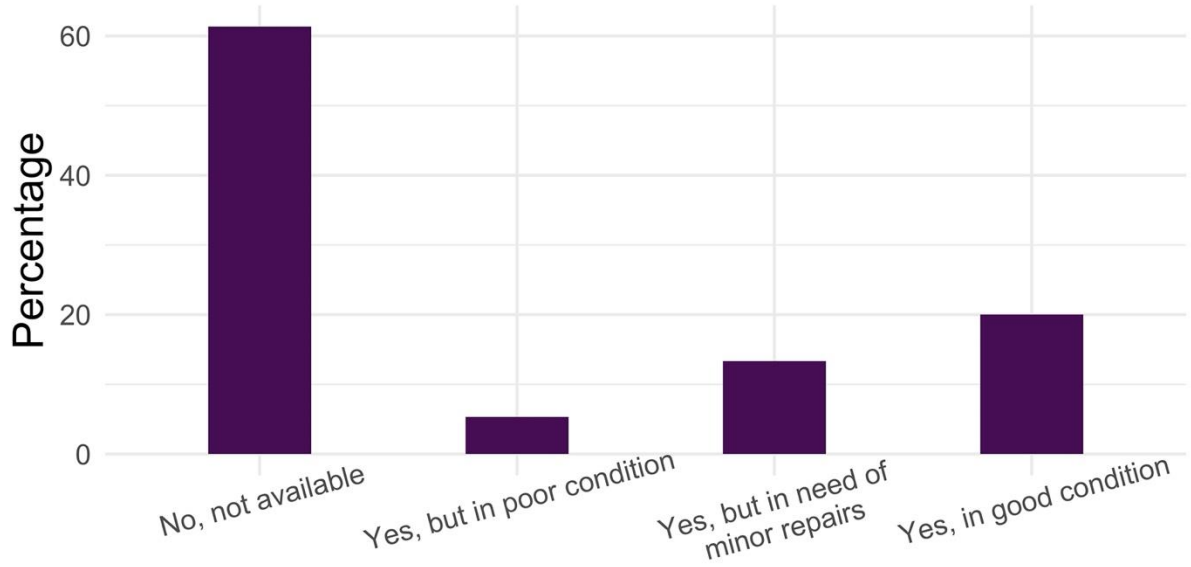


Figure 5. 4: Percentage of Teachers Who Have Access to the Internet at School

Source: Ministry of Education, Youth, and Sport (2018).

Presenting in figure 5.4 is the percentage of teachers who have access to the internet at their schools. As can be clearly seen, approximately 60% of the teachers indicated that they cannot access the internet at all because internet connection is not available at school. About 5% of the teachers stated that the internet is available at the school, but it is in poor condition, and it will need substantial repair before it can be of good use to them. Only 20% of the schoolteachers said that the school internet is working properly regardless of the speed of the internet itself. It should also be highlighted that although the percentage of students with internet access is apparently higher than that of the teacher, it is not directly comparable, as

internet access at school refers to institutional internet connection through WiFi or network cable. The teachers themselves may also be able to connect to the internet using their mobile phones even if it is not counted as institutional internet access. Having said that, there is a lot of room for future improvement in terms of digital infrastructure at school because to promote digitalization of education and encourage the use of educational technology in the classroom, fast and stable internet connection is essentially momentous for the success.

5.2.3. Economic Environment

This subsection will delve into the macroeconomic situation to study whether Cambodia's current economic environment is conducive to effective implementation of the educational technology roadmap because adoption of educational technology requires purchases of advanced technological devices, development of digital system, and provision of capacity building programs, which translates into demand for substantial financial investment from both public and private entities in and beyond the educational sector.

With that said, the presence of the COVID-19 pandemic is taking a toll on the growth of the Cambodian economy. Prior to the pandemic, the country was one of the fastest growing nations in the world and has witnessed a rapid growth from 1998 to 2019, with an average annual growth rate of 7% contributed by four main sectors, including agriculture, manufacturing industry, tourism, and construction (World Bank Databank, 2021). The government's commitment to structural reform since 2013 has substantially accelerated and supported the integration of Cambodian manufacturing industries into regional and global production network. ASEAN Economic Integration in 2015, in addition, also offers Cambodia a leverage to improve its industrialization, technological advancement in manufacturing production, labor productivity, and overall competitiveness in the regional and global market. As a result, poverty rate has plummeted dramatically from 47.8% in 2007 to 13.0% in 2014 (Royal Government of Cambodia, 2019). However, owing to the disruptions caused by the pandemic, the economic growth experienced a 3.1% decline in 2020, but is projected to bound and grow at a rate of 4% in 2021 and 5.2% in 2022 with the future outlook still containing high levels of uncertainties and risks (World Bank, 2021b). In addition, due to the change in the national poverty line lately to USD 2.7 per capita per day by the Ministry of Planning, poverty rate has seen an increase to 17.8% along with the decrease in the per capita consumption expenditure of the lowest two quintiles (National Institute of Statistics, 2020b).

Figure 5.5. presents the country's GDP per capita between 2012 and 2020. By the end of 2014, Cambodia has been recategorized into the lower-middle-income country group and dubbed as the "Asia's New Tiger Economy" by the Asian Development Bank owning to its rapid development. However, as have been mentioned early, 2020 shows a contraction of economic growth due to the COVID-19 pandemics which also reflects in the amount of GDP per capita, a clear drop in the figure leaving the per capita income in 2020 of only USD 1,512. This, nevertheless, has a negative impact on the Cambodian government's vision of becoming an upper-income-country by 2030 and high-income country by 2050, and hence some national policies are likely to be revisited and revised to take into account the delays. Another main challenge for the RGC is to maintain a high growth rate, and that the country will need to continue to reform its economic, financial, and administrative structure to attract more foreign direct investment (FDI), and find innovative approaches to keep its industries running.

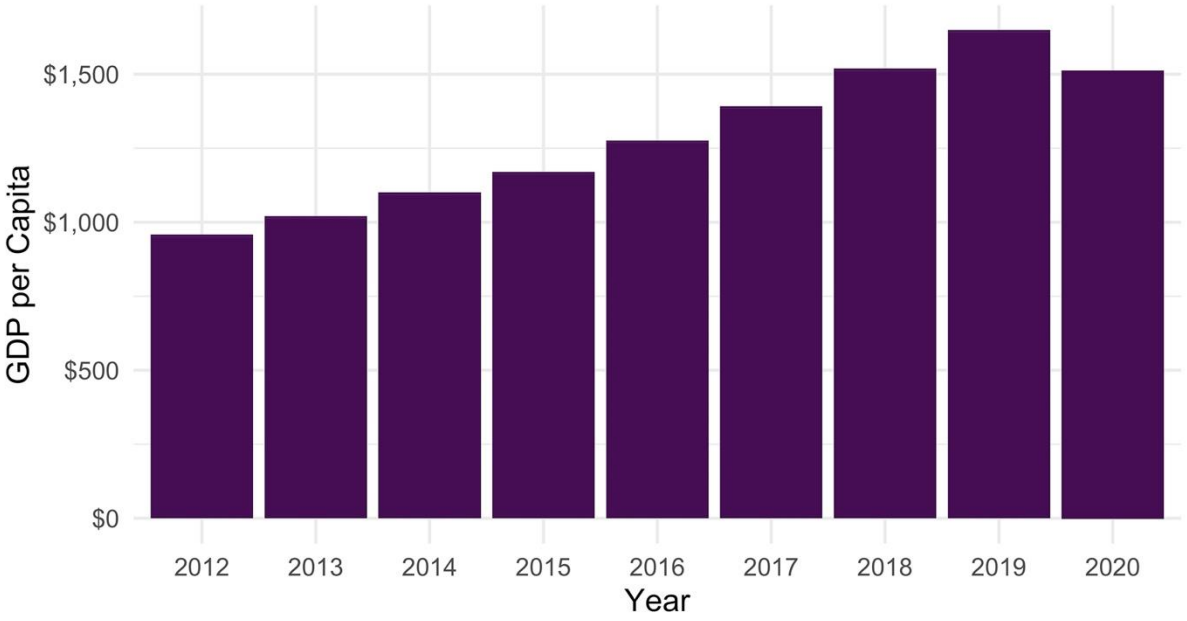


Figure 5. 5: Gross Domestic Product Per Capita between 2012 and 2020

Source: World Development Indicator. World Bank (2021).

In addition, the pandemic has influenced the economic side of the education sector because apart from the public funding, Cambodian households also contribute significantly to the improvement and expenditure of Cambodia's education sector (Brehm, 2017). Moreover, in order for schools to have an adequate capacity to invest in educational technology, it is not sustainable to only depend on external support from the government. Schools need to find other ways to acquire considerable financial resources, and one of which is to request for voluntary contribution from the community. With that said, it leads to a question of households' ability to contribute financially. Not to mention that general household income is also facing severe reduction during the pandemic. Stringent measures have been put in place in an attempt to cope with the outbreak, which have acutely disturbed various economic activities, causing job losses and reduced working hours and thereby income losses. According World Bank Cambodian Office's statistic, the proportion of household main earners that were able to maintain employment, as of March 2021, dropped to 69%, 13 percentage points lower compared to the pre-pandemic era (World Bank, 2021a). Moreover, in the same period, approximately 45% of households still faced the continuous struggle of income losses. Such challenges are likely to pose a significant constraint on the efforts to adopt technology in Cambodia's education system since both government and households are in shortage of necessary financial resources to fund the investments in educational technology. On an optimistic note, the government is expressing commitment to increase public expenditure on education sector as we have mentioned in section 3 and 4 of this roadmap.

5.2.4. Ecological Environment

The ecological theory of knowing defines learning as a process of successfully participating in and interacting with social and ecological systems (Barab & Roth, 2006). It is in this sense that the learning system consists of not only individuals interacting with one another but also with the ecological, biological, and physical environments around them. Barab and Roth call this the Life-Word trajectory, in which learning is not simply to get the highest score possible but to put what we have learned into actions in the real world. Through these interactions, students

and the nature surrounding them which they interact with are transformed. It is also for this reason we can always argue that education in a broad sense is intertwined with ecological environment. And so is educational technology which is a tool to facilitate learning process. Therefore, understanding the ecological environment of Cambodia is essential in order to comprehend educational technology.

To begin, Cambodia has a total area that is entirely situated in the Tropical Monsoon climate, which is wet and dry and thus hot all year round. Such a high temperature is particularly not an advantage for education because it has a direct impact on individual students at least in two ways. First, the hot environment reduces agricultural and industrial outcomes as well as productivity of workers effectively making the country poorer (Dell et al., 2012). As a consequence, it affects the country's ability to invest in education. Second, students at any given age or grade in hotter countries tend to perform worse relative to those in colder countries. A 1°F increase in annual temperature is associated with 0.02 standard deviation lower math scores in the PISA test (Park et al., 2020). Even within the same country, students living in a hotter region are more likely to do less well compared to students from colder places (ibid). These research studies tell causality, so it is especially worrisome as it is predicted that global temperature would continue to rise due to reckless behaviors of industrialized countries which has produced a lot of pollution. Having said that, a nationwide school-level measures of air conditioning policy in Cambodia would help mitigate such effect on students.

Cambodia also has a 443km coastline at the Gulf of Thailand and an exclusive economic zone of 55,600 squared kilometer which is enriched with mangrove forests, coral reefs, seagrass, and other coastal biodiversity, and these have played a vital role in ecosystem productivity including supplying the population with fish and protecting coastal region from eroding (Chea & Kobjaiklang, 2017). Nevertheless, this short coastline puts the country in a disadvantageous position, as longer coastline allows for better marine transportation and thus facilitate international trade. It has been well-known among economists that major developed cities are located near the sea because such places can trade with other regions easily, and hence they can reap of gain from maritime trade. Simply put, international trade through the sea effectively contributes to the development of those cities. On the other hand, most landlock countries especially those in Africa tend to be poor. Nonetheless, Cambodia can also be seen as a "land-link" country acting as a central point that connects all the countries in the mainland South-East Asia, and that can be an advantage for land transport and thereby regional trade.

Dominant income generating activities for rural households in the Coastal, Plain, and Tonle Sap regions, where vast majority of the Cambodian people live, are fishing, wet rice cultivation, and animal husbandry which mostly rely on the rich natural resources and floodplain resulting from annual rise of the Mekong and Tonle Sap rivers. The latter carries water from the Tonle Sap Lake (the Great Lake) to the Mekong River between November and April and from the Mekong to the Lake between May and October. Simply, the 115-kilometer-long Tonle Sap River flows from the Great Lake to Mekong River six months in a year and another six months a year in the opposite direction, and that is very unique. Tonle Sap Lake is also the very heart of Cambodia's fertile soil and natural resources. Due to its extremely unique socio-ecological system, it provides Cambodians a big source of freshwater fish and rice and vital income generation. Having said that, heavy monsoons and the seasonal flooding can also be devasting to educational system, as it normally destroys schools or prevents the school from operating properly. In the aftermath of the flooding, such disasters often interrupt children's attendance and thereby negatively influence their performance and educational attainment, for infrastructure such as building reconstruction is typically slow and sometimes delayed due to

limited budget. Empirically speaking, research study has shown that children who have experienced natural calamity such as flooding or Tsunami are worse-off in terms of academic performance and have higher rate of absenteeism (Siriwardhana et al., 2013).

Beyond the realm of water lies the forestry resources. Cambodia is predominantly a low-lying country and bordered on three sides of densely forested mountainous areas resembling a pan, the center of which is the lowland region, where the Cambodian population is used to growing paddy rice. Figure 5.6 below illustrates the topography of Cambodia in more details. With that said, the national forest is also one of the most important natural resources in the country as it provides not only timber but also various non-timber forest products. such as fuelwoods, oils, medical plants/herbs, fishes, insects, spices etc. and a source of income generating activities, economically speaking. In addition, forest ecologically speaking helps protect soil erosion and regulate hydrological system particularly of the Mekong and Tonle Sap River.

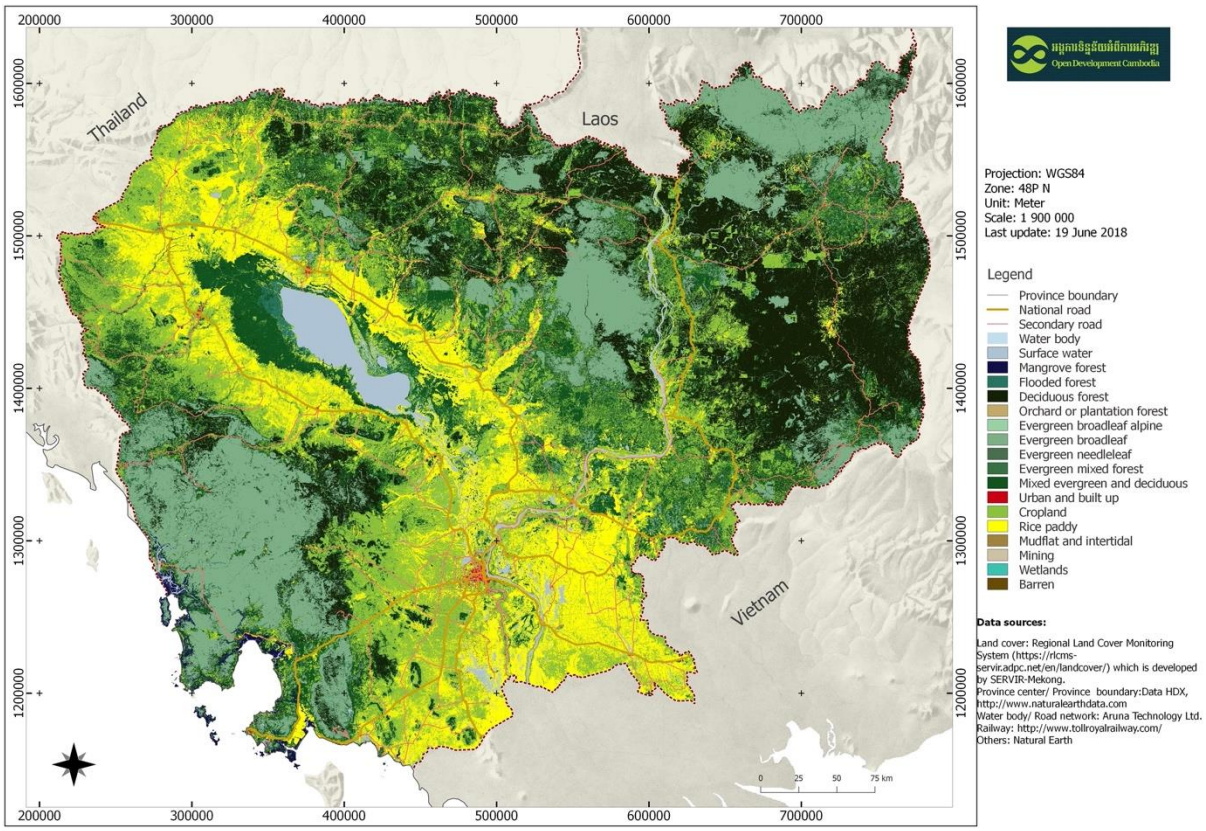


Figure 5. 6: Topographical Map of Cambodia

Source: Open Development Cambodia.

5.2.5. Political Environment

Since the election in 1993, Cambodia has been a constitutional monarchy with his majesty the king as the head of state and prime minister as the head of government. The latter is chosen by the Cambodian population in a democratic and multi-party election done every five years. This system has proven effective, as the country has largely experienced peace and stability while its people has begun to recover from the traumatizing past. Cambodian government itself has also shown a strong political support for science, technology, and innovation and given priorities and scholarships for students who choose STEM majors at the university as have

been mentioned in the previous sections. In addition, Cambodia's position in the international political area has also been remarkable especially during the pandemic contributing to the prosperity of the Southeast Asian and Asia Pacific region as a whole. But while it is expected that Cambodia will be able to maintain its internal hard-earned peace and solidarity in long term, potential external challenges should also be addressed, in particular, the race for supremacy and recent trade war between the United States and China leading to the imposition of tariff on various products from rival countries. This is likely to have a severe effect not only on the use of technology due to increase in its price, but also on existing international orders and global affairs, political serenity and the future of the entire Asia Pacific region. Not to mention the Cambodian economy itself which relies heavily on international trade and export. Therefore, prudent steps should be taken, and the country has to be prepared for the scenario of external threats and sudden financial collision.

5.2.6. SWOT Analysis

This subsection shows summarized key drivers from the STEEP analysis above and presents opportunities and threats for each driver.

Table 5. 1: Opportunities and Threats for Key Drivers

Drivers	Opportunities	Threats
Young but rapid-aging population	• Demographic dividend. • High familiarity with technology	• Short period of demographic window so the country's population will become old before they become rich • Country's technological development level stagnates
Large majority of population consists of people in generation Z and Alpha	○ Increase in consumption of technological products and services	○ Communication and teamwork skills decreases which will slow down scientific collaboration and progress
Enabling environment for technological adoption	• Increasing demand for consumption of technology and technological products and services • Increase demand for internet connection	• Increase in cyber threats, crimes, and attacks
Rising labor cost	○ Increase welfare of working population who can better afford technological products and services ○ Demand for skilled labors and technicians increases	○ Reduce competitiveness in international trade leading to unskilled job loss and income

Strong economic growth	• More investment in education from both household and government	• Increase demand for more energy which might not be sufficient for overall consumption
Improve energy production through construction of hydroelectric dam and combustion	○ Encourage the expansion and use of technological products and services	○ Environmental degradation and negative impact on biodiversity ○ Economic externalities leading to loss of income and investment in education
Strong regional collaboration	• Free flow of ideas, innovation, and technologies	• Trade war between China and the USA weaken regional integration
Internal political support for science, technology, and innovation	○ Rapid development of science, technology, and innovation. ○ Increase in number of STEM specialists	○ External political threats ○ Sudden financial crisis
Hot and rising temperature	• N/A	• Decrease productivity • Lower student's learning outcome
Geographical location of Cambodia	○ Being a central point linking countries in mainland South-East Asia	○ Short coastline tends to reduce maritime trade

Source: Authors.

5.3. Strategic Products and Services

From the STEEP and SWOT analyses which were done by desk review method and the data that the research team collected through in-depth interview and roundtable panel discuss and the consensus among EduTech committee members and participants during the consultation and validation workshop, four pillars/areas of products/services have been identified namely the Essentials, Management System, Courseware, and Capacity Building. Each product or service in each area/pillar is listed down by order of importance from the most important or of higher priority to the least important or of lower priority, and that the areas of products or services that is listed first is of more significance. Appraisal of importance of each product or service is also based on a few factors including economic impacts, current and future market potentials, and overall national development agenda.

5.3.1. The Essentials

Products and/or services that are classified in this pillar are considered as indispensable because they provide essential tools for other products/services to operate, and that is the reason why they are put in the first pillar, which comprises electricity, computer, and the internet.

Electricity: Electricity is the core element for almost any type of electronic and technological devices. It also increases tendency in self-employment for both genders moving them away from traditional agriculture and poverty (Chhay & Yamazaki, 2021). In terms of education, a lack of access to electricity will pose several challenges including restricted access to rich and digital schooling resources available on the Internet. In addition, lack of energy to power lightbulbs and computers means students will not be able to study or do their homework after the sun goes down. Similarly, schools that do not have any access to electricity means they are limited in their capacity to provide computer access, internet, and laboratories, all of which has a negative impact on students' learning outcome.

In Cambodia, electricity coverage is not universal. After suffering from three-decade civil war, Cambodia energy infrastructure was almost entirely in ruin. In 1998 and 2008, there were only about 15 and 26.4% of Cambodian households have access to electricity grid as source of lighting, yet this figure has risen to 80% in 2019 (National Institute of Statistics, 2020a) due to government intense electrification policies. Besides, 11% of the population use battery as the main source of power, followed by solar at 8% and other sources of energy at 1% (National Institute of Statistics, 2017). But if we looks at the availability of electricity at school, roughly 50% of them are having access to one that is good condition, 28% are in need of minor repairs to be fully functional while 12% of the school are using electricity infrastructure that requires substantial investment to improve, and 10% have no access to electricity at all (Ministry of Education Youth and Sport, 2018). Having said that, electricity is not completely stable, and frequent blackout can be an issue between March and May when energy consumption increases due to hot weather. In addition, only about 76% of rural households are electrified. Therefore, there is still room for further actions and improvement to achieve universal coverage and energy independence. The latter notion comes from the fact that Cambodia is still importing electricity from neighboring countries including Vietnam and Thailand and relies largely on diesel/heavy fuel oil to generate electricity. With that said, the National Strategic Development Plan 2019 – 2023 has showed the RGC's interest in the continual development of hydropower, combustion, and solar energy and a tendency in the use of civil nuclear energy through initial investment in the science and technology of radiation.

Computer: Access to computers at home and at schools is likely to improve student's learning outcome in multiple ways. Computer (web-based) software has the potential to provide personalized self-paced study which is very difficult to achieve in class with many other students. In addition, a computer can offer individualized content of instruction tailored to students' own needs to enhance their strengths and improve their weaknesses. Therefore, it holds the future promise of boosting and enriching student's academic experience and thereby economic and social return to education. In fact, many empirical studies have substantiated such claim (Bulman & Fairlie, 2016). Despite limited number of Cambodian students who have a computer at his/her disposal as shown in figure 5.2, access to computers in public schools has increased manifold in the last 20 years using findings from research studies such as Chinn & Fairlie (2007) as a benchmark for comparison. With that said, to achieve the aforementioned goals of improving access to the internet through computers or bring-your-own-device and personalized learning, it is absolutely necessary that each student should have a personal computer, or at least they should be able to use any computer at home for homework and digital learning.

The Internet: The Internet connection is another indispensable technology that is required to promote teaching and learning during the era of Industrial 4.0 in which vast majority of technological devices are interconnected through the internet. Moreover, the Internet represents

a potentially valuable wellspring of information in which students can search for a wide range of educational resources. It should also be highlighted that the Internet allows for access to a rich online learning materials including courseware such as digital learning platform. Computers, the Internet, and computer-aided instructional software, due to their interactive nature, will engage students especially those in the fields in which computers are used considerably such as coding/programming in a way that conventional teaching approaches cannot.

5.3.2. Management System

The management system here refers to computer software and/or mobile application (services) which are employed for administrative and logistic supports. Such system is also introduced with the purpose to digitalize schools, making them paperless institutions. There are quite many advantages of doing so, including better organization of admin tasks, time-saving, resource-saving, and even physical space saving. In addition, there is plenty of research evidence which suggests that such software also facilitates the interaction between students and teachers and school leadership (Islam, 2013; Sáiz-Manzanares et al., 2019), and that leads to immediate actions in case student's challenge arises and encourages the development of process-oriented responses. In addition, it reduces teachers' workloads allowing them to have more time to focus on teaching and helping students learn, and at the same time it also supports students' personalized learning and complement their learning experience. Moreover, management system decreases the cost and improve the quality of education delivered to students. Likewise, the government can have a better understanding on common and existing obstacles through intelligent use of data as the management system is centralized. In return, they can more sensibly manage schools and provide immediate solutions when possible. Having said that, such software might require educational data mining skills to make potential use of such raw data. Also, such a concept is made largely possible only through the system monitoring and management of a central authority which should be the ministry in charge of education and who would be able to demand all educational institutions both public and private to feed them data.

Learning Management System (LMS)*:* A learning management system is a software application that provides teachers a framework that manages all aspects of student learning process, namely administration, documentation, tracking student progress, and delivering educational courses or skills training programs. A more centralized and advanced LMS would also allow the tracking of student progression and learning outcome through their entire schooling life even if they change school from one place to another across the country. Furthermore, LMS allows students to view both synchronous and asynchronous multimedia lectures, download course materials, submit their homework and class assignments, take online quizzes, view their own study progress, and communicate with their classmates and teachers. Some modern LMS also includes discussion board and syllabus which provides students an overview of lessons/topics that will be covered. Moreover, for general education level in which students are mostly under 18 years old, LMS might include parental supervisor to continue to alert parents of their children schooling progression in order to engage parents and community which is found to be an effective way of improve the educational quality in Cambodian context (Chea & Chen, 2021). It is crucial to understand that numerous research evidence has shown significantly positive effect of household contribution to the children learning process (Dalziel et al., 2017).

***University/School Management System**:* A school management system like Odoo is very popular and is another software application at school level that makes school administrative work paperless and much simpler to handle and optimize the school resources by centralizing school complicated information so that the school can conduct, monitor, and analyze activities, process, and progress. The system requires a server or cloud hosting and a person to maintain it regularly. While it might sound costly, having one is very beneficial because it can be used to track daily activities of the school and is also a solution to the management of library and students' information etc. In addition, school management system allows users or staff to manage their workflow and that of the university digitally from streamlining operations like admission, enrollment, tuition fee payment, entrance exam, issuing transcript, to current students and alumni management. At the end of the semester, printing a student's certificate or degree will take the time of personnel at the academic affair office only a few minutes. This software is particularly useful for not only big and small school but also growing school, as it improves communication within the school. Such software also works for university with minimum adaptation.

***Education Management Information System (EMIS)**:* EMIS is the national level software application which allows the ministry in charge of education to manage all the schools in the country digitally. It is worth noting that the original idea of EMIS describes it as just a systematic framework that provides the architecture and standard for reporting educational data and statistic to the government. But as the Cambodian society is moving towards digital technology, EMIS should be transformed digitally too to make educational information management more efficient and effortless. Furthermore, the government can easily collect, store, and analyze unified educational and school data so that they can improve the quality of educational delivery and respond to challenges quickly and in a more effective manner. Bear in mind that such valuable data can also provide the government evidence to support strategic decision-making, facilitate policy formulation and budgeting, and monitor and evaluate progression towards certain goals. In addition, the private sectors and academia namely universities, policy think-tanks, and research institutes can use the information for various purposes including research to provide evidence-based policy recommendations for the ministry of education. It should be noted that there currently exists a national EMIS in Cambodia under the Ministry of Education, Youth, and Sport, but the features are too simple to handle complex task and provide a deep understanding of the current situation and answers to particular questions of interest from academic perspective.

***Human Resource Management System (HRMS)**:* A human resource management system for education is another software application at the national level which ensures that daily human resource processes are easily manageable and accessible and performs typical human resource management tasks digitally. These tasks would normally include recruiting and deploying both teaching and non-teaching staff to areas or schools where it appears to be lack of teachers, storing educational staff data such as their qualification and training records, managing their payroll and other benefits, monitoring their attendance, and overseeing their performance. With such system, the government would now be able to manage its current educational staff, assess their capacities, easily conduct skills training needs survey, and deliver a skills training program that correspond to the current demands. It is also important to note that all of these management systems are intertwined one way or another. Figure 5.7 illustrates the functions of the systems more holistically and details the interconnection among themselves and between them and users including students, parents, teaching and non-teaching staffs, schools, academics, industries, and government. In addition, it shows how users can interact with the systems and with one another.

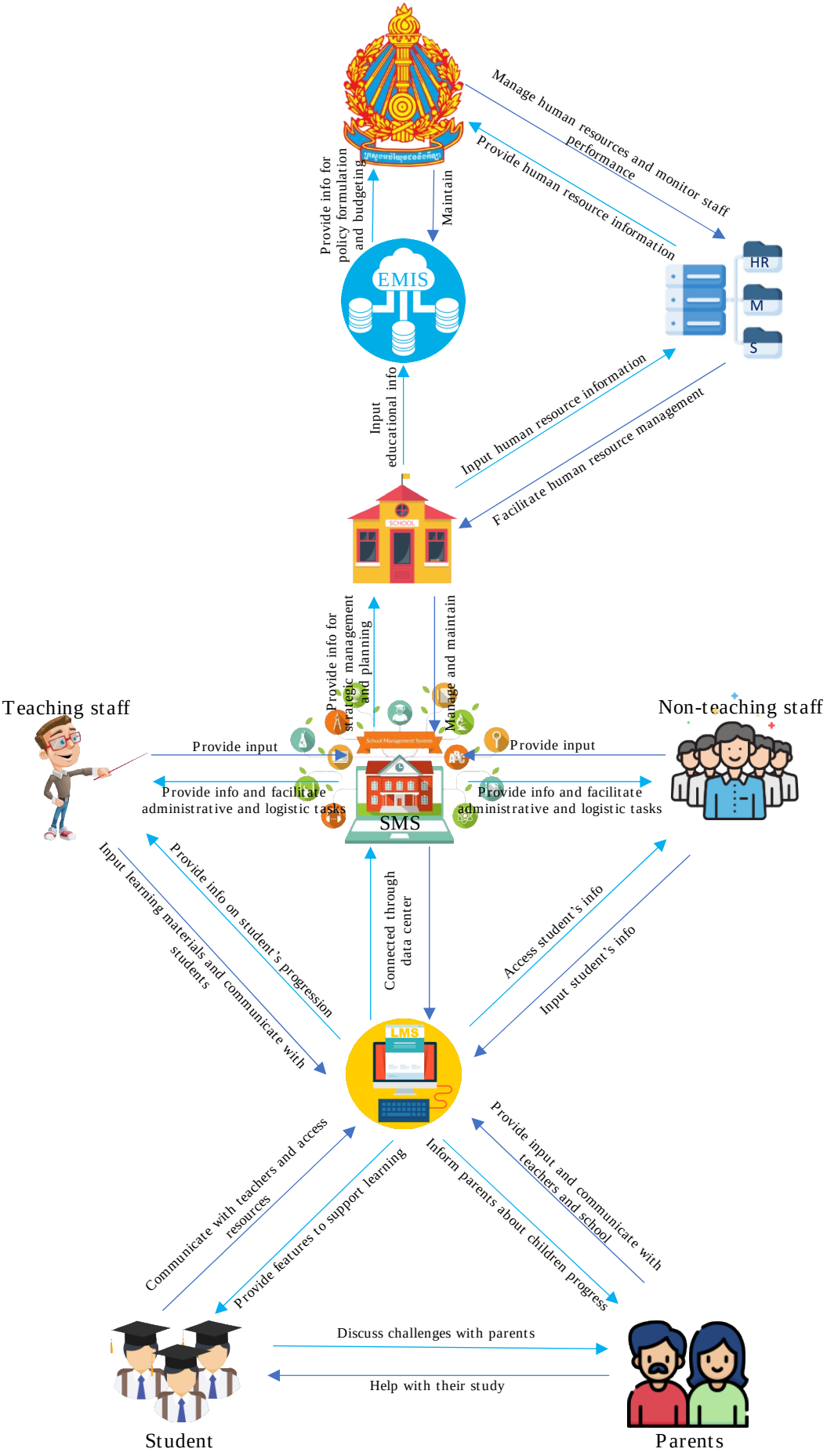


Figure 5. 7: Educational Management System Interconnection

5.3.3. Courseware

Courseware includes computer software used mainly for educational purpose, computer-assisted instruction software, digital resources, and online materials, such as journal articles and books as well as e-learning platforms. Courseware offers many advantages. It supports personalized learning and allows for flexible and self-directed learning. It provides multimedia tools such as graphics, sound, and animation that induce learning and create an interactive stimulated environment. Nevertheless, courseware should be used as an auxiliary tool according to its advantages and features to provide support for student's learning. It should not be employed to substitute teachers rather it ought to assist teachers in instruction because without much physical interaction and socialization in class, students might lose their communication and collaboration skills when they reach adulthood. They might only know how to work with computer and machine but not with human.

***Digital Learning Platform**:* Digital learning platform here refers to a platform or website that provides Massive Open Online Courses or often called MOOC in short. Digital learning platform aims to provide unlimited, easy, and open access to up-to-date digital resources, including video lectures, reading materials, and homework/problem sets via web. Many MOOC websites also present multimedia contents that bring scientific theories and concept alive and offer very dynamic courses on STEM, all of which totally immerse students in scientific activities and stimulate their interest in science and technology. In addition, such websites supply students, teaching assistants, and teachers, a user's discussion board which is a communication channel and more importantly, a supporting/interactive community which absolutely enriches learners' experience. In addition, most courses including the full bachelor or master degree programs are very affordable and flexible, and that students can start whenever they want and study at their own pace. Having access to educational resources 24-hour a day helps foster student's learning even after regular school hours. It has also been documented by many studies that not all students are active during the regular school hours. Some find it easier and more productive to concentrate their learning at night. As a result, MOOC is very popular among international students and working population. Research evidence has also indicated a favorable associated effect of digital learning on learning outcomes of student in China (Zhonggen et al., 2019), Lithuania (Kliziene et al., 2021), and Saudi Arabia (Alhazzani, 2020). It is worth noting that creating a national e-learning platform that also provides rich online learning resources on top of synchronous and asynchronous courses, is one of the main goals of the national roadmap.

***Video game and gamified software application**:* Gamified learning software application uses gaming or game-design element and principles in a non-gaming environment to deliver teaching contents and engage students. Gamification learning process is among the latest approaches in teaching and learning, and the technologies that are used to create such services are also among the latest development in the educational field. Gamified learning software is useful and successful in inducing learning and creating a learning atmosphere because, like playing a game, the software makes learning much more enjoyable and entertaining. But while empirical study suggests that students who completed the gamified learning application performed better than those who did not, they tend to also did poorly on written assignment and participated less in class activities (Domínguez et al., 2013). Other advantages include higher student's engagement in online learning, improvement in experiential learning, more flexibility to revisit and resubmit homework and assignment (Saleem et al., 2022 and references therein).

On the other hand, it might also be problematic if the gamified software is too addictive. Additionally, it can also demotivate learners who fear losing the game. Another downside is that gamification is likely to demand a lot of investment in educational technology and many technologies used in the Fourth Industry Revolution, including artificial intelligence (AI) and immersive tech which is used to create virtual and augmented reality (VR/AR). Therefore, it can be very daunting and expensive to develop for some countries or some private companies within a country. Not to mention that a user will need to buy a VR headset and software license in order to start learning, and that can mostly be afforded by middle- and high-income families. Ultimately, such multimedia teaching and learning approach might create educational inequality and widen the skill gaps between children from rich households and those with disadvantageous background.

5.3.4. Capacity Building

Capacity building is neither a strategic product or service nor technology in itself. However, it is indispensable from technology because technological products and services are merely a tool or instrument to help users who must have certain level of knowledge or skills to operate it or take advantages of it. Otherwise, such tools are of little to no use for individuals. Not to mention that it is economically a negative return to investment in physical capital.

Digital literacy: Digital literacy means having the essential skills that one needs to live, learn, and work in the modern society, where communication and access to information are increasingly digitalized. Besides, digital literacy also means using technology or technological products/ services like the internet, social media platforms, and smartphone or tablet etc. to search for, access, manage, manipulate and create information. To be more specific, digital literacy, based on the Joint Information Systems Committee's (JISC) Digital Capacity Framework, consists of six types or aspects of literacy as shown in the figure 5.8 below including

- *Media literacy*: ability to use multimedia for new creation and innovation or to produce communications.
- *Information literacy*: ability to search for information, and critically evaluate and share it in a professional way that it will not harm anyone else.
- *ICT literacy*: ability to use digital devices, online services, and software applications to complete tasks.
- *Identity literacy*: ability to ensure e-safety and manage identity on the internet.
- *Digital scholarship*: ability to develop oneself through professional and research practice using digital resources.
- *Communication and collaboration*: ability to clearly express your ideas and opinion, ask relevant questions, maintain eye-contact, earn respect from counterparts, and build trust online just as when communicating face-to-face.

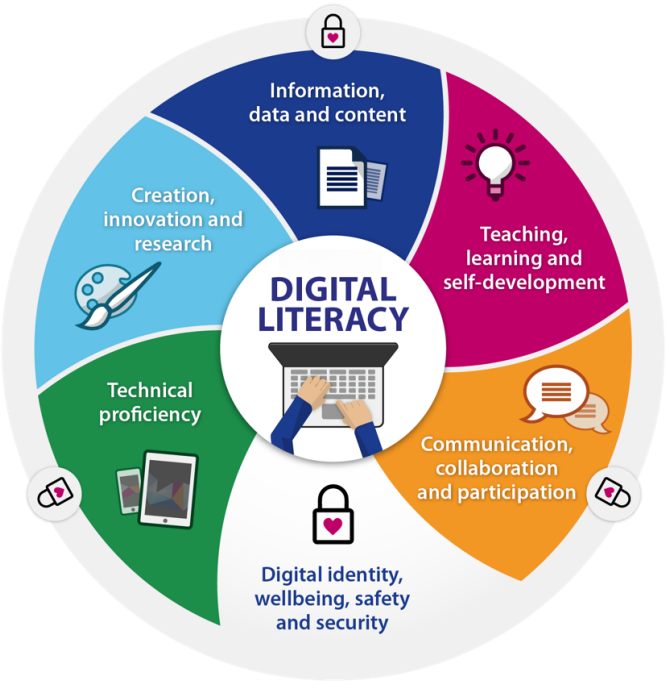


Figure 5. 8: Six Elements of Digital Literacy

Source: Adapted from Joint Information Systems Committee's (JISC) Digital Capacity Framework[1].

Hybrid Learning Pedagogy Training: In addition to digital literacy, a crucial skill that should be possessed by everyone, modern school teachers should also have hybrid learning pedagogy competency. Hybrid learning pedagogy refers to teachers trying to incorporate multimedia devices and ICT technologies into their teaching and student learning process. Blended learning is also a type of hybrid learning, and it has forcefully become popular due to the COVID-19 pandemic, which restricts face-to-face communication and physical classroom. Figure 5.9 presents a case study of the practical use of hybrid learning pedagogy in an Art School in Hong Kong, China. Nevertheless, to be able to do that, teachers must be trained to use technologies first and then they should be trained again on how to incorporate the technologies into their daily teaching to improve the students' learning outcome.

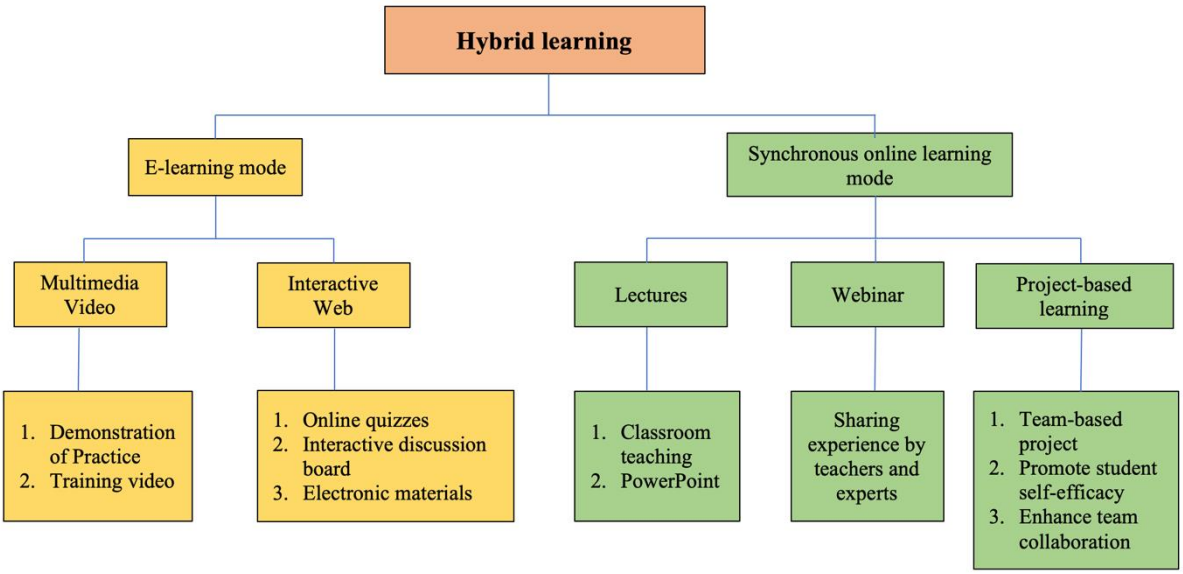


Figure 5. 9: Framework of the Hybrid Learning in Performance Arts Education

Source: Adopted from Li et al. (2021).

[1] https://repository.jisc.ac.uk/6611/1/JFL0066F_DIGIGAP_MOD_IND_FRAME.PDF

In order to provide a clearer picture on how these aforementioned strategic products and services can help achieve the roadmap's vision and goals, figure 5.10 demonstrates what pillars aims to accomplish which objectives. As these pillars are interconnected, and so are the goals, it is natural that one pillar can have a positive effect on more than one goal. The timeline to achieve each goal is provided in section 5.5, where the activities and indicators are mapped and laid down in detail.

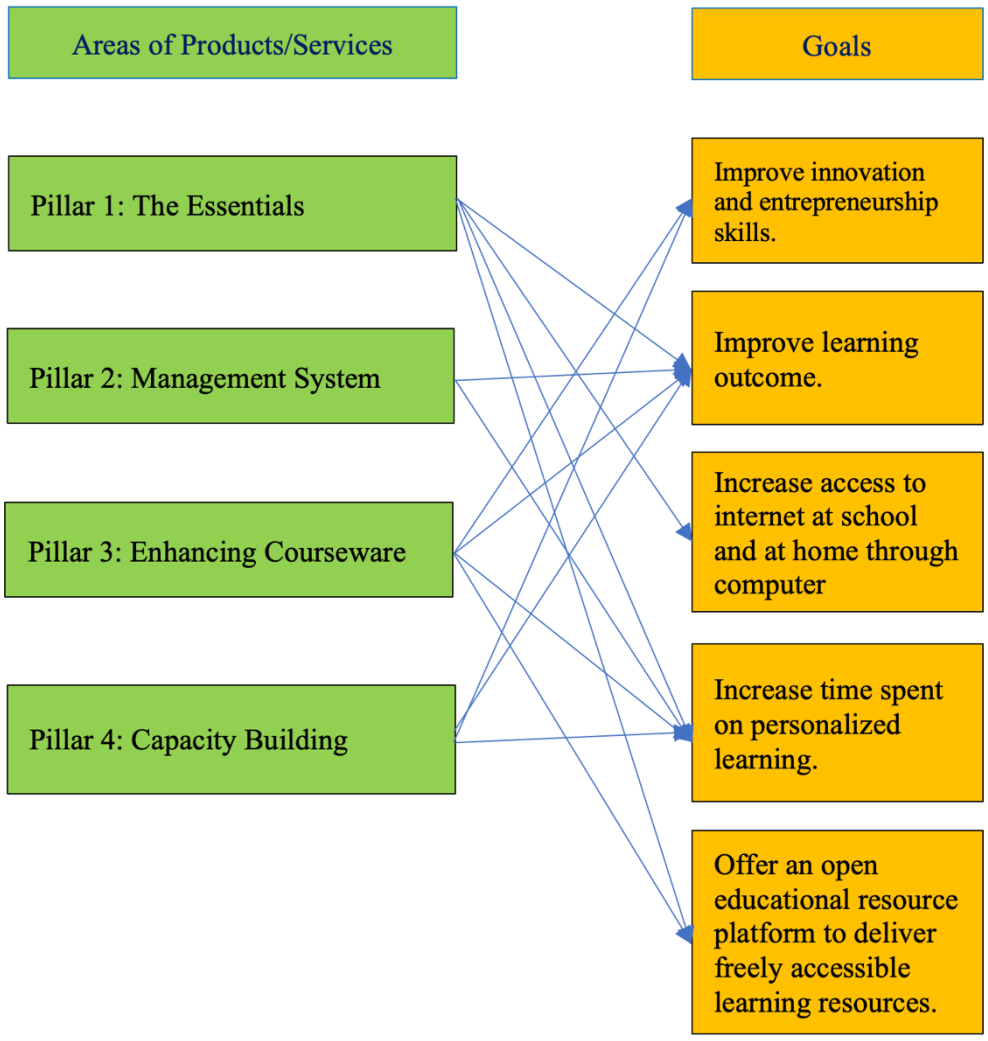


Figure 5. 10: Mapping from Strategic Products/Services to Roadmap Goals

Source: Authors.

5.4. Key Technology

Key technologies refer to technologies that should be used to develop strategic products and services mentioned in section 5.3. Such technologies have also been discussed upon and prioritized by the technical experts consisting of members of the Educational Technology Roadmap Committee, academics, relevant authorities and specialists from GDSTI under MISTI. Prioritization is in turn based on the technologies' strategic importance, economic and environmental impact, affordability, technical practicality, and whether or not such technologies can be adapted in Cambodia given its geographical and socio-economic context.

More importantly, the experts also consider if the technologies are likely to be replaced in the very near future, and the team thereby will examine the latest growing technology. It is also worthwhile to note that some technologies can be utilized to develop multiple products and services. For instance, we can use blockchain and cloud technology to develop all the management system and digital learning platforms. And as a result, figure 5.11 below which illustrates mapping from strategic products/services to key technology also shows multi-directional blue lines linking various technologies to products and services and vice versa. It should be highlighted that only three pillars are listed down in this subsection as capacity building is not directly a strategic products or service, but it is as well important because without human resources and skills necessary to operate such technologies, products, or services, they will be all of little to no use.

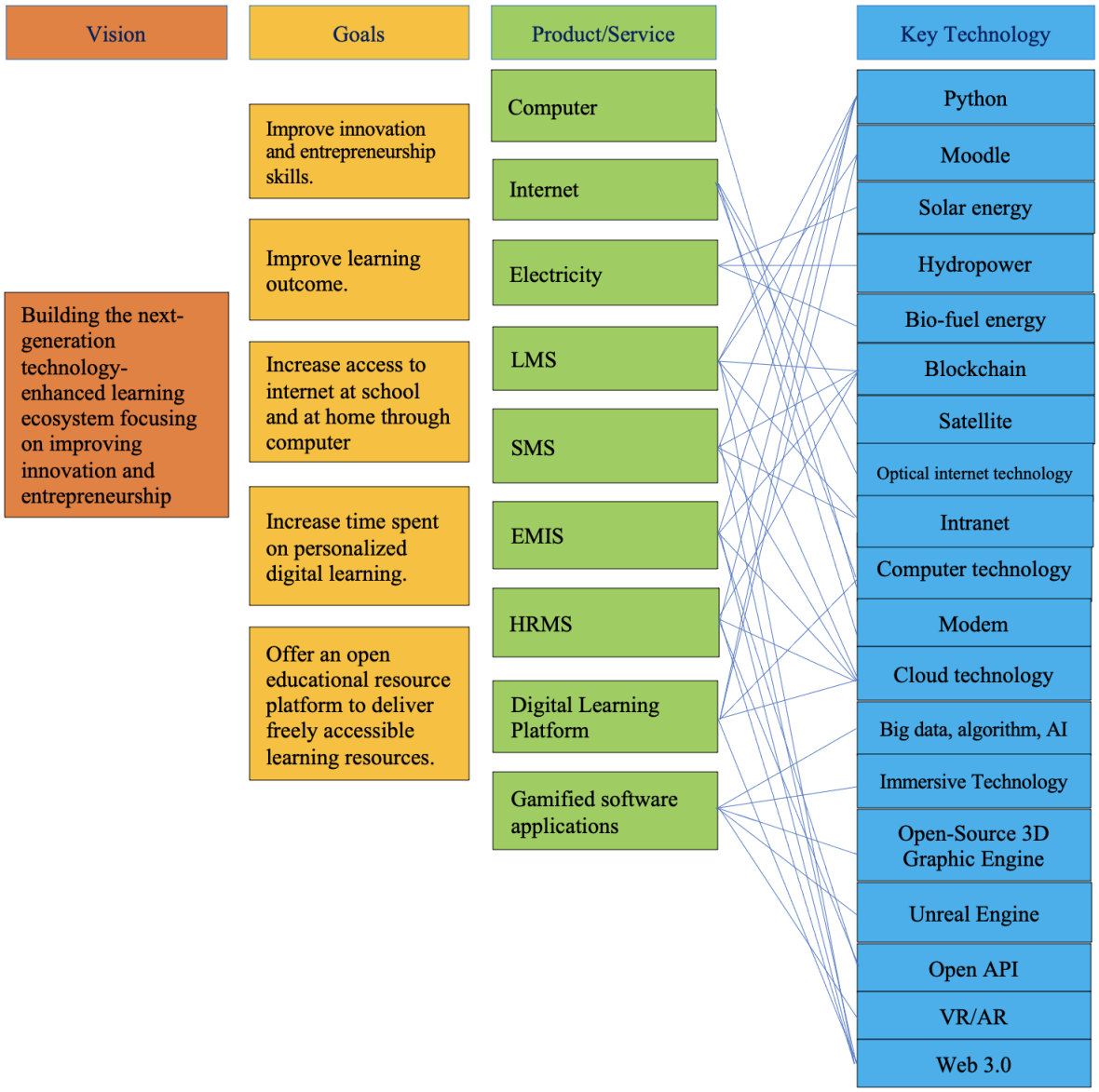


Figure 5. 11: Mapping from Strategic Products/Services to Key Technologies

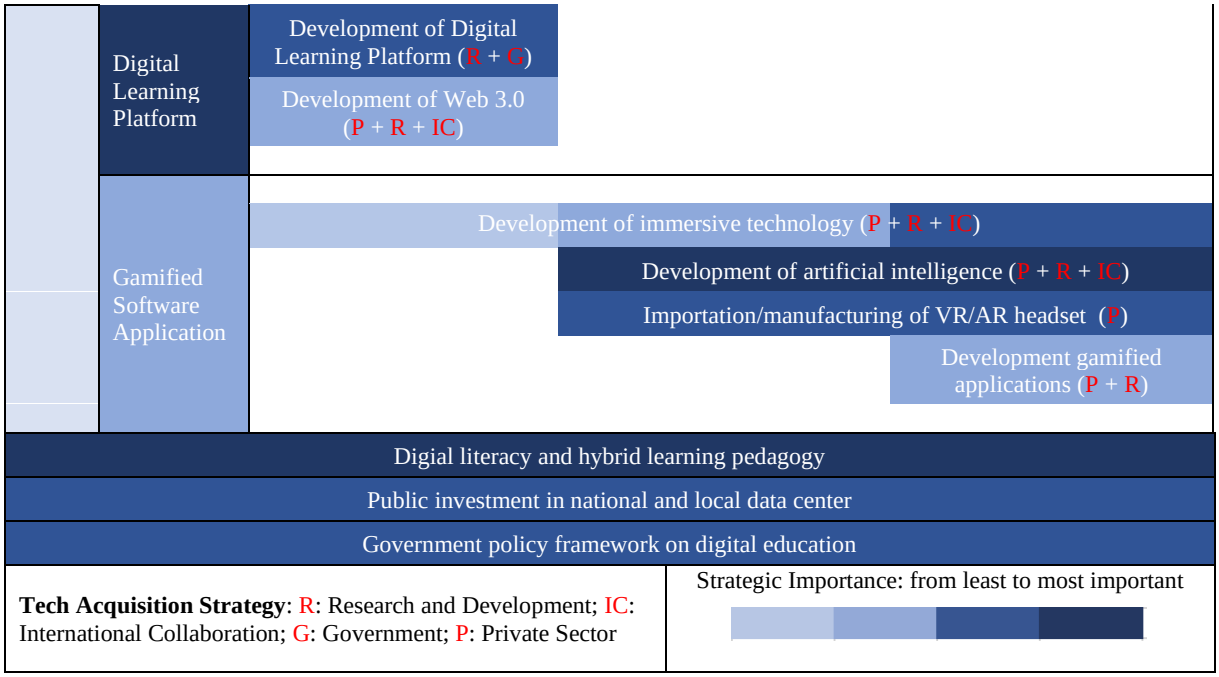
Source: Authors.

5.5. Charting Macro Technology

This section maps the educational technology. To put it another way, this section discusses when one should acquire, development, and/or import what technology/products/services and given that the technology is at one disposal, it tells what one should do next to realize the goals. To begin, table 5.2. demonstrates the mapping of macro-technology by year and strategy for acquisition of technology. Bear in mind that charting the technology by time frame has to align with government's major development direction and existing key performance indicators or expectations which we got from reviewing relevant major policies mentioned in section 4.

Table 5. 2: Charting Macro Technology

Vision: Building the next-generation technology-enhanced learning ecosystem focusing on improving innovation and entrepreneurship skills.										
Objective:		Creating a central repository and increase access to internet			Increase time spent on personalized learning			Improve learning outcome and innovation and entrepreneurship skills.		
		2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Product/Service	Electricity	Importation/manufacturing of solar energy panels (P)								
		Hydropower development (G)								
		Bio-fuel energy (G + P)								
	Computer				Local computer manufacturing and assembly (P)					
		Development of computer technology (P + R + IC)								
		Importation of laptop and desktop computer (P)								
	Internet				Launch of satellite (P + IC + G)					
		Development of optical internet technology (P + R)								
		Development of intranet (P + R)								
		Manufacturing modem and wifi router (P)								
	LMS	Development of cloud and blockchain technology (P + IC + R + G)								
		Development of LMS (R + G)								
	SMS	Development of SMS (R + G)								
	EMIS				Development of EMIS (R + G)					
	HRMS				Development of HRMS (R + G)					



Source: Authors.

On the description of table 5.2, first, we will begin with electricity that the government is strongly committed to achieve energy independence through stable and renewable power. The mapping reflects this statement; as solar panel can help generate clean energy. And given that Cambodia's geographical weather is typically warm, solar energy is given high strategic importance and should be a priority for development between now and 2030. On the other hand, hydropower is still in the NSDP development agenda, but the government at the same time has also shown concerns over the environmental impact. Therefore, it is expected that the energy development focus would shift towards solar and nuclear power. But the technology used to develop the latter is highly advanced and sophisticated, so a deeper understanding and more research studies would be required, and it will take some time. Bio-fuel energy/combustion has perhaps the most environmental impact among the three energy sources mentioned here, so it should be considered only for temporary solution to stable energy. Having said that, it is impossible to rely solely on solar and nuclear power as the only future sources of energy, and it is by no mean that this roadmap is trying to suggest such a direction. Not to mention the significant challenges of investment cost and waste disposal which derive from the use of nuclear power. Therefore, even though solar energy is prioritized in this roadmap, diversification of energy sources is indispensable.

In respect to computers, the short-term strategy would be to continue to import laptop and desktop computers from the international market while Cambodia is still in the process of developing its own computer tech in order to build sufficient technological knowledge and capacity to manufacture or assemble computer hardware. Regardless of that, the country can start with the manufacturing of small components, such as computer fan, keyboard, power supply, and mouses. Once certain knowledge about computer technology can be built, industries can proceed to manufacture Random Access Memory (RAM), video card, hard disk drive, mainboard, and then the Central Processing Unit (CPU) along with other hardware including monitor and printer. One should also expect that there will be an overlapping period in which importation and local manufacturing co-exist, as at the beginning the country will need a certain amount of time until it can produce in large quantity to supply local market, and

that import of computer hardware is no longer necessary mostly due to higher price than that manufactured locally.

Talking about the internet, the top priority should be the satellite launching, for Cambodia does not currently have one in the space yet. Despite the fact that it is very useful as a communication tool, satellite is expensive and requires highly capable technical staff to operate. Not to mention the understanding on how to build and launch one. Furthermore, the private sector especially major Internet Service Providers (ISP) should lead the development of optical internet technology to strengthen the companies' capacity to provide the internet services to rural areas in the country, improve the internet speed, and maintain its stability. The benefit for them in turn is that such ISP would be able to grab a large share of the fast-growing market of the internet users in Cambodia. The figure has been mentioned in the previous sub-section, and it is expected to continue to intensify corresponding to national development policies. In addition, the need of optical internet would also lead to higher demand for modem/Wi-Fi routers, as the product is complementary to the internet service. As a result, it is a market opportunity for hardware manufacturers. Intranet is of lower priority since it is a substitute product or service for very remote rural areas in which the internet service cannot cover.

The development of any type of management system and the digital learning platform mentioned above requires blockchain and cloud technology. They are, therefore, a must has catalyst in order to build the other things successfully. It is then recommended that the government would also take actions to play a significant role in the initiation process, for these technologies are related to cyber-safety -security and -sovereignty. Once the technology and necessary physical infrastructure are in place, the building of all the management system and digital learning platform themselves are largely just a programming activity, and that just need time and proper deployment of the software. To improve the user's experience on the world wide web, Web 3.0 should be considered even though its strategic importance is not as high as the blockchain technology. Notwithstanding that, it is perhaps important to raise the concern about data security and internet ethical issues here too because when such management is launched and connected to the internet, there can be a potential for security breach and loss of data. In another scenario, criminals can hack into the system, steal the data, and blackmail the users or the institution, and the results can be a big tragedy with millions of dollar loss in ransom (Ou & Chea, 2021). It is expected that with the growth of the Internet and e-system, cyber-criminal activities would also jump. Therefore, this roadmap would also suggest the promulgation of the Cybercrime Law or the like to safeguard the entire management system and typical user's data. Strengthening and improving national cyber security system infrastructure and software is another priority.

Globally, gamified software applications that aid teaching and learning process are currently still in the early-stage of development and for a developing country, it should not be a subject matter in short-term because attention and resources should be directed elsewhere. However, artificial intelligence should be a focus in medium- and long-term because its usefulness is far beyond just for developing games. AI applications such as face recognition and Apple's Siri are already found in our daily life. Finally, to achieve the objectives of the roadmap, proposed action plans are also outlined in subsequent tabulations. Table 5.3, 5.4, 5.5, and 5.6 shows activities and provides performance indicators and targets for each pillar, respectively, to achieve the goals of this roadmap and how to measure success.

Table 5. 3: Mapping Pillar 1 Technology

Product/Service: Pillar 1		Short Term			Medium Term			Long Term			Target				
		2022	2023	2024	2025	2026	2027	2028	2029	2030	Baseline	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target													
Product/Service	Electricity	Increase electricity coverage (G)									93%	100%	100%	100%	% of villages having energy supply.
	Computer	Increase number of students who have access to home computers (P)									20%	35%	50%	65%	% of students having access to computers to do homework at home
		Increase number of students who have access to school computers that are in good condition (G)									22%	50%	60%	70%	% of schools with access to computers in good condition
	Internet	Increase number of students who have access to internet connection at home (P)									43%	55%	70%	85%	% of students having access to internet at home
		Increase number of students who have access to stable internet connection at school (G)									20%	35%	55%	75%	% of school with access to the internet
Commercialization and practical use		Private sectors will lead the importation of necessary materials for manufacturing.									R: Research and Development IC: International Collaboration G: Government Leading P: Private Sector Leading				
Infrastructure		National internet gateway.													
Law and regulation		Cybercrime Law; national energy policy; national education policy 2030.													

Table 5. 4: Mapping Pillar 2 Technology

Product/Service: Pillar 2		Short Term			Medium Term			Long Term			Target			
		2022	2023	2024	2025	2026	2027	2028	2029	2030	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target												
Product/Service	LMS	Complete development of LMS (R + G)									100%	100%	100%	LMS digital platform is launched by MoEYS
					Implement LMS at public schools (G)						0%	30%	60%	% of public school that use LMS platform
	SMS	Complete development of SMS (R + G)									100%	100%	100%	SMS digital platform is launched by MoEYS
					Implement SMS at public schools (G)						0%	30%	60%	% of public school that use SMS platform
	EMIS				Complete building of and implement EMIS platform (R + G)						0%	100%	100%	EMIS digital platform is launched by MoEYS
	HRMS				Complete building of and implement national HRMS platform (R + G)						0%	100%	100%	HRMS platform is launched by MoEYS
Commercialization and practical use		LMS and SMS can be sold to, developed further, and used by private school including universities and TVET school.									R: Research and Development IC: International Collaboration G: Government Leading P: Private Sector Leading			
Infrastructure		National data center												
Law and regulation		Cybercrime law; guidelines on monitoring and management of national education information; review and implement national education policy.												

Table 5. 5: Mapping Pillar 3 Technology

<table>
<tr><td colspan="2" rowspan="2">Product/Service: Pillar 3</td><td colspan="3">Short Term</td><td colspan="3">Medium Term</td><td colspan="3">Long Term</td><td colspan="4">Target</td></tr>
<tr><td>2022</td><td>2023</td><td>2024</td><td>2025</td><td>2026</td><td>2027</td><td>2028</td><td>2029</td><td>2030</td><td>Short Term</td><td>Medium Term</td><td>Long Term</td><td>Measure</td></tr>
<tr><td colspan="12">Performance Indicator and Target</td></tr>
<tr><td rowspan="3">Product/Service</td><td rowspan="2">Digital Learning Platform</td><td colspan="3">Complete the development of national digital learning platform (R + G)</td><td colspan="6"></td><td>100%</td><td>100%</td><td>100%</td><td>National digital learning platform is launched by MoEYS.</td></tr>
<tr><td colspan="3"></td><td colspan="6">Encourage students at general education level to use digital learning platform (G + P)</td><td>10</td><td>25</td><td>50</td><td>number of students per hundred students.</td></tr>
<tr><td colspan="3"></td><td colspan="6">Encourage students at general education level to use digital learning platform (G + P)</td><td>1.0</td><td>1.5</td><td>2.0</td><td>average time spent on personalized digital learning increase per hour per week.</td></tr>
<tr><td>Video Game/ Gamified Software Application</td><td colspan="3"></td><td colspan="6">Develop and increase the use of gamified/computer-assisted instruction software at public schools (R + G + P)</td><td>0%</td><td>10%</td><td>35%</td><td>% of public schools with gamified and/or computer-assisted instruction software.</td></tr>
<tr><td colspan="2">Commercialization and practical use</td><td colspan="9">The technology used to develop digital learning platform and gamified software can certainly be initiated by the private sector through R&D funding and innovation budget.</td><td colspan="4" rowspan="3">R: Research and Development
IC: International Collaboration
G: Government Leading
P: Private Sector Leading</td></tr>
<tr><td colspan="2">Infrastructure</td><td colspan="9">National data center.</td></tr>
<tr><td colspan="2">Law and regulation</td><td colspan="9">Draft and implement policy on the use of educational technology in teaching and learning.</td></tr>
</table>

Table 5. 6: Mapping Pillar 4 Technology

Product/Service: Pillar 4		Short Term			Medium Term			Long Term			Target			
		2022	2023	2024	2025	2026	2027	2028	2029	2030	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target												
Product/Service	Digital literacy							Digital/technology literacy including basic coding skills is incorporated into national currilum at the secondary level (G)			0%	0%	100%	National curriculum at secondary school comprises digital literacy subject(s).
		Provide training workshops related to digital literacy/technology at secondary school to improve student's understanding about ICT technology and/or STEM (G + IC + P)									78	78	78	number of courses delivered per 3 years
		Provide training workshops related to digital literacy/technology at secondary school to improve teacher's understanding about ICT technology and/or STEM (G + IC + P)									78	78	78	number of courses delivered per 3 years
	Hybrid Learning Pedagogy Training	Provide training workshops related to hybrid learning pedagogy to build teacher capacity to incorporate multimedia and ICT technology into teaching (G + IC + P)									30	30	30	number of courses delivered per 3 years
		Provide training workshops related to hybrid learning pedagogy to build teacher capacity to incorporate multimedia and ICT technology into teaching (G + IC + P)									3000	3000	3000	number of teachers trained per 3 years
Commercialization and practical use		Public or private university which offers major related to educational technology or ICT engineering should lead the training provision.									R: Research and Development IC: International Collaboration G: Government Leading P: Private Sector Leading			
Infrastructure		Fully-furnished conference hall/training center.												
Law and regulation		Draft and implement policy on the use of educational technology in teaching and learning.												

Section 6: Conclusion and Recommendation

Cambodia has made tremendous efforts to overhaul its education system and has undertaken several remarkable initiatives related to capacity building and career pathways, curriculum development, physical infrastructure construction, and facilities improvement for education. While these achievements deserve commendations, conventional challenges of developing countries also faced by Cambodia continue to be an issue, leading to an attempt to address them through various methods, including this roadmap, which is an attempt to outline a solid framework to incorporate educational technology into teaching and learning approaches, with the ultimate purpose to improve students' overall learning outcomes as well as innovation and entrepreneurship skills. Nevertheless, it should also be acknowledged that the roadmap alone will not entirely solve the learning crisis without strong participation and commitment from the academia, private sector, and community. It is in this regard that this roadmap is co-produced following a series of discussion, consultation, and validation workshops with all relevant actors whose name and contribution is credited in the appendix.

But why does one need the private sector and academia? To answer the question, one has to understand that while the government does make policy and national development agenda, the private sector and entrepreneurs know more about their markets and consumers, and R&D which leads to innovation generally originates at university or research institute etc. Therefore, all the actors have to be able to sit, have a dialogue, and work together through building solidarity for the benefits of students and society, industrial development, and thereby socio-economic growth of the country. This roadmap, therefore, would call for the development of a collaborative framework for the academia, industry, government, and civil society (representing community/citizens) stakeholders to address problems of learning, innovation, and entrepreneurship. In addition, it is also suggested that the one should inaugurate a recurrent forum to provide a platform for the representatives from the government, industries, and civil societies along with academia to discuss the educational issues that Cambodia is facing. It should be highlighted again that strengthening the quality of education, science, and technology is the government's top priority as indicated in the NSDP 2019 – 2023, key policy priority 3.1. Such a strong collaboration would also help push for talent development, innovation, and knowledge mobilization including knowledge production, dissemination, exchange, transfers, and co-creation.

References

Alhazzani, N. (2020). MOOC's impact on higher education. *Social Sciences & Humanities Open*, *2*(1), 100030.

Barab, S. A., & Roth, W.-M. (2006). Curriculum-Based Ecosystems: Supporting Knowing From an Ecological Perspective. *Educational Researcher*, *35*(5), 3–13.

Brehm, W. (2017). The contemporary landscape of education in Cambodia: Hybrid spaces of the public and private. In K. Brickell & S. Springer (Eds.), *The Handbook of Contemporary Cambodia*. Abingdon, Oxon: Routledge.

Bulman, G., & Fairlie, R. W. (2016). Chapter 5 - Technology and Education: Computers, Software, and the Internet. In E. A. Hanushek, S. Machin, & L. B. T.-H. of the E. of E. Woessmann (Eds.) (Vol. 5, pp. 239–280). Elsevier.

Carneiro, P., & Heckman, J. J. (2002). The Evidence on Credit Constraints in Post-Secondary Schooling. *The Economic Journal*, *112*(482), 705–734.

Chea, V., & Chen, S. (2021). New Generation Schools: Addressing Cambodia's Chronic Inability to Deliver Quality Education. *ISEAS Perspective*, *2021*(60).

Chea, V., & Kobjaiklang, C. (2017). The Rise of Cambodia: Understanding Khmer Society and Culture. In R. Rojjanaprapayon (Ed.), *Comparative Studies in ASEAN Cultures and Societies*. Bangkok: Semadhama Publishing House.

Chea, V., & Wongboonsin, P. (2020). Do Remittances Increase Household Investment in Education? Evidence from Cambodia During and After the Global Financial Crisis. *Journal of Population and Social Studies*, *28*(1), 1–21.

Chea, V., You, S., & Song, S. (2021). *What Skills Training Do Cambodian Garment Workers Need?* (Working Paper Series No. 126). Phnom Penh.

Chhay, P., & Yamazaki, K. (2021). Rural electrification and changes in employment structure in Cambodia. *World Development*, *137*, 105212.

Chinn, M. D., & Fairlie, R. W. (2007). The determinants of the global digital divide: a cross-country analysis of computer and internet penetration. *Oxford Economic Papers*, *59*(1), 16–44.

Dalziel, P., Buchanan, J., Finegold, D., Mayhew, K., Warhurst, C., & Dalziel, P. (2017). Education and Qualifications as Skills. In J. Buchanan, D. Finegold, K. Mayhew, & C. Warhurst (Eds.), *The Oxford Handbook of Skills and Training*. Oxford: Oxford University Press.

Dell, M., Jones, B. F., & Olken, B. A. (2012). Temperature Shocks and Economic Growth: Evidence from the Last Half Century. *American Economic Journal: Macroeconomics*, *4*(3), 66–95.

Department of Curriculum Development. (2015). *Curriculum Framework of General Education and Technical Education*. Phnom Penh: Ministry of Education, Youth and Sport.

Department of Education Management Information System. (2018). *Private Education Statistics & Indicators 2017 - 2018*. Phnom Penh.

Department of Education Management Information System. (2019). *Public Education Statistics & Indicators 2018 - 2019*. Phnom Penh: Ministry of Education, Youth and Sport.

Department of Education Management Information System. (2020). *Private Education Statistics & Indicators 2019-2020*. Phnom Penh.

Department of Education Management Information System. (2021). *Private Education Statistics & Indicators 2020-2021*. Phnom Penh.

Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J.-J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, *63*, 380–392.

Gellman, M. (2010). World Views in Peace Building: a Post-Conflict Reconstruction Challenge in Cambodia. *Development in Practice*, *20*(1), 85–98.

Islam, A. K. M. N. (2013). Investigating e-learning system usage outcomes in the university context. *Computers & Education*, *69*, 387–399.

Kampuchean Action to Promote Education. (2013). *Enrolment Trends in Phnom Penh: A Needs Assessment*. Phnom Penh.

Kao, S. (2020). Family socioeconomic status and students' choice of STEM majors. *International Journal of Comparative Education and Development*, *22*(1), 49–65.

Kliziene, I., Taujanskiene, G., Augustiniene, A., Simonaitiene, B., & Cibulskas, G. (2021). The Impact of the Virtual Learning Platform EDUKA on the Academic Performance of Primary School Children. *Sustainability*.

Li, Q., Li, Z., & Han, J. (2021). A hybrid learning pedagogy for surmounting the challenges of the COVID-19 pandemic in the performing arts education. *Education and Information Technologies*, 1–21.

Ministry of Education Youth and Sport. (2018). *Education in Cambodia: Findings from Cambodia's experience in PISA for Development*. Phnom Penh: Ministry of Education, Youth and Sport.

Ministry of Education Youth and Sport. (2019a). *Cambodia's Education 2030 Roadmap: Sustainable Development Goal 4*. Phnom Penh: Ministry of Education, Youth and Sport.

Ministry of Education Youth and Sport. (2019b). *Education Strategic Plan 2019 - 2023*. Phnom Penh: Ministry of Education, Youth and Sport.

Ministry of Education Youth and Sport. (2020). *New Generation School Annual Achievement Report: Year 4 Implementation (Jan - Dec 2019)*. Phnom Penh.

Ministry of Education Youth and Sport. (2021). *New Generation School Annual Report 2020*. Phnom Penh.

Ministry of Labour, & ILO. (2014). *Policy on Labor Migration in Cambodia*. Phnom Penh: Ministry of Labor.

National Institute of Statistics. (2009). *General Population Census of Cambodia 2008: National Report on Final Census Results*. Phnom Penh: Ministry of Planning.

National Institute of Statistics. (2017). *Cambodia Socio-Economic Survey 2017*. Phnom Penh: Ministry of Planning.

National Institute of Statistics. (2020a). *National Report on Final 2019 Census Results*. Phnom Penh: Royal Government of Cambodia.

National Institute of Statistics. (2020b). *Report of Cambodia Socio-Economic Survey 2019/20*. Phnom Penh: Ministry of Planning.

Ou, P., & Chea, V. (2021). Cyber Threats During Covid-19 Pandemic: The Risk at Your Fingertip. In R. Hör & T. Hesketh (Eds.), *Future of Work*. Phnom Penh: Konrad-Adenauer-Stiftung, Cambodia.

Park, R. J., Goodman, J., Hurwitz, M., & Smith, J. (2020). Heat and Learning. *American Economic Journal: Economic Policy*, *12*(2), 306–339.

Qing, L. (2007). Student and Teacher Views About Technology: A Tale of Two Cities? *Journal of Research on Technology in Education*, *39*(4), 377–397.

Rahamathulla, M. (2021). Cyber Safety of Children in the Association of Southeast Asian Nations (ASEAN) Region: a Critical Review of Legal Frameworks and Policy Implications. *International Journal on Child Maltreatment: Research, Policy and Practice*, *4*(4), 375–400.

Rao, N., Sun, J., Pearson, V., Pearson, E., Liu, H., Constas, M. A., & Engle, P. L. (2012). Is Something Better Than Nothing? An Evaluation of Early Childhood Programs in Cambodia. *Child Development*, *83*(3), 864–876.

Royal Government of Cambodia. (2006). *National Strategic Development Plan 2006-2010*. Phnom Penh: Royal Government of Cambodia.

Royal Government of Cambodia. (2014). *National Strategic Development Plan 2014-2018*. Phnom Penh: Royal Government of Cambodia.

Royal Government of Cambodia. (2015). *Cambodia Industrial Development Policy 2015 – 2025*. Phnom Penh: Royal Government of Cambodia.

Royal Government of Cambodia. (2019). *National Strategic Development Plan 2019-2023*. Phnom Penh: Ministry of Planning.

Royal Government of Cambodia. (2021). *Cambodia Digital Economy and Society Policy Framework 2021 - 2035*. Phnom Penh: Royal Government of Cambodia.

Sáiz-Manzanares, M. C., Marticorena-Sánchez, R., Díez-Pastor, J. F., & García-Osorio, C. I. (2019). Does the Use of Learning Management Systems With Hypermedia Mean Improved Student Learning Outcomes?. *Frontiers in Psychology*.

Saleem, A. N., Noori, N. M., & Ozdamli, F. (2022). Gamification Applications in E-learning: A Literature Review. *Technology, Knowledge and Learning*, *27*(1), 139–159.

Siriwardhana, C., Pannala, G., Siribaddana, S., Sumathipala, A., & Stewart, R. (2013). Impact of exposure to conflict, tsunami and mental disorders on school absenteeism: findings from a national sample of Sri Lankan children aged 12–17 years. *BMC Public Health*, *13*(1), 560.

UNICEF Cambodia. (2019). *Education: UNICEF Country Program 2019 - 2023*. Phnom Penh: UNICEF Cambodia.

United Nations Department of Economic and Social Affairs. (2019). *World Population Prospects: The 2019 Revision*. New York: United Nations.

World Bank. (2018). *Learning to Realize Education's Promise*. Washington D.C: World Bank.

World Bank. (2021a). *Cambodia Economic Update: Living with Covid*. Phnom Penh: World Bank Cambodia Country Office.

World Bank. (2021b). *Cambodia Economic Update: Road to Recovery*. Phnom Penh: World Bank Group.

World Bank. (2021c). *Data for Better Lives*. Washington D.C: The World Bank.

World Bank Databank. (2021). World Development Indicator. Retrieved from https://databank.worldbank.org/data/source/world-development-indicators

Zhonggen, Y., Ying, Z., Zhichun, Y., & Wentao, C. (2019). Student satisfaction, learning outcomes, and cognitive loads with a mobile learning platform. *Computer Assisted Language Learning*, *32*(4), 323–341.

Appendix A
Scoring Strategic Products/Services

Products/Services	Code	Evaluation Criteria			Sum	Opportunity	Threat
		Economic Impact	Strategic Importance	Potential for Success			
Leaning Application	1	3	5	5	13	Nationwide expansion, equity, low cost	traditional system, decrease social connections
Educational Machine/Toy	2	4	5	4	13	Inspire kids, Independent learning, promote creativity	Individualism
Gamification(Simulation/VR)	3	5	5	5	15	creativity, Interest, collaboration, build courage	addiction, emotional well-being
Personalized education platform (Nooks, Coursera)	4	3	5	5	13	personalized, open access to world class education	replace traditional university, cultural issue
Online Community(teacher)	5	2	5	5	12	experiencing, sharing, networking	Time
Simulation (key simulation)	6	0	0	0	0	ensure practice, clear understanding of concept, risk mitigation	isolated from real world
Online/offline learning resources	7	3	5	5	13	All time access, self-paced learning	-
digital learning platforms for kids	8	5	5	5	15	project-based learning, inspire to explore tech, innovative mindset	reduced social & play time
Knowledge-sharing session	9	5	5	5	15	Inspiration, Access to quality learning resource	-
Products STEM toys	10	3	3	4	10	manufacturing/job market, affordable price, design based on local context	lack of raw materials, less investor, limited HR
Tech Museum/Science Museum	11	4	4	4	12	provide knowledge in Tech to students, attract students' interest in STEM, align with government policy and strategy	Big investment
Services: Tech Edu for Kids	12	4	4	4	12	Improve HR in Tech, raise awareness in tech for parents	lack of support
Tech Community	13	4	4	4	12	increase digital literacy & awareness	-
Tech Talk-show/Aspiration for Kids and Adults	14	2	4	4	10	-	-
Tech Learning Guidelines and Aspiration	15	2	4	4	10	-	-
Tech Modeling (Competition/Events)	16	2	4	4	10	-	-
Industry-linkage	17	4	4	4	12	-	-

Tech-investment	18	4	4	4	12	-	-
Policy-support/ regulation	19	4	4	4	12	-	-
Tech-ecosystem/infrastructure	20	3	5	4	12	PPP, affordability, create resources, investment, collaboration, creation of business & tech	law/policy implementation, lack of cooperation
Digital learning materials	21	3	5	5	13	Young population, mobile phone possession, internet cost	English literacy, digital literacy, internet penetration
VR/AR	22	3	4	3	10	Technology adoption of young generation, STI policy commitment	Investment
Digital Literacy Promotion	23	5	5	5	15	tech adoption capacity of young generation, in education strategic plan	lack of investment, need external resource
Tech-startup for Education	24	5	5	4	14	PPP, gov't policy support	small investment, lack cooperation, business environment not conducive
Job-market analysis platform	25	5	5	5	15	ambitions of young generation/investor	linkage of internal job & domestic job, lack of data
Translation platform (for academic fields/terminology)	26	3	3	4	10	commitment to preserve Khmer language, policy of digital transformation	Big investment
Khmer apps/websites	27	2	3	5	10	patriotism, support from private sector	Lack of Khmer materials, Khmer supporting operating system, writing system, technical words

Appendix B:

The Ministerial Decision to Establish Educational Technology Roadmap Committee

ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ

ក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
Ministry of Industry, Science, Technology & Innovation
លេខ: ២៣១ MISTI / ២០២១

សេចក្តីសម្រេច
ស្តីពី
ការបង្កើតគណៈកម្មការដឹកនាំ និងសម្របសម្រួលដល់ការអនុវត្តគម្រោង
អភិវឌ្ឍផែនទីបង្ហាញផ្លូវសម្រាប់បច្ចេកវិទ្យាកសិកម្ម
បច្ចេកវិទ្យាសុខាភិបាល និងបច្ចេកវិទ្យាអប់រំ

ទេសរដ្ឋមន្ត្រី រដ្ឋមន្ត្រីក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍

- បានឃើញរដ្ឋធម្មនុញ្ញនៃព្រះរាជាណាចក្រកម្ពុជា
- បានឃើញព្រះរាជក្រឹត្យលេខ នស/រកត/០៩១៨/៩២៥ ចុះថ្ងៃទី០៦ ខែកញ្ញា ឆ្នាំ២០១៨ ស្តីពីការតែងតាំងរាជរដ្ឋាភិបាលនៃព្រះរាជាណាចក្រកម្ពុជា
- បានឃើញព្រះរាជក្រឹត្យលេខ នស/រកត/០៣២០/៤២១ ចុះថ្ងៃទី៣០ ខែមីនា ឆ្នាំ២០២០ ស្តីពីការតែងតាំងនិងកែសម្រួលសមាសភាពរាជរដ្ឋាភិបាល
- បានឃើញព្រះរាជក្រមលេខ នស/រកម/០៦១៨/០១២ ចុះថ្ងៃទី២៨ ខែមិថុនា ឆ្នាំ២០១៨ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីការរៀបចំនិងការប្រព្រឹត្តទៅនៃគណៈរដ្ឋមន្ត្រី
- បានឃើញព្រះរាជក្រមលេខ នស/រកម/០៣២០/០០៩ ចុះថ្ងៃទី២៦ ខែមីនា ឆ្នាំ២០២០ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីការបង្កើតក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
- បានឃើញអនុក្រឹត្យលេខ៤៨ អនក្រ.បក ចុះថ្ងៃទី៦ ខែមេសា ឆ្នាំ២០២០ ស្តីពីការរៀបចំនិងការប្រព្រឹត្តទៅរបស់ក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
- យោងលិខិតលេខ ១៣២៦ ឧបន ចុះថ្ងៃទី០៩ ខែកក្កដា ឆ្នាំ២០២១ ស្តីពីលទ្ធផលកិច្ចប្រជុំលើកទីមួយនៃក្រុមប្រឹក្សាជាតិវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
- យោងលិខិតចាត់តាំងសមាសភាពឱ្យចូលរួមក្នុងគណៈកម្មការគណៈកម្មការដឹកនាំ និងសម្របសម្រួលដល់ការអនុវត្តគម្រោងអភិវឌ្ឍផែនទីបង្ហាញផ្លូវសម្រាប់បច្ចេកវិទ្យាកសិកម្ម បច្ចេកវិទ្យាសុខាភិបាល និងបច្ចេកវិទ្យាអប់រំ
- យោងតាមសំណូមពរការងារចាំបាច់របស់ក្រសួង

សម្រេច

ប្រការ១.

ត្រូវបានបង្កើតគណៈកម្មការដឹកនាំ និងសម្របសម្រួលដល់ការអនុវត្តគម្រោងអភិវឌ្ឍផែនទីបង្ហាញផ្លូវសម្រាប់បច្ចេកវិទ្យាកសិកម្ម បច្ចេកវិទ្យាសុខាភិបាល និងបច្ចេកវិទ្យាអប់រំ ដែលមានសមាសភាព៖

១. ឯកឧត្តមបណ្ឌិត **ចែម គាតិថ្វី**	រដ្ឋមន្ត្រីប្រតិភូអមនាយករដ្ឋមន្ត្រី និងជារដ្ឋលេខាធិការក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	ប្រធាន
២. ឯកឧត្តមបណ្ឌិត **ហ៊ិល សៀងហោង**	អគ្គនាយកនៃអគ្គនាយកដ្ឋានវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍ នៃក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	អនុប្រធាន

៣. លោកស្រីបណ្ឌិត **លី សុខនី**	ប្រធាននាយកដ្ឋានសហប្រតិបត្តិការវិស័យវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍ នៃអគ្គនាយកដ្ឋានវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិក

ប្រការ២_

គណៈកម្មការដឹកនាំ និងសម្របសម្រួលដល់ការអនុវត្តគម្រោង មានតួនាទី និងភារកិច្ចដូចតទៅ៖

- ធានានូវការសិក្សារបស់គម្រោង ត្រូវបានបន្សុី និងតិតគួរច្បាស់លាស់ជាមួយនឹងយុទ្ធសាស្ត្រពាក់ព័ន្ធនានា
- ធានានូវការសិក្សារបស់គម្រោង និងប្រើប្រាស់ធនធានបានយ៉ាងល្អនិងគ្រប់គ្រងជ្រោយ រាប់ទាំងមូលដ្ឋានចំណេះដឹងក្នុងប្រទេស និងក្នុងតំបន់
- ផ្តល់យុទ្ធសាស្ត្រក្នុងការអនុវត្ត និងជួយដោះស្រាយបញ្ហានិងហានិភ័យនានាក្នុងពេលអនុវត្តគម្រោង
- ពិនិត្យនូវវឌ្ឍនភាព និងសម្របសម្រួលជាមួយថ្នាក់ដឹកនាំជាន់ខ្ពស់ និងក្រសួង-ស្ថាប័នពាក់ព័ន្ធនានា
- ពិនិត្យ និងផ្តល់យោបល់លើ សេចក្តីព្រាងកម្រងសំណួរសម្រាប់ការធ្វើអង្កេតនិងលទ្ធផលដែលទទួលបាន
- ពិនិត្យ និងផ្តល់យោបល់លើវិធីសាស្ត្រនានាដែលជាកំ ឱ្យប្រើប្រាស់ក្នុងគម្រោង
- ណែនាំអំពីឱកាសដើម្បីទទួលបានប្រយោជន៍ និងសារៈសំខាន់ជាអតិបរិមាពីលទ្ធផលនៃការសិក្សាគម្រោង

ប្រការ៣_

ត្រូវបានបង្កើតអនុគណៈកម្មការចំនួន៣ ដើម្បីទទួលអនុវត្តគម្រោងខាងលើតាមបច្ចេកវិទ្យា ដូចមានសមាសភាពខាងក្រោម៖

ក. អនុគណៈកម្មការអភិវឌ្ឍផែនទីបង្ហាញផ្លូវសម្រាប់បច្ចេកវិទ្យាកសិកម្ម៖

១. លោក **ប្រាក់ ជាតិថូ**	អគ្គនាយករង នៃអគ្គនាយកដ្ឋានកសិកម្ម នៃក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និងនេសាទ	ប្រធាន
២. លោក **រាម ច័ន្ទវណ្ណា**	អគ្គនាយករងនៃអគ្គនាយកដ្ឋានសហគ្រាសធុនតូច និងមធ្យម និងសិប្បកម្ម	សមាជិក
៣. លោកបណ្ឌិត **ច្រី សុផល**	អគ្គនាយករងនៃអគ្គនាយកដ្ឋានវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិក
៤. លោកបណ្ឌិត **ប៉ុក សំកុល**	អនុប្រធាននាយកដ្ឋាននៃវិទ្យាស្ថានជាតិវិទ្យាសាស្ត្រ បច្ចេកវិទ្យានិងនវានុវត្តន៍	សមាជិក
៥. លោកបណ្ឌិត **ចិន សុវណ្ណ**	អនុប្រធាននាយកដ្ឋាននៃអគ្គនាយកដ្ឋាន វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិក
៦. លោកបណ្ឌិត **ប៉ុល ចាន់ធី**	នាយករងវិទ្យាស្ថានស្រាវជ្រាវ និងអភិវឌ្ឍន៍កសិកម្មកម្ពុជា	សមាជិក
៧. កញ្ញា **តាំង ចាន់រស្មី**	ប្រធានការិយាល័យនៃអគ្គនាយកដ្ឋាន វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិកអចិន្ត្រៃយ៍
៨. លោកបណ្ឌិត **ប៊ុនតុង ហុរាវិន**	នាយកផ្នែកស្រាវជ្រាវ និងផ្សព្វផ្សាយ នៃសាកលវិទ្យាល័យភូមិន្ទកសិកម្ម	សមាជិក

៩. Prof. Alamgir Hossain	សកលវិទ្យាធិការរង នៃសាកលវិទ្យាល័យបច្ចេកវិទ្យា និងវិទ្យាសាស្ត្រកម្ពុជា	សមាជិក
១០. លោក ឈរ វិទ្ធី	នាយកប្រតិបត្តិកសិដ្ឋានគីរីសួគ៌	សមាជិក
១១. លោក លន់ យ៉ែង	អគ្គលេខាធិការសហព័ន្ធស្រូវអង្ករកម្ពុជា	សមាជិក

ខ. អនុគណៈកម្មការអភិវឌ្ឍផែនទីបង្ហាញផ្លូវសម្រាប់បច្ចេកវិទ្យាសុខាភិបាល៖

១. ឯកឧត្តម វេជ្ជ. ហុក គីមចេង	អគ្គនាយកនៃអគ្គនាយកដ្ឋានបច្ចេកទេសសុខាភិបាល នៃក្រសួងសុខាភិបាល	ប្រធាន
២. ឯកឧត្តម នាង ម៉ៅ	អគ្គនាយក នៃអគ្គនាយកដ្ឋានបច្ចេកវិទ្យាគមនាគមន៍ និងព័ត៌មាន នៃក្រសួងប្រៃសណីយ៍និងទូរគមនាគមន៍	សមាជិក
៣. លោកបណ្ឌិត ជាតិ សុផល	ប្រធាននាយកដ្ឋានតាមដាន ត្រួតពិនិត្យ និងវាយតម្លៃការអនុវត្តគោលនយោបាយនៃអគ្គនាយកដ្ឋានវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិកអចិន្ត្រៃយ៍
៤. លោកសាស្ត្រាចារ្យបណ្ឌិត ហេង សុភាព	នាយកវេជ្ជវិទ្យាស្ថានជាតិសុខភាពសាធារណៈ	សមាជិក
៥. លោកសាស្ត្រាចារ្យជំនួយ ម៉ម សុវត្ថា	សាកលវិទ្យាធិការង នៃសាកលវិទ្យាល័យវិទ្យាសាស្ត្រសុខាភិបាល	សមាជិក
៦. លោកបណ្ឌិត វ៉ា វណ្ណិត	អនុប្រធានមន្ទីរពិសោធន៍ជាតិ នៃវិទ្យាស្ថានជាតិវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិក
៧. លោកបណ្ឌិត ង្វង់ វាសនា	ប្រធានផ្នែកវីរុសសាស្ត្រ នៃវិទ្យាស្ថានប៉ាស្ទ័រកម្ពុជា	សមាជិក
៨. លោកស្រី វេជ្ជ. ឃឹម ណាំហ្គេច	វេជ្ជបណ្ឌិតចក្ខុរោគ នៃមន្ទីរពេទ្យកាល់ម៉ែត	សមាជិក
៩. លោកឱសថបណ្ឌិត ជា ស៊ីន	ព្រឹទ្ធបុរសមហាវិទ្យាល័យឱសថសាស្ត្រ នៃសាកលវិទ្យាល័យពុទ្ធិសាស្ត្រ	សមាជិក
១០. លោក ប៊ិន សុជាតិ	ទីប្រឹក្សាស្តីបនិក និងគ្រប់គ្រងអាជីវកម្ម នៃកម្មវិធីប្រព័ន្ធគ្រប់គ្រងមន្ទីរពេទ្យឌីជីថល ពេទ្យយើង នៃក្រុមហ៊ុនហ្វឺសវីម៉ិនថេក អេស៊ា ឯ.ក.	សមាជិក
១១. លោក វេជ្ជ. និត ប៊ុនតុងយី	នាយកប្រតិបត្តិ នៃក្រុមហ៊ុនមីតដុកទ័រ	សមាជិក
១២. Prof. Alamgir Hossain	សាកលវិទ្យាធិការរង នៃសាកលវិទ្យាល័យបច្ចេកវិទ្យា និងវិទ្យាសាស្ត្រកម្ពុជា	សមាជិក
១៣. លោកស្រី ណាស់ ចរិយា	ប្រធានគ្រប់គ្រងផ្នែកធានាគុណភាព នៃសហគ្រាសផលិតឱសថ ប៉េប៉េអឹម	សមាជិក

គ. អនុគណៈកម្មការអភិវឌ្ឍផែនទីបង្ហាញផ្លូវសម្រាប់បច្ចេកវិទ្យាអប់រំ

១. ឯកឧត្តមបណ្ឌិត សាន វឌ្ឍនា	អនុរដ្ឋលេខាធិការ នៃក្រសួងអប់រំ យុវជន និងកីឡា	ប្រធាន
២. ឯកឧត្តមបណ្ឌិត សេង សុភាព	ប្រធានបណ្ឌិត្យសភាបច្ចេកវិទ្យាឌីជីថលកម្ពុជា នៃក្រសួងប្រៃសណីយ៍និងទូរគមនាគមន៍	សមាជិក

ក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
៨៥ មហាវិថីព្រះនរោត្តម សង្កាត់ផ្សារថ្មី៣
ខណ្ឌដូនពេញ ភ្នំពេញ ១២២០៥ (ព្រះរាជាណាចក្រកម្ពុជា)

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៣. លោកបណ្ឌិត បោង អង្គារ៉ា	អគ្គនាយករង នៃវិទ្យាស្ថានជាតិវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិក
៤. ឯកឧត្តមបណ្ឌិត ឡេង ភីរម្យ	នាយកវិទ្យាស្ថានបច្ចេកវិទ្យាគីរីរម្យ	សមាជិក
៥. លោកបណ្ឌិត សៀវ សុខលី	អនុប្រធាននាយកដ្ឋាននៃអគ្គនាយកដ្ឋាន វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិកអចិន្ត្រៃយ៍
៦. លោកបណ្ឌិត សុខ សូត្រ	ព្រឹទ្ធបុរសមហាវិទ្យាល័យអប់រំ នៃសាកលវិទ្យាល័យភូមិន្ទភ្នំពេញ	សមាជិក
៧. លោកបណ្ឌិត សុង សុភក្តិ	នាយកមជ្ឈមណ្ឌលនវានុវត្តន៍អប់រំ នៃវិទ្យាស្ថានបណ្តុះបណ្តាល និងស្រាវជ្រាវដើម្បីអភិវឌ្ឍន៍កម្ពុជា	សមាជិក
៨. លោក ឆែម សិរីវិត្ថីលៀម	ប្រធានមជ្ឈមណ្ឌលសេដ្ឋកិច្ចនីជីថល ប្រកបដោយបរិយាប័ន្ននៃវិទ្យាស្ថានចក្ខុវិស័យអាស៊ី	សមាជិក
៩. លោក ទេព សុវណ្ណ	ប្រធានការិយាល័យនៃអគ្គនាយកដ្ឋានវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិក
១០. លោក អ៊ិត ហ៊ីនលី	មន្ត្រីនៃអគ្គនាយកដ្ឋានវិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍	សមាជិក
១១. Prof. Alamgir Hossain	សាកលវិទ្យាធិការរង នៃសាកលវិទ្យាល័យបច្ចេកវិទ្យា និងវិទ្យាសាស្ត្រកម្ពុជា	សមាជិក

ប្រការ៤..

អនុគណៈកម្មការអភិវឌ្ឍផែនទីបង្ហាញផ្លូវបច្ចេកវិទ្យាទាំង៣នេះ មានតួនាទី និងភារកិច្ចដូចតទៅ៖

- ទទួលអនុវត្តការងារទៅតាមទិសដៅដែលបានដាក់ចេញដោយគណៈកម្មការដឹកនាំ និងសម្របសម្រួលដល់ការអនុវត្តគម្រោង
- សម្របសម្រួល ប្រមូល និងផ្តល់ធាតុចូលនានាតាមក្រសួង-ស្ថាប័ន ឬអង្គភាពសាមីដែលពាក់ព័ន្ធនឹងការសិក្សារបស់គម្រោងទៅតាមរបៀបវារៈនៃការអនុវត្ត
- ធានានូវសង្គតិភាពព័ត៌មាន និងទិន្នន័យដែលទទួលបាន និងផ្តល់ជូន និងទទួលស្គាល់ដោយក្រសួង-ស្ថាប័ន ឬអង្គភាពសាមី
- សម្របសម្រួលការងារទាំងបច្ចេកទេស និងរដ្ឋបាលនៅតាមក្រសួង-ស្ថាប័ន ឬអង្គភាពសាមី
- ពង្រឹងសមត្ថភាព (សមាជិក) បន្ថែមលើវិស័យ តាមរយៈសិក្ខាសាលា និងវគ្គបណ្តុះបណ្តាលនានា ដែលរៀបចំដោយគម្រោង
- ជាមន្ត្រីបង្គោលតាមក្រសួង-ស្ថាប័ន ឬអង្គភាពសាមីសម្រាប់ការអនុវត្តសកម្មភាពនានារបស់គម្រោង
- ទទួលអនុវត្តភារកិច្ចផ្សេងទៀតដែលបានដាក់ចេញដោយគណៈកម្មការដឹកនាំ និងសម្របសម្រួលគម្រោង។

ប្រការ៥..

ពេលប្រធានគណៈកម្មការដឹកនាំ និងសម្របសម្រួលដល់ការអនុវត្តគម្រោង អវត្តមាន ឬមានករណីចាំបាច់ ប្រធានគណៈកម្មការដឹកនាំនិងសម្របសម្រួលដល់ការអនុវត្តគម្រោង អាចផ្តល់សិទ្ធិជូនអនុប្រធាន ដើម្បីដឹកនាំការប្រជុំតាមការប្រគល់សិទ្ធិពីប្រធាន។

ក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
៤៥ មហាវិថីព្រះនរោត្តម សង្កាត់ផ្សារថ្មី៣
ខណ្ឌដូនពេញ ភ្នំពេញ ១២២០៥ (ព្រះរាជាណាចក្រកម្ពុជា)

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ប្រការ៦..

សមាជិកគណៈកម្មការ និងអនុគណៈកម្មការនីមួយៗ ត្រូវចូលរួមប្រជុំតាមការអញ្ជើញរបស់ប្រធាន និងទទួលខុសត្រូវតាមបន្ទុកការងារដែលបានបែងចែក។ ប្រធានអនុគណៈកម្មការនីមួយៗ ត្រូវរាយការណ៍ការងារជាប្រចាំ និងតាមការចាំបាច់ ជូនប្រធានគណៈកម្មការដឹកនាំ និងសម្របសម្រួលដល់ការអនុវត្តគម្រោង។

ប្រការ៧..

នាយកខុទ្ទកាល័យ អគ្គនាយក អគ្គាធិការ ប្រធានមជ្ឈមណ្ឌល គ្រប់អង្គភាពពាក់ព័ន្ធ និងសាមីខ្លួន ត្រូវទទួលបន្ទុកអនុវត្តសេចក្តីសម្រេចនេះ ចាប់ពីថ្ងៃចុះហត្ថលេខាតទៅ។

ថ្ងៃ ២៤ ខែ កត្តិក ឆ្នាំឆ្លូវ ត្រីស័ក ព.ស.២៥៦៥
ធ្វើនៅរាជធានីភ្នំពេញ ថ្ងៃទី ១០ ខែ វិច្ឆិកា ឆ្នាំ២០២១

ទេសរដ្ឋមន្ត្រី
រដ្ឋមន្ត្រីក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា
និងនវានុវត្តន៍

កិត្តិសេដ្ឋាបណ្ឌិត **ចម ប្រសិទ្ធ**

កន្លែងទទួលៈ
- ទីស្តីការគណៈរដ្ឋមន្ត្រី
- គ្រប់ក្រសួង-ស្ថាប័នពាក់ព័ន្ធ
- គ្រប់ថ្នាក់ដឹកនាំក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
- ដូចប្រការ៧
- ឯកសារ-កាលប្បវត្តិ

ក្រសួងឧស្សាហកម្ម វិទ្យាសាស្ត្រ បច្ចេកវិទ្យា និងនវានុវត្តន៍
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ខុទ្ទកាល័យឯកឧត្តមកិត្តិសេដ្ឋាបណ្ឌិត ទេសរដ្ឋមន្ត្រី
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