"We must make STEM subjects part of their (children/students) everyday language....In preparing our youth for the future, we must take advantage of available technologies, adapt global best practices, and engineer a teaching-learning environment suited to our needs. Technology is the argument of our time and a major indicator of social progress. The irony in our context is the absence of technology in classrooms for a generation of students who are exposed to, and live in the digital age. To ensure that teachers are not disconnected from their students, professional development of teachers should integrate technology, digitalization, artificial intelligence, and automation."

(His Majesty King Jigme Khesar Namgyel Wangchuck, 2020)

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STATUS OF STEM EDUCATION IN BHUTAN'S SECONDARY SCHOOLS

Karma Utha • Sonam Rinchen • Rinchen Dorji

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ACRONYMS

GNH	Gross National Happiness
STEM	Science, Technology, Engineering and Mathematics
ICT	Information and Communication Technologies
CL4STEM	Connected Learning for STEM
NQT	Newly Qualified Teachers
CLIx	Connected Learning Initiative
OER	Open Education Resources
SCE	Samtse College of Education
RUB	Royal University of Bhutan
MSS	Middle Secondary Schools
HSS	Higher Secondary Schools
CS	Central Schools
CDEO	Chief Dzongkhag Education Officer
REC	Royal Education Council
MoE	Ministry of Education
BCSEA	Bhutan Council for School Examination and Assessment
PD	Professional Development
SIM	Self-Instructional Materials
PP	Pre-Primary
EIE	Education in an Emergency
PISA-D	Programme for International Student Assessment for Development
OECD	Organization for Economic Cooperation and Development
RGoB	Royal Government of Bhutan
SEN	Special Education Need
NNC	New Normal Curriculum
BPST	Bhutan Professional Standards for Teachers

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CHAPTER 01: STUDY CONTEXT

1.1 Introduction

Bhutan is best known for its unique developmental philosophy of promoting Gross National Happiness (GNH) over Gross Domestic Product. GNH is a humanistic development philosophy coined and promulgated by His Majesty King Jigme Singye Wangchuck, the fourth hereditary monarch of Bhutan in the early 1970s. GNH emphasises the achievement of happiness and general wellbeing of the citizens over economic prosperity, which is the conventional measure of a country's development. Science, Technology, Engineering and Mathematics (STEM) Education is vital to the realization of this philosophy as the quality of mathematics and science education is central in building human capital, especially in the case of Bhutan, where science and technology are still in infancy. Thus, the way STEM subjects are taught in schools and colleges of Bhutan can play a critically paramount importance in achieving the national vision of realizing a GNH state.

STEM knowledge has gained more attention with rapid advancements in information and communication technologies (ICT). It has become a necessity for people of all ages to attain and apply scientific knowledge effectively and efficiently to be successful citizens in an increasingly science and technology dominated world. In particular, students need to be well equipped with higher order STEM knowledge, as the lack of understanding of basic STEM principles can result in an inability to solve numerous scientific problems.

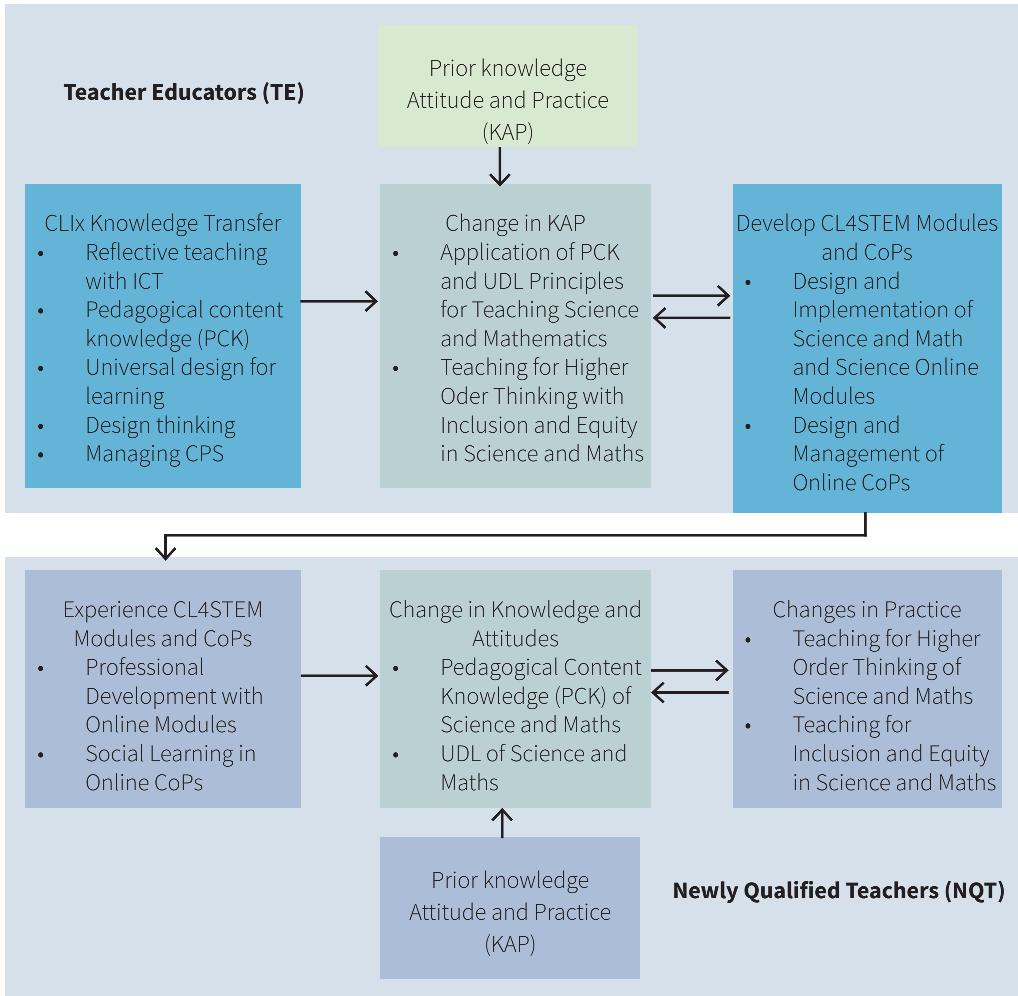
STEM education in Bhutan has undergone many changes to suit the emerging needs of learners. The subjects follow a spiral curriculum as shown in Figure 3.1 in Chapter 2 (page 15). Science as a subject is not included in key stage 1, but Mathematics is included. In key stages 2 and 3, students study General Science consisting of Physics, Chemistry, and Biology content. In key stages 4 and 5, Science is bifurcated into Physics, Chemistry, and Biology. However, in key stage 5, students can choose between Mathematics and Biology whereas Physics and Chemistry are compulsory.

1.2 About CL4STEM

The CL4STEM Project aims to pilot an innovation and research its effectiveness and potential scaling for building the capacities of newly qualified teachers (NQTs) of middle and higher secondary school in science and mathematics and for fostering higher order learning in their classrooms inclusively and equitably. It is a South-South collaboration among higher education institutions to adapt and pilot the Connected Learning Initiative (CLIx) (https://clix.tiss.edu), to new contexts in Bhutan, Nigeria, and Tanzania. CLIx as an innovative STEM teaching practice was developed and already scaled in India.

Figure 1.1

Theory of Change



The pilot involves the building of teachers' professional capacities through their engagement with curated modules based on Open Education Resources (OER) and their participation in online communities of practice. It also involves a knowledge transfer of CLIx to teacher educators in partner institutions to build their capabilities to design and curate OERs and to design and manage online communities of practice.

The associated research studies focus on two broad areas. First, the Impact Study analyses the impact of innovation on teachers' Knowledge, Attitudes, and Practice (KAP) for higher order teaching and learning of science and mathematics inclusively and equitably. Second, the Innovation Diffusion Study, generates knowledge on the processes of adoption of the innovation for specific local contexts and the conditions that support scaling.

Knowledge generated from this project will be disseminated to stakeholders in federal/provincial Ministries of Education and relevant regulatory and professional bodies to seed it into the policy agenda of these countries. Further, key insights from this project would be shared with other researchers and opinion leaders in the spirit of creating global public goods.

1.3 Project partners

The present study is funded by the International Development Research Centre (IDRC) under the Global Partnership for Education Knowledge and Innovation Exchange (GPE-KIX). The Centre for Applied Sciences and Technology Research (CASTER), Ibrahim Badamasi Babangida University, Lapai (IBBUL), in Nigeria is the lead of the CL4STEM project consortium, which includes Samtse College of Education (SCE) under Royal University of Bhutan (RUB), Open University, Tanzania (OUT) as country partners; and the Tata Institute of Social Sciences, India (TISS) as the technical consultant.

The Ibrahim Badamasi Babangida University Lapai (ibbu.edu.ng) in Nigeria is a registered and accredited higher education institution with a mandate to train teacher educators, student-teachers, and in-service teachers within and outside Nigeria. IBBUL is involved with the process of Vision 2020 policy on education and collaborates with state government viz. the State Ministry of Education (SMOEs), Science and Technical School Boards, Secondary Education Boards, Education

Resource Centre, and Teachers' Registration Council of Nigeria.

Samtse College of Education, Royal University of Bhutan (www.sce.edu.bt) is the only teacher education college that educates and prepares teachers for secondary schools in the Bhutanese education system. SCE plays a strategic role in building quality STEM teachers (including ICT-enabled approaches) that are academically sound and professionally competent enough to prepare the younger generation of Bhutanese children who are locally rooted and globally competent to navigate the challenges of the 21st century.

The Open University of Tanzania (OUT) (www.out.ac.tz) is an autonomous and accredited public University, which offers certificate, diploma, undergraduate and postgraduate degree programs through open and distance learning in Tanzania. OUT is the key site for the delivery of ICT based pre and in-service teacher education in Tanzania and has an extended mandate through the UNESCO Chair on teacher education and curriculum. OUT has existing relationships with key stakeholders in the teacher education space in Tanzania, such as the Tanzania Institute of Education that develops and oversees curricula and learning materials for secondary schools, other teacher training institutions, and the two ministries of the central and local government that deal with education at secondary school level.

Tata Institute of Social Sciences (TISS), Mumbai in India (www.tiss.edu) is among South Asia's premier research and teaching universities in social sciences. The Centre of Excellence in Teacher Education (CETE), an Independent Centre on the TISS Mumbai Campus, engages in teaching, research, and field action, and has multidisciplinary expertise in the use of ICT in Education for quality reform at scale. CETE was awarded the UNESCO King Hamad Prize for Excellence for using ICTs in education in 2018 for its flagship 'Connected Learning Initiative' (CLIx).

The leadership team for the CL4STEM project is as follows:

- Principal Investigator: Prof. Nuhu George Obaje, IBBUL
- Principal Technical Consultant: Prof. Padma Sarangapani, TISS
- Lead Investigator – Bhutan: Dr. Rinchen Dorji, SCE
- Lead Investigator – Tanzania: Dr Edephonce Nfuka, OUT
- Lead Technical Consultant – Knowledge Transfer: Prof. Mythili Ramchand, TISS
- Lead Technical Consultant – Innovation Diffusion Study: Dr Vikas Maniar, TISS
- Nodal Officer: Mr. Abdullahi Abubakar Kawu, IBBUL
- Advisor: Prof. Steve Nwokeocha, IBBUL

1.4 Importance of CL4STEM Project in Bhutan

In the 21st century, scientific and technological innovation has become increasingly important in our daily lives. STEM education is crucial for the technological advancement and economic growth of the nation. Bhutan is a developing country with human resources that contribute to the social and economic development of the nation and are required in the field of science and technology.

Although the increasing need for STEM education is felt by the nation, the development of STEM education curriculum is still in its nascent stage. Teaching and learning take place with minimal use of technology in most Bhutanese classrooms despite the students' daily exposure to numerous technologies as digital natives. Moreover, resources are notably limited in the field of STEM education. These limitations have resulted in a traditional method of teaching and learning, which is attributed to rote learning wherein the students are not able to apply their knowledge in a real-life situation (Utha et al., 2021). Further, it is reported that Bhutanese students are unable to understand the core concepts and apply knowledge to real-life situations across grades and subjects. In addition, Bhutanese students' average academic performance in Mathematics and Science are below average in PISA-D assessment when compared to other OECD countries (BCSEA, 2020 & 2019).

Coinciding with the 113th National Day Celebration on 17th December 2020, His Majesty King Jigme Khesar Namgyel Wangchuck, the Fifth King of Bhutan, issued the Royal Kasho (Edict) on Education Reform. The following excerpt from the Royal Kasho on Education Reform explicitly states:

> We must make STEM subjects part of their (children/students) everyday language….In preparing our youth for the future, we must take advantage of available technologies, adapt global best practices, and engineer a teaching-learning environment suited to our needs. Technology is the argument of our time and a major indicator of social progress. The irony in our context is the absence of technology in classrooms for a generation of students who are exposed to, and live in the digital age. To ensure that teachers are not disconnected from their students, professional development of teachers should integrate technology, digitalization, artificial intelligence, and automation. (His Majesty King Jigme Khesar Namgyel Wangchuck, 2020)

This clearly articulates His Majesty's vision for a radical reconceptualization and transformation of Bhutan's education system that harnesses and optimizes the power of technology and STEM in redefining the purpose and future of Bhutan's education system.

In the nation's efforts to realize this vision of education, SCE's role cannot be undermined. The CL4STEM project is timely and the aims of this project perfectly align with the overall national education goals and aspirations. This project specifically will provide capacity building programs for teachers and ensure a robust STEM education in the country by weaving in technology as primary teaching, learning, and assessment tools for STEM disciplines. The Project will challenge STEM teacher educators at SCE to develop and curate Open Educational Resources (OER) for STEM education, which will be organically created by Bhutanese STEM teacher educators to model good practices of integrating technology into classroom teaching and learning as pronounced by our beloved His Majesty in the Royal Kasho on Education Reform.

1.5 Need for situation analysis

Given the scope and focus of the CL4STEM project, this study will investigate the factors responsible for the development of STEM subjects in the schools of Bhutan. The importance of STEM education and the need for technology investments in education has already been highlighted in the Royal Decree on Education Reform shared earlier. STEM Education is vital to the realization of GNH, the country's guiding development goal and philosophy. In spite of the commendable achievements Bhutan's education system has made in the field of education ever since the real development of modern education was initiated in the early 1960s, Bhutanese students' academic attainments in STEM disciplines have been rather unsatisfactory. The way STEM subjects are currently taught in the Bhutanese schools and colleges needs to be reviewed urgently and realigned with the 21st century educational approaches.

Further, the knowledge of STEM subjects has gained more attention with rapid advancements in information and communication technologies (ICT). It has become a necessity for people of all ages to attain and apply scientific knowledge effectively and efficiently to be successful citizens. In particular, students need to be well-equipped with higher order STEM knowledge, as the lack of understanding of basic STEM principles can result in an inability to develop a scientific mindset and fail to solve basic scientific problems.

Towards this, a situational analysis was carried out to better understand the situation in the implementing (schools) and implementer (SCE) agencies. The understanding drawn and the recommendations made by the study will help in planning the implementation phase.

1.6 Brief background on data collection

The situation analysis adopted a mixed method approach for data collection. Of the different types of mixed methods, a convergent parallel mixed method was used to collect quantitative and qualitative data. According to Creswell (2019), a convergent parallel mixed method converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem. Quantitative data was mostly based on the data collected from the survey and other secondary sources. Secondary data mostly included policy related documents available on relevant Ministries websites, school documents, and a few relevant research articles. Qualitative data was collected through interviews.

Of the 20 Dzongkhags in Bhutan, five Dzongkhags namely, Thimphu (West), Zhemgang (Central), Paro (West), Trashigang (East), and Samtse (South), were selected by

region for the present study. The northern region was not selected owing to its remote location and climatic condition. All STEM teachers and principals of Middle Secondary Schools (MSS), Higher Secondary Schools (HSS) and Central Schools (CS) of these five Dzongkhags participated in the survey. Survey participants included 165 STEM teachers and 24 Principals.

The interview participants included six Principals, five Lead Teachers, four Chief District Education Officers (CDEO), and six Academic Heads of the schools from five Dzongkhags. In order to facilitate easy reference, coding is used as reflected in Table 1.1.

Table 1. 1

Dzongkhag and Participants' Code

Dzongkhag		Dzongkhag code	Principal code	Academic head code	LEAD	CDEO
Zhemgang		D1	P1	A1	L1	C1
Thimphu	Thimphu Dzongkhag	D2a	P2a	A2a	L2a	C2a
	Thimphu Throm	D2b	P2b	A2b	L2b	C2b
Paro		D3	P3	A3	L3	C3
Samtse		D4	P4	A4	L4	C4
Trashigang		D5	P5	A5	L5	C5
Total			6	6	5	4

CHAPTER 02: OVERVIEW OF EDUCATION SYSTEM

2.1 Country context

Bhutan is a small landlocked kingdom nestled deep in the Eastern Himalayas bordered by the world's two most populous nations, India to the south and China to the north. The country has a population of over 754,000 and a territory of 38,394 square kilometers (14,824 sq m). Bhutan is characterised by steep mountains and deep valleys, which has led to scattered patterns of settlement. Although Dzongkha is the official language, the mediums of instruction in schools are Dzongkha and English. Other dialects, such as Lhotsamkha, Sharchopkha or Tsangla, Kurtoepkha, Khengkha, Mangdepkha, and Bumthapkha, are also widely spoken. The majority of people follow Buddhism followed by Hinduism. Other religious faiths are also practiced.

Education practices in Bhutan started in the form of monastic education. The practice was said to be through informal relationships between the master and the disciples. Formal monastic education started in the 17th century AD at Chari in Thimphu by Zhabdrung Ngawang Namgyel (Dorji, 2005), a Buddhist saint and statesman revered as the founding father of Bhutan. Monastic education is comprised of learning the alphabet, spelling, and reading and then proceeds to the memorization of ritual and other relevant text and scriptures. Faith and devotion to the teacher and the texts play an important role in monastic education and hence, the authority of the text and the teacher is hardly questioned (Utha, 2015).

Modern education came to Bhutan only in the early 1960s. Though much progress has taken place in the modern education system, like in the monastic education, teacher's authority is still respected and everything in the textbook becomes a bible for learning.

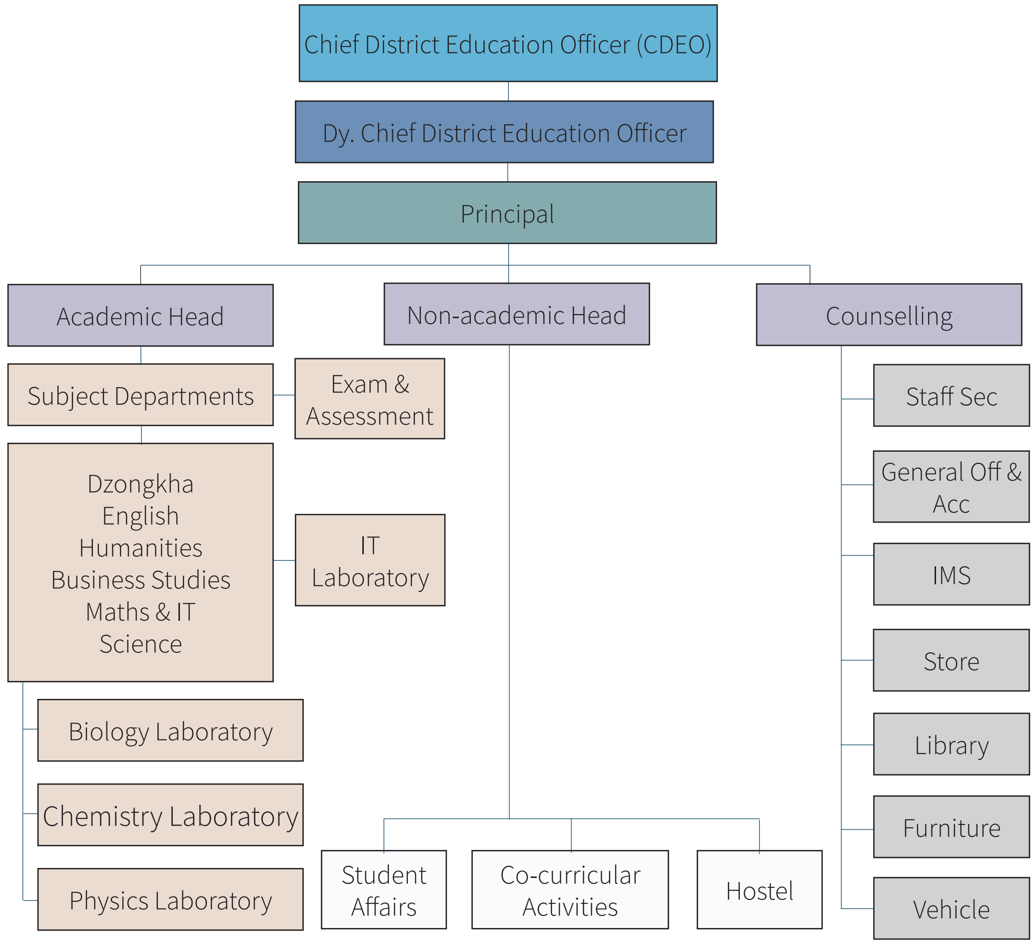
2.2 Education administration

The Ministry of Education (MoE) has four departments: Department of School Education (DSE), Department of Adult and Higher Education (DAHE), Department of Youth and Sports (DYS), and Directorate of Services (DoS). The Department of Curriculum and Professional Development (DCPD) which was known as Royal

Education Council (REC) till 2021 is set to be under DSE with the new restructuring of agencies under the Ministry of Education. DCPD looks after the curriculum matters of the school. A separate body under MoE is the Bhutan Council for School Examination and Assessment (BCSEA). BCSEA takes care of examinations and assessments. The organisational structure of the Departments in the Ministry of Education is expected to undergo a radical transformation with the current nationwide education reform. The organizational structure of Dzongkhag education (school included) is shown in Figure 2.1.

Figure 2.1

Organizational Structure of Dzongkhag Education



The Academic Head looks after academic matters and supervises the subject departments and exam and assessment committees. Lead teachers, though not reflected in the organogram, support the Academic Head.

2.3 Education policy and funding

2.3.1 Policy

Out of the many policies on education, the focus of this study is on the State education policy, allocation of instructional hours, ICT, students with special needs, and teachers' professional development.

State education policy. The state education policy of the Royal Government of Bhutan (MoE, 2019) confirms that:

a. The State shall endeavour to provide education for improving and increasing knowledge, values, and skills of the entire population and direct education to wards the full development of human personality.

b. The State shall provide free education to all children of school-going age up to the tenth standard and ensure that technical and professional education is generally available and that higher education is equally accessible to all based on merit.

However, the present ruling government Druk Namdrup Tshogpa has started offering free education to all school-going children up to the Class XII, beginning from the 2019 academic year.

Instructional hours. On the instructional hours, the policy states, "The annual school academic calendar shall ordinarily consist of 800 instructional hours delivered over 150 instructional days. Variations to this will consider class cohorts, seasonal conditions, and other relevant factors. Details on instructional hours shall be maintained and reviewed periodically in school management and operational guidelines" (MoE, 2014, p32). Schools are mandated to follow a period of 50 minutes to achieve the instructional hours required per academic year for each subject. The total instructional hours in secondary schools (middle) is divided among the various subjects (current practice), as reflected in Table 2.1.

Table 2. 1

No. of Periods Allocated per Subject

Sl. No.	Subject	No of periods (50 minutes) allocated per week
1	English	6
2	Dzongkha	6
3	Mathematics	5
4	All other subjects	3

However, some schools follow instructional hours of 45 minutes to 1 hour, but care is taken to meet the total instructional hours (all interviewees). Also, Classes XI and XII get an almost equal number of instructional hours for all subjects. There are practices of extra classes being carried out beside the instructional hours to cover the syllabus (MoE, 2014).

Information and Communication Technology (ICT). On ICT, the education policy states that ICT shall be promoted in schools through adequate resources to leverage the power of ICT in teaching and learning (MoE, 2019). Until 2019, ICT was offered only in Classes IX to XII as an optional subject. However, recognizing the increasing importance of ICT in education, MoE has started offering ICT as a compulsory subject from Classes PP to XII in various years (REC, 2021), as reflected in Table 2.2.

Table 2. 2

ICT Classes

Sl No	Start year	Classes
1	2017	IV-VI
2	2018	VII-VIII
3	2019	IX
4	2020	PP-X
5	2021	XI-XII

Some schools had not been able to offer ICT as a compulsory on time due to lack of infrastructure and equipment. This was accounted due to COVID-19 pandemic.

Special needs. On children with special needs, the policy states, "Schools shall put in place appropriate measures for all students, including children with special educational needs, across all grades to ensure equitable access to and participation in school. This includes support with specialized, appropriate educational services and facilities, including trained personnel" (MoE, 2019, p5). In an effort to introduce inclusive education approaches across the whole education system, the Ministry of Education has currently been able to establish or introduce special educational needs (SEN) programmes in a total of 18 (crosscheck this from SEN Division at MoE) mainstream schools. In addition to these schools with SEN programmes, Wangsel Institute at Drugyel, Paro offers a specialized education to children with hearing impairment and Muenselling Institute at Khaling in Trashigang caters for the education of children with visual impairment. The Ministry of Education has considered inclusive education practices as a critical component of the development of education in the country and has published an official document defining Standards for Inclusive Education in Bhutan (MoE, n.d.) and has inclusive education as one of the eight standards outlined in the Bhutan Professional Standards for Teachers (BPST), which is used to assess schoolteachers' professional competencies (MoE, 2019). However, diverse learners' needs are catered to in every school.

Professional development.: Bhutan considers teachers as the cornerstone of the education system and they need to be constantly updated with the latest knowledge and teaching pedagogies. This is carried out through continuous professional development to result in effective classroom delivery. Considering the importance, the Human Resource Policy (THRP) 2014 and In-Service Education of Teachers (INSET) Master Plan mandated that every teacher receive a minimum of 80 hours of need-based PD program in a year (MoE, 2014). The MoE has established the Teacher Professional Support Division (TPSD) under the DSE in 2016 to oversee the PD process and monitor its effectiveness.

2.3.2 Education funding

The capital budget layout for the 7th to 12th 5-year plan for MoE and RUB (GNHC, 2016, p.47; MoE, 2014, p.116) is reflected in Table 2.3 and Table 2.4.

Table 2. 3

Education Budget outlay for MoE (Nu. in Million)

Budget	7th Plan (1992-1997)	8th Plan (1997-2002)	9th Plan (1997-2007)	10th Plan (2007-2013)	11th Plan (2013-2018)	12th Plan (2019-2023)
Total Government Budget	15,590.70	34,981.70	70,000.00	73,611.76	92,000.00	1,15,364.00
Education Budget	1,738.00	3,292.70	10,209.40	9,489.10	7438.74	3,500.00

The total education budget outlay is divided among the 20 Dzongkhags schools.

Table 2. 4

Education Budget outlay for RUB (Nu. in Million)

Budget	11th Plan (2013-2018)	12th Plan (2019-2023)
Total Government Budget	92,000.00	1,15,364.00
Education Budget for RUB	1086.45	1000

The education budget reflects Royal University of Bhutan (RUB) budget allocation also as most of the RUB students are funded by the government. The total education budget outlay for RUB is divided among the colleges.

2.4 Academic structure

The present education system is an outcome of decades of planned development and has always played a central role in the pursuit of political, cultural, environmental, and socio-economic development of the country as a unique, progressive, peaceful, and sovereign nation. The school education system consists of seven years of primary education (PP-VI), two years of lower secondary education (VII-VIII), two years of middle secondary education (IX-X), and two years of higher secondary education (XI-XII).

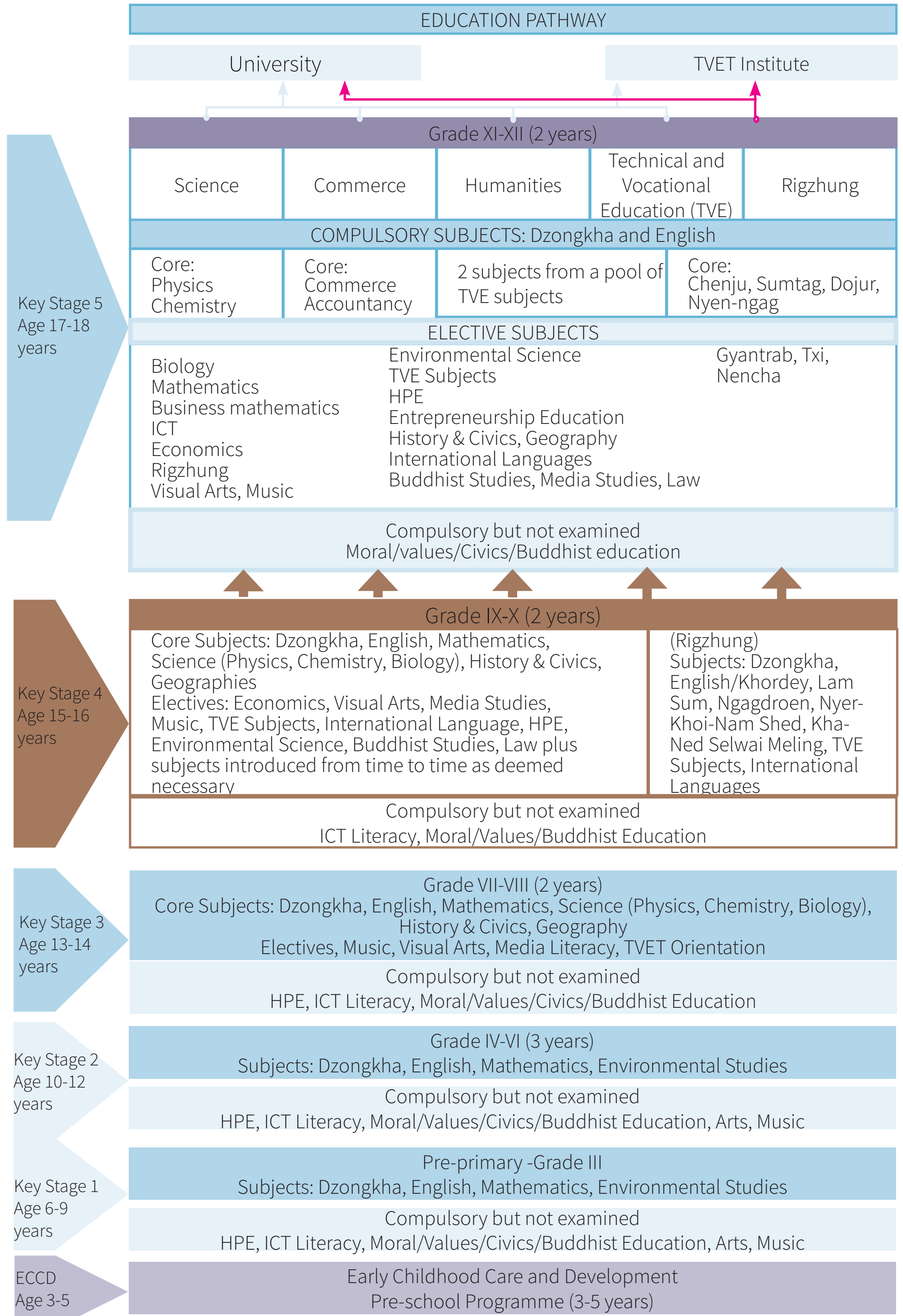
The REC (2021) adapted the UNESCO-IBE module with eight stages of the curriculum cycle starting from curriculum dialogue and formulation, curriculum design, system management and governance, development of textbooks and teaching-learning materials, capacity building for curriculum implementation, processes of curriculum implementation, and curriculum evaluation and student assessment.

The 21st-century education elucidates the study of core subjects where interdisciplinary themes of global awareness, financial, economic, business and entrepreneurial literacies, and civic, health and environment literacies are integrated. This is to foster the learning of innovative skills, life and career skills, information, media, and technology skills. REC opines that this should be diversified to accommodate the study of many current and emerging learning areas (REC, 2021).

STEM education in Bhutan has undergone many changes to suit the emerging needs of Bhutanese learners. The subjects follow a spiral curriculum as shown in Figure 3.1. Science as a subject is not included in key stage 1, but Mathematics is included. In key stages 2 and 3, students study General Science consisting of Physics, Chemistry, and Biology content. In key stages 4 and 5, Science is bifurcated into Physics, Chemistry, and Biology. However, in key stage 5, students can choose between Mathematics and Biology whereas Physics and Chemistry are compulsory.

Figure 3.1

Education Pathway and the Core and Elective Subjects at Different Levels



(Adopted from MoE, 2014)

Note: ICT education begins from class PP to X as a compulsory subject.

2.5 Teacher education

The Royal Government of Bhutan has accorded the highest priority to education since the inception of modern education. There are two colleges of education specialising in teacher training, Samtse College of Education (SCE) and Paro College of Education (PCE). SCE specialises in educating and preparing pre-service and in-service teachers for secondary schools whereas PCE educates and prepares pre-service primary school teachers and teachers for special needs education. SCE currently offers Postgraduate Diploma in Education (PgDE), Postgraduate Certificate in Higher Education (PgCert in HE), and Master of Education (M. Ed) in various secondary school subject disciplines. The pre-service Bachelor of Education (B. Ed) programme that used to be the main flagship teacher education programme at SCE has been discontinued with the graduation of the final cohort of these students in July 2022. This new change has been in effect to align with country's policy of changing the entry level for pre-service secondary teacher education programmes to a Bachelor's degree to enhance the quality of standards teachers in the secondary school system.

2.6 Country specific project risks

This section of the report presents the country specific risks that might potentially affect the implementation of the project activities with respect to climate change, rural-urban migration and COVID-19 pandemic.

2.6.1 Climate change

Bhutan has three climatic zones: (a) the southern plains, which are subtropical and characterized by high humidity and heavy rainfall; (b) the central belt of flat valleys characterized by cool winters and hot summers with moderate rainfall; and (c) high valleys with cold winters and cool summers (Royal Government of Bhutan [RGoB], 2006). The southern plains experience monsoon from June to September during which flash floods and landslides are common occurrences. Snowfall is observed most of the time in the year in the higher valleys.

Like other countries in the world, Bhutan is prone to climate change that not only have a negative impact on its environment but also pose a threat to its sustainable development and the livelihoods of its people. This is because approximately 80% of the country's population depends on subsistence farming for livelihoods, which

are prone to increasing climate change hazards. Further, many existing settlements are situated in increasingly hazard-prone areas, such as steep slopes or flood-prone riverbeds, which make them vulnerable to the effect of natural calamities and disasters.

Both monsoon and snowfall have an impact on education. In the southern plains, classes sometimes get called off as students are not able to travel to schools when the rivers swell and incessant rain washes away bridges. In the higher valleys, some of the schools remain open from April to September only (C2a verbal communication). Further, some sections of students stay as day students. They have to walk long distances crossing rivers and mountains to reach schools (Pelden, 2019). They are exposed to the challenges of landslides, floods, swollen rivers, and other hazards. These concerns raise the issue of equal access to education, as schools in Bhutan follow one common curriculum and practice. The students are also required to follow the same board examination both at the Dzongkhag level and at the national level.

School infrastructure and other facilities have not adapted to the climatic conditions of the country. For example, schools in the higher elevations do not have a classroom heating system. Similarly, schools in southern plains might have fans installed to overcome the summer heat. Often, the noise of the fans distracts the students from attentive listening and participation. Such lack of infrastructure facilities designed to fit the varying climatic conditions affect the overall ambience and quality of learning.

2.6.2 Rural-urban migration

Many types of migration take place in Bhutan. According to the National Statistics Bureau of Bhutan (2018), migration is broadly classified as lifetime migration (Table 2.5) and resident migration (Table 2.6). The resident migration is a temporary migration.

Table 2. 5

Migration Status by Gender

Lifetime migration status	Thousands			Percentages		
	Male	Female	Total	Male	Female	Total
Non-migrant	173.5	178.3	351.9	24.4	25.0	49.4
Internal migrant, rural-rural	61.6	57.7	119.3	8.7	8.1	16.8

Internal migrant, rural-urban	70.3	70.7	141.0	9.9	9.9	19.8
Internal migrant, urban-rural	13.3	12.8	26.1	1.9	1.8	3.7
Internal migrant, urban-urban	17.3	18.0	35.3	2.4	2.5	5.0
Immigrant, urban	13.4	1.8	15.1	1.9	0.3	2.1
Immigrant, rural	21.2	2.1	23.3	3.0	0.3	3.3
Total	370.5	341.4	712.0	52.0	48.0	100.0

Table 2.5 shows seven broad types of life time migration status in Bhutan. It is evident from the Table that compared to other types of migration, rural-to-urban is the largest category of migrants with 141 thousand people, which is 19.8 per cent of the total population.

Table 2. 6

Recent Migration Status by Gender

Lifetime migration status	Thousands			Percentages		
	Male	Female	Total	Male	Female	Total
Non-migrant	255.7	262.2	517.9	35.9	36.8	72.7
Internal migrant, rural-rural	27.7	23.5	51.2	3.9	3.3	7.2
Internal migrant, rural-urban	23.4	23.2	46.7	3.3	3.3	6.6
Internal migrant, urban-rural	15.5	13.1	28.7	2.2	1.8	4.0
Internal migrant, urban-urban	16.4	16.2	32.6	2.3	2.3	4.6
Immigrant, urban	12.5	1.8	14.3	1.8	0.3	2.0
Immigrant, rural	18.9	1.4	20.3	2.7	0.2	2.9
Total	370.2	341.5	711.7	52.0	48.0	100.0

The recent migration status in Table 2.6 shows that nearly 7% of Bhutan's population falls under the recent rural-to-urban migration status. Reports show Thimphu, the capital city of Bhutan with a 27.5% in-migration rate. Recent migration by young adults are mostly attributed to seeking employment, education, and marriage, with marriage being the least status (NSB, 2018). Migration rate of males is higher when compared to females.

The migration practice leads to fallow agricultural land and empty households (locally known as Gungtongs) in villages. There were 4800 Gungtongs reported in the 2017 census. Unsuitability of land for agriculture, human-wildlife conflict, lack of infrastructure like roads, poor access to drinking water and electricity, and shortages of employment opportunities in rural areas are some of the reasons cited for rural-urban migration (Gelmo, 2020).

The migration practice has an impact on education at both rural and urban levels. A number of rural primary schools have been closed due to inadequate number of school-going children. Such incidences compel the remaining children to travel long distances to attend school or live in hostels at a very young age depriving them of the emotional and psychological support of their parents and immediate family members. In urban areas, the migration has increased the pressure on the existing resources and infrastructure due to excess student enrollment.

2.6.3 Impact of the COVID-19 pandemic

Since the COVID-19 outbreak in the country towards the beginning of 2020, education has been hit hard like many other sectors. Students, teachers, schools, colleges, and universities have been affected irreparably. Following the COVID-19 pandemic outbreak, educational institutions were forced to close due to frequent lockdowns. Teaching and learning shifted from face-to-face to online virtual mode. Students and teachers faced a plethora of challenges with this sudden shift to virtual teaching. The financial status of parents and families in providing smart phones or laptops for online learning, unreliable internet connectivity, and inability to subscribe for 3G/4G data packages to support student's online learning were reported as expensive and unaffordable (P4, C2a). For example, C4 said that only about 37% of the parents in Samtse Dzongkhag provided data recharges for their children for learning.

To address these challenges, the Ministry of Education (MoE) initiated and offered online teaching through national radios channels and tele-teaching via the Bhutan Broadcasting Service (BBS) national television to reach education and learning undisrupted to students who did not own smartphones or were located in remote areas. Self-Instructional Materials (SIM) were developed for the benefit of the same group of students (C2a). Some forms of mobile classes were offered by subject teachers to lower grade students from PP-III. MoE initiated education in an emergency (EIE), which prioritised and adapted the standard existing curriculum to fit the educational needs during the COVID-19 crisis (REC, 2020).

Students from high-risk areas were relocated to low-risk areas. For instance, Classes X and XII students of Phuntsholing (southern Bhutan) were relocated to the central part of Bhutan. The 'New Normal' curriculum was developed by REC and implemented in schools from 2021 academic year. Examinations were postponed in higher and middle secondary schools. However, examinations in lower secondary schools were replaced by continuous assessment (CA) components done virtually. In the colleges of the Royal University of Bhutan (RUB), online examinations were conducted through a virtual learning environment (VLE) with an e-proctoring invigilation facility in a few colleges.

Teachers in schools and colleges employed various ICT tools to develop and deliver online lessons. However, the lack of adequate skills and knowledge about ICT tools and techniques had made this transition process difficult and arduous (Tamang et al., 2021). All interview participants reported lack of adequate resources as one of the challenges faced by teachers to maintain the quality and standard of teaching and learning. The demand to prepare online lessons with limited ICT knowledge and skills in a very unfavourable setting with inadequate access to ICT tolls and equipment further compounded the already heavy workload of teachers. Most teachers found monitoring students' online stressful and ineffective.

Besides academic constraints, COVID-19 poses challenges to school managers. P4 stated that some plans and activities could not be carried out especially during the lockdown. However, it was shared that some of the activities could be completed with proper planning and contingency plans. This Principal also asserted that COVID-19 made a tremendous impact, as it disturbed the whole education system and complicated the management of human resources and curriculum.

Though COVID-19 continues to pose tremendous challenges in teaching and learning, teachers were given opportunities to explore various online teaching and learning tools and techniques. The pandemic has helped teachers to upscale and enhance their competencies to teach online classes effectively by using various ICT tools and social media apps. For instance, P3 said, "the role of ICT was exceptional in the sense that it kept everyone on toes and even the most digitally backward got awakened. Had it not been for COVID-19, ICT would have remained a dream for many teachers". Despite the continuous effort put in by teachers, the status of quality of teaching and learning is yet to be ascertained.

2.6.4 National assessments of literacy, numeracy, and STEM skills

PISA D National Report 2019. More than 2000 Bhutanese students aged between 15 and 16 years attended the PISA-D test in 20017 (BCSEA 2019). PISA-D was conducted by the Organization for Economic Cooperation and Development (OECD). The assessment focused on numeracy and scientific literacy and the following section provides a brief discussion of the PISA-D results in numeracy and science.

Mathematics/numeracy. In PISA-D, the numeracy skills of students were assessed on four parameters namely quantity, change and relationships, space and shape, and uncertainty and data. Bhutan's students achieved an average solution rate of 38.84% in the PISA-D 2017 mathematical literacy assessment, which was significantly higher than the PISA-D average solution rate of 30.65%. Boys performed better than girls in Mathematics (BCSEA, 2019). PISA-D findings also revealed that students in Bhutan performed significantly better in comparison to top PISA-D countries, but slightly (2% to 4%) below students in Sweden, and significantly below students in Singapore.

Further, the PISA-D highlighted the strengths and weaknesses of Bhutanese students. The students were good at interpreting, applying, and evaluating mathematical outcomes when compared to students of most of the PISA-D countries. However, they found it difficult to formulate situations mathematically, and with tasks related to the content area.

Scientific literacy. In PISA-D 2017, students were assessed on three areas namely scientific competencies, scientific knowledge, and attitude towards science. The results revealed that the students achieved an average solution rate of 45.10% in scientific literacy assessment, which was significantly higher than the PISA-D average solution rate of 38.28%. The findings also revealed that boys performed better than girls in science. Students in Bhutan performed significantly better than those of top PISA-D countries. The results highlighted that Bhutan's solution rates were better than low performing PISA reference countries and almost at par with the OECD average while considering the common PISA items (BCSEA, 2019).

Although Bhutan performed better than most PISA-D countries, a huge performance gap was found between Bhutan and PISA countries. Bhutan's performance is about 23 to 35 points (% points) below OECD averages. Moreover, Bhutanese students' weaknesses were identified primarily in items that require interpretation of data.

CHAPTER 03: OVERVIEW OF THE FIVE DZONGKHAGS

3.1 A brief profile of the five Dzongkhags

A brief profile of each of the five Dzongkhags namely Thimphu, Paro, Trashigang, Zhemgang, and Samtse is presented.

Thimphu. Thimphu is the capital of Bhutan and is located in Western Bhutan. It has a population of 0.14 million scattered within an area of 1,794.87 km2 (National Statistics Bureau [NSB], 2020). It is well connected with roads and is a 45-minute drive from the Paro International Airport. Thimphu experiences a cold and dry winter with temperatures ranging from -3^{0}C to 15^{0}C and mild summer with a temperature ranging from 12^{0}C to 25^{0}C. Thimphu receives moderate rainfall of 1397mm. Dzongkha and English languages are predominantly spoken by residents of Thimphu. Other dialects, such as Lhotsamkha, Sharchopkha or Tsangla, Kurtoepkha, Khengkha, Mangdepkha, and Bumthapkha, are also spoken.

Under Thimphu Dzongkhag, the schools are broadly classified into two divisions, viz., Thimphu Throm and Thimphu Dzongkhag. The former is located within the city and the latter in the periphery. Each division has its own administrative and management systems.

Samtse. Samtse is one of the four Dzongkhags located in southern Bhutan. It has a population of 63000 (National Statistics Bureau [NSB], 2020). Although Lhotshampkha is the dominant language spoken by the heterogeneous Lhotshampa community, the population also speaks Dzongkha, English and other dialects. Samtse experiences hot and humid summer with an average temperature of 17^{0}C in winter and 35^{0}C in summer. It receives moderate to heavy rainfall of about 1500-4000 mm annually. It is connected with roads and shares an international border with the Indian states of Sikkim to the west and West Bengal to the south. SCE is situated in Samtse.

Paro. Paro is located in the northwest of Bhutan. It is a historic town with many sacred sites and historical buildings scattered throughout the area. It is also home to Paro Airport, Bhutan's only international airport. It has a population of 35000 (NSB, 2020) and Dzongkha is the predominant and official language of the community. English

and other local dialects are also widely spoken. Paro enjoys a cool and warm summer with temperatures ranging from 14^{0}C to 26^{0}C. However, winter can be severe with temperatures ranging from -5^{0}C to 14^{0}C.

Trashigang. Trashigang Dzongkhag is in eastern Bhutan. It has a population of 71768. The main language is Sharchopkha or Tsangla. However, English, Dzongkhag, and other dialects are also spoken by the residents. The domestic airport of Yonphula is situated south of Trashigang, less than an hour's drive by car. It is one of the few Dzongkhags to have domestic airports. The district enjoys a pleasant winter with temperature ranging from 24^{0}C to 12^{0}C and moderate summer with 34^{0}C to 22^{0}C. The annual rainfall is between 1000 mm and 2000 mm. Sherubtse College at Kanglung located on the highway between Trashigang and Yonphula, is one of the oldest and largest colleges in the country.

Zhemgang. Zhemgang Dzongkhag is located in the south-central part of Bhutan. It has rich biodiversity and is home to numerous endangered animal species including the golden langur. It has a population of 17763. Khengkha is the dominant language but other dialects are also spoken like in other parts of the country. Although much of the district has warm and humid climatic conditions, its northern regions have moderately cool temperatures.

3.2 Information on Dzongkhag wise schools, resources and facilities

Quantitative indicators in Table 3.1 shows the class range, the number of teachers, the number of STEM teachers, and support staff in the schools of five Dzongkhags.

Table 3. 1

Dzongkhag wise Information about School

School district		Name of the school	Class range	No of teachers	No of STEM teachers	No of support staff
Thimphu	Thimphu Dzongkhag	Yangchen Gatshel MSS	PP-X	26	9	26
		Wangbama CS	IX-XII	28	12	28
		Khasadrapchu MSS	PP-X	48	13	23
		Kuzhugchen MSS	PP-X	31	5	6
	Thimphu Throm	Babesa HSS	VII-XII	32	11	11
		Zilukha MSS	PP-X	50	5	5
		Yangchenphu HSS	VII-XII	62	24	11
Zhemgang		Sonamthang CS	VII-XII	44	12	25
		Buli CS	PP-X	29	8	11
Paro		Shari HSS	IX-XII	33	11	8
		Drukgyel CS	IX-XII	39	17	47
		Khangkhu MSS	PP-X	44	11	7
		Lamgong MSS	PP-X	53	6	8
Trashigang		Gongthung HSS	PP-X	25	7	10
		Dungtse CS	VII-X	25	10	10
		Bartsham HSS	VII-XII	30	11	11
		Tashitse HSS	IX-XII	26	8	12
		Dungtse MSS	VII-X	23	9	20
Samtse		Yoeseltse MSS	PP-X	30	7	8
		Peljorling HSS	PP-XII	66	12	12
		Gomtu HSS	PP-XII	68	30	9
		Tendruk CS	PP-XII	81	19	10
		Dorokha CS	IX-XII	33	11	20
		Samtse HSS	IX-XII	32	10	14

Quantitative indicators in Table 3.2 show the ICT facilities available in schools in the five Dzongkhags.

Table 3. 2: *ICT Facilities Available in Schoolos of the Five Dzongkhags*

School District		Name of the school	Laptops	Desktops	Projectors	Printers	Photocopiers	Generator/Inverter/UPS	Tablets	Smart boards	Smart TVs	Scanners	Web Cameras	Sound system
Samtse		Yoeseltse MSS	0	22	7	2	0	0	0	0	0	0	0	1
		Peljorling HSS	1	18	1	4	2	0	0	0	0	1	0	1
		Gomtu HSS	1	35	3	5	1	0	0	0	3	1	0	3
		Tendruk CS	4	85	5	5	2	0		0	0	1	1	2
		Dorokha CS	4	40	0	1	0	0	0	0	0	1	0	1
		Samtse HSS	0	40	2	2	1	0	0	0	17	2	0	2
Trashigang		Gongthung HSS	1	30	4	4	1	0	0	4	2	0	0	1
		Dungtse CS	0	23	1	5	1	0	0	0	4	1	20	
		Bartsham HSS	22	43		5	2	0	0	0	1	0	0	1
		Tashitse HSS	0	40	2	3	0	0	0	0	1	3	0	1
		Dungtse MSS	4	30	1	6	1	0	0	0	5	2	0	0
Paro		Shari HSS	3	60	6	5	2	0	0	1	1	2	0	2
		Drukgyel CS	0	50	12	11	2	1	0	2	2	2	0	1
		Khangkhu MSS	3	60	9	3	1	0	0	1	1	3	0	1
		Lamgong MSS	4	90	3	4	1			1	2			
Zhemgang		Sonamthang CS	5	45	12	3	1	1	0	0	0	0	3	1
		Buli CS	5	42	17	6	0	1	0	2	3	2	9	3
Thimphu	Thimphu Dzongkhag	Yangchen Gatshel MSS	12	35	16	6	2	2	36	1	5	2	4	2
		Wangbama CS	11	68	18	5	2	3	0	0	2	1	2	2
		Khasadrapchu MSS	6	55	16	8	1	0	0	0	0	1	20	1
		Kuzhugchen MSS	33	56	17	5	2	0	0	0	8	1	0	0
	Thimphu Throm	Babesa HSS	0	40	9	6	2	0	0	0	0	0	0	2
		Zilukha MSS	6	77	12	5	1	4			3	1		3
		Yangchenphug HSS	10	60	32	6	1	0	0	0	0	0	0	2

Number of Devices in School

Table 3.3: shows school wise information on students' access to smartphones.

Table 3. 3: *Total Percentage of Students who own Smartphones*

School District		Name of school	Students who own a smartphone (%)	Total no. of students in school: Class IX M	Class IX F	Class IX T	Class X M	Class X F	Class X T	Class XI M	Class XI F	Class XI T	Class XII M	Class XII F	Class XII T
Thimphu	Thimphu Throm	Yangchenphug HSS	95	56	71	127	95	105	200	171	255	426	191	230	421
		Zilukha MSS	90	88	88	176	54	51	105						
		Babesa HSS	40.7	31	35	66	39	49	88	28	52	80	41	48	89
	Thimphu Dzongkhag	Kuzhugchen MSS	90	24	21	45	14	16	30						
		Khasadrapchu MSS	85	123	73	196	87	33	120						
		Wangbama CS	50	35	44	79	45	45	90	73	85	158	38	73	111
		Yangchen Gatshel MSS	40	31	30	61	27	41	68						
Zhemgang		Buli CS	34	34	38	72	43	55	98						
		Sonamthang CS	30	68	73	141	73	69	142	41	62	103	54	73	127
Paro		Lamgong MSS	80	35	33	68	33	30	63						
		Khangkhu MSS	98	69	61	130	47	61	108						
		Drukgyel CS	100	72	89	161	62	107	169	87	92	179	67	107	174
		Shari HSS	90	39	37	76	40	38	78	97	83	180	59	70	129
Trashigang		Dungtse MSS		50	73	123	50	61	111						
		Tashitse HSS		41	37	78	29	44	73	76	76	152	71	72	143
		Bartsham HSS		49	66	115	61	75	136	62	75	137	59	66	125
		Dungtse CS	50	50	73	123	49	61	110						
		Gongthung MSS	0	15	33	48	26	31	57						
Samtse		Samtse HSS	80	126	52	178	137	71	208	134	68	202	145	77	222
		Dorokha CS	50	123	139	262	111	130	241	42	32	74	40	33	73
		Tendruk CS	30	126	125	251	143	118	261	57	51	108	42	61	103
		Gomtu HSS	60	73	78	151	43	51	94	21	55	76	20	28	48
		Peljorling HSS	80	123	129	252	86	109	195	57	55	112	44	49	93
		Yoeseltse MSS	10	35	35	70	31	40	71						

This was expected because some schools have a school policy that prohibits students to carry smart phone to school (one of the Principal of Trashigang Dzongkhag). These is the reason why in some schools, the information on students' access to smartphones is missing.

Table 3.4 shows the number of students taking STEM subjects school wise. It is clear from the table that there are almost equal number of male and female students in each class.

Table 3. 4: *Number of Students taking STEM Subjects*

School districts		Name of school	Class IX M	Class IX F	Class IX T	Class X M	Class X F	Class X T	Class XI M	Class XI F	Class XI T	Class XII M	Class XII F	Class XII T
Samtse		Yoeseltse MSS	35	35	70	31	40	71	20			17		
		Peljorling HSS	123	129	252	86	109	195	12	15	35	8	10	27
		Gomtu HSS	73	78	151	43	51	94	18	19	31	19	8	16
		Tendruk CS	126	125	251	118	118	236	0	16	34	0	12	31
		Dorokha CS	123	139	262	111	130	241	38	0	0	21	0	0
		Samtse HSS	74	52	126	66	71	137		18	56		17	38
Trashigang		Gongthung MSS	15	33	48	26	31	57						
		Dungtse CS	50	73	123	49	61	110	11			11		
		Bartsham CS	49	66	115	61	75	136	60	12	23	60	14	25
		Tashitse HSS	78	37	115	73	44	117		30	90		30	90
		Dungtse MSS	50	73	123	50	61	111	12			8		
Paro		Shari HSS	39	36	75	40	38	78		13	25		11	19
		Khangkhu MSS	69	61	130	47	61	108						
		Lamgong MSS		46	46	63	30	93	11					
Zhemgang		Sonamthang CS	68	73	141	73	69	142		12	23			
		Buli CS	34	38	72	43	55	98						
Thimphu	Thimphu Dzongkhag	Yangchen Gatshel MSS	31	30	61	27	41	68	13			4		
		Wangbama CS	35	44	79	45	45	90		13	26		9	13
		Khasadrapchu MSS	50	73	123	54	33	87						
		Kuzhugchen MSS	24	21	45	14	16	30	39			41		
	Thimphu Throm	Babesa HSS	31	35	66	39	49	88	42	52	91	52	48	89
		Yangchenphug HSS	56	71	127	95	105	200		60	102		71	123

(Total no. of students taking STEM Subjects)

The survey questions were also designed to help find data on Dzongkhag wise school students' performance in STEM subjects as depicted in Table 3.5.

Table 3. 5: *Dzongkhag wise Pass Percentage in STEM for Classes X and XII*

School District		Name of school	Class X overall pass % 2018	2019	2020	Class X pass % in STEM 2018	2019	2020	Class XII overall pass % 2018	2019	2020	Class XII pass % in STEM 2018	2019	2020
Samtse		Peljorling HSS	92.6	94.3	94.12				100	90.4	95.8			
		Gomtu MSS	96.1	89,05	97.1	94.6	88	70.8			94.7			87.5
		Tendruk CS	84	83	89.7	15	13	8	85	94	93.67	80	90	90
		Dorokha CS		89	95.96		85	92						
		Samtse HSS	88.4	91.87	98.5	70.65	83.34	82	86.71	90.38	97.6	94	96	97
Trashigang		Gongthung MSS	100	100	100	100	100	100						
		Dungtse CS	100	95.8	100	100	95.5	100						
		Bartsham HSS	100	97.4	96.5	99	94.6	93			91			81.9
Paro		Drukgyel CS		98	100						100			
		Khangkhu	100	100	100	65	74	75						
		Lamgong MSS	92	98.6	91.3									
Zhemgang		Sonamthang CS	100	0.88	100		88.28	100						
		Buli CS	100	96	88	100	96	63						
Thimphu	Thimphu Dzongkhag	Yangchen Gatshel MSS		83.05	95.16		83.05	95.16						
		Wangbama CS	94.4	96.23	98.97	94.4	96.23	98.97	92.6	94.4	98.97	92.64	94.38	98.97
		Khasadrapchu MSS	96.94	94.06	100	96.9	94.4	100						
		Kuzhugchen MSS	100	100	100	100	100	100						
	Thimphu Throm	Babesa HSS	95.8	98.7	93.54	78.9	86.5	82.9			92.31			83.33
		Zilukha MSS	96.1	93.8	95.9									
		Yangchenphug HSS	96.76	99.1	99	95	98	97	88.45	95.02	96.91	86.5	95.47	92.6

*Blank cells indicate missing data or not applicable.

Table 3.6 depicts the overall pass percentage and STEM pass percentage for Classes X and XII for the last three consecutive years in six districts. Overall pass percentage show a linear progression from 2018 to 2020 for Classes X and XII. Similarly, the pass percentage in STEM subjects reveals the same kind of progression over the years for classes X and XII. However, it is to be noted that in the STEM subjects, the mean performance is just above average. The pass percentage is higher as students have to get just 35% in a subject to pass.

Table 3.6 portrays the overall performance of Classes X and XII Bhutanese students in STEM subjects for the three consecutive years 2018-2020.

Table 3. 6

Classes X and XII Pass Percentage for 2018, 2019, and 2020

Grade	Subject	2018			2019			2020		
		Gender			Gender			Gender		
		M	F	T	M	F	T	M	F	T
X	Mathematics	96.97	97.04	97.01	88.44	86.1	87.16	79.45	78.34	78.94
	Physics	95.33	95.15	95.23	90.97	87.82	89.24	96.63	97.79	97.17
	Chemistry	83.78	85.2	84.55	78.26	79.96	79.19	97.26	96.83	97.06
	Biology	94.57	94.21	94.37	95.98	95.52	95.73	90.15	88.72	89.4
XII	Mathematics	91.82	94.07	92.56	79.31	81.11	79.92	87.85	88.21	87.97
	Physics	98.48	98.95	98.68	96.31	95.62	96.02	97.64	98.05	97.83
	Chemistry	92.94	94.73	93.71	95.63	97.02	96.25	96.68	98.76	97.62
	Biology	99	99.05	99.03	99.62	99.48	99.53	98.97	99.39	99.21

(BHSEC, 2019; BHSEC, 2020; BHSEC, 2021)

The overall pass percentage in all the STEM subjects is above 70% (Table 3.6). However, in some cases, the performance over the years is decreasing. For example, in Class X mathematics, the percentage is decreasing from 97.01% in 2018 to 78.94% in 2020. Similar trend is observed in Biology in Class X and Mathematics in Class XII. But it is notable that Class XII students' performance in Biology is very encouraging with little above 99%. Both Table 3.5 and 3.6 depicts the overall academic performance in STEM but students mean score in each STEM subject is not encouraging. A discussion on this is reflected in Chapter 6.

ACTIVITIES IN THE SAMPLE DZONGKHAG SCHOOLS

4.1 Attitudes and practice concerning ICT in education

ICT has a huge impact on the way students learn. The effect of ICT is felt more when data are exchanged over the internet of things and cloud computing to provide intelligent automation through artificial intelligence (MoE, 2019). The education system has to be responsive to such trends and accordingly prepare students to participate meaningfully and productively in the digital world. In response to this, MoE has been initiating the introduction of ICT in schools for all class levels since 2017. Although it was envisioned that ICT subjects are taught across Classes PP-XII by 2021, it is already 2022 and ICT subjects are yet to be introduced in some classes and schools. This plan has been adversely affected the COVID-19 pandemic outbreak, schools readiness in terms of infrastructure and equipment, and teachers competencies in terms of ICT knowledge and skills.

All interviewees of this study expressed that ICT played a vital role in continuing teaching and learning in schools during the COVID-19 pandemic. All CDEOs reported that teachers were trained to use online teaching strategies to cope with the demands of virtual teaching. Yet internet speed, lack of proper ICT infrastructure, minimal exposure of students, teachers' minimal knowledge on the use of ICT in teaching, and additional expenses by teachers and parents on data packages were cited as some challenges faced by many (A5, A2b, A, A1, C3, C1). In some schools, providing access to ICT was not possible because of the large student numbers. Hence, access to ICT was prioritized for students preparing for high stake examinations (C2a). In addition, some teachers were said to be technophobic, while few teachers were least bothered to enhance their ICT knowledge (A2a).

4.1 Teacher proficiency of applying ICT in education

The teaching profession is not an exception in the wave of ICT-driven change. The role of teachers is unique in this context, as they have to embrace ICT as a way of life and be the agents of ICT-based human capital development (Alazam et al., 2012). The need to enhance the ICT capacity of teachers is considered a key intervention to ensure the successful integration of ICT into teaching. The Bhutan Education Blueprint 2014-2024, which was developed as an official guiding education policy document to transform Bhutan's education system states that teachers need to use ICT pervasively in their teaching to improve the quality of education.

Since most of the teachers have not studied ICT in their school/college/teacher training period, there was a need to undertake PD programs focused on ICT enabled teaching to enhance their knowledge and skills. Table 4.1 shows the PD programs undertaken by the teachers of five Dzongkhags.

Table 4. 1

Number of PD and Time spent on it by Teachers

Dzongkhag		No. of STEM teachers	The average no of PD attended in the year (focused in ICT enabled)			No of hours of PD attended in the year (focused in ICT enabled)		
			2018	2019	2020	2018	2019	2020
Thimphu	Thimphu Dzongkhag	16	0.56	0.63	1.56	0.75	0.75	4.06
	Thimphu Throm	39	0.59	0.64	0.82	0.82	0.63	2.41
Zhemgang		16	2.06	1.13	1.94	2.13	2.00	2.38
Paro		12	0.17	0.67	1.25	0.75	2.38	10.33
Trashigang		29	0.28	0.24	0.31	0.97	0.56	1.34
Samtse		53	0.13	0.32	0.79	2.15	5.13	2.87

Table 4.1 indicates that the average number of PD in ICT undertaken by the teachers is minimal. This is in line with the interview data where all participants said that teachers had minimal knowledge on the use of ICT to support teaching and learning. The survey also revealed that many teachers did not attend any PD in three years, whereas a few teachers attended more than 80 hours in a year. Most of the NQTs had not attended any PD as per the data from this study. According to a lead teacher (L4), "Compared to previous years, PD at both cluster and school levels reduced due to frequent closing of schools. Despite all the challenges posed by COVID-19, PD requirements of needy schools were addressed by having face to face and online meetings".

4. 2 ICT in education infrastructure and resources

Access to ICT infrastructure and internet are prerequisites for the successful integration of ICT in teaching and learning. Recognising the importance of internet and computers in enhancing the quality of education, the Sustainable Development Goal (SDG) indicator 4. a.1 emphasises the need for member countries to increase the proportion of schools with good access to the internet and computers for pedagogical purposes (MoE, 2019a). Although the majority of secondary schools and few primary schools in Bhutan are connected to internet, the iSherig-II Review Report (MoE, 2019a) indicates that most of these schools are still challenged with inadequate bandwidth. Although all secondary schools have a computer lab with 10 to 32 working computers, the computer labs in most of these schools are adequate only for delivering the existing ICT literacy curriculum.

Equipment and digital learning resources. Table 4.2 provides information on ICT devices owned and used to support teaching by teachers in the five Dzongkhag schools.

Table 4. 2

Device Owned and Used by Teachers for Teaching and Learning

Dzongkhag		No. of STEM teachers	ICT devices owned by the teacher (%)		ICT devices teachers frequently used in teaching (%)			
			Laptop	Smart phone	Laptop	Smart phone	Projector	Smart TV
Thimphu	Thimphu Dzongkhag	16	100.00	93.70	100.00	93.70	93.70	12.50
	Thimphu Throm	39	94.87	92.31	94.87	92.31	82.05	15.63
Zhemgang		16	93.75	81.25	93.75	81.25	93.75	0.00
Paro		12	100.00	91.67	100.00	91.67	100.00	0.00
Trashigang		29	100.00	97.44	100.00	97.44	92.31	0.24
Samtse		53	94.34	81.13	94.34	81.13	62.26	33.96

Table 4.2 shows that almost all the teachers own a laptop and a smartphone. They use these devices to support their teaching and learning. A small section of schools in Thimphu, Trashigang, and Samtse are said to use smart televisions in the classrooms

for teaching. The table also shows that projectors are used in classrooms during teaching. The data showed that only 62.26% of teachers in Samtse Dzongkhag use projectors for teaching. This could be because 33.96% of teachers use smart televisions. The use of printers and photocopiers were not prominent in the survey data though a few teachers mentioned using them.

As per the Principals' survey data, the percentage of students having access to smartphones is reflected in Table 4.3.

Table 4. 3

Students having Access to Smartphone

Dzongkhag		Students who have access to a smartphone (%)
Thimphu	Thimphu Dzongkhag	40-90
	Thimphu Throm	40-95
Zhemgang	30-34	30-34
Paro	1-98	1-98
Trashigang	0-50	0-50
Samtse	10-80	10-80

Some school students in two Dzongkhags i.e., Trashigang and Paro show students as not having access to smartphones. One of the Principals of Trashigang Dzongkhag attributed this situation to the school level policy prohibiting students to bring smart phones to school.

This study also looked at the various means of communication, use of digital multimedia, and engagement in online teaching. The information generated from the survey is presented in Table 4.4.

Table 4. 4

Communication Tools used by Teachers

Dzongkhag		Communication via email (%)	Communica-tion via social media (Wechat, Telegram, WhatsApp, Facebook …) (%)	Internet and so-cial me-dia use to up-date news (%)	Digital applica-tion use in teaching-learning* (%)	En-gaged in online teach-ing in the past three years (%)
Thimphu	Thimphu Dzongkhag	100	100	100	100	100
	Thimphu Throm	82.05	100	100	100	100
Zhemgang		87.50	100	100	100	100
Paro		100	100	100	100	100
Trashigang		89.74	100	100	100	100
Samtse		77.36	100	100	100	100

*Video, simulation PowerPoint, Mentimeter, Google doc …

Table 4.4 shows that most of the teachers use email to communicate in addition to social media apps. Social media apps are mostly used for reading news. In response to their choice of digital applications to support their teaching, all teachers selected videos as the commonly used application. This information was supported by the lead teachers in the interviews. Many teachers mentioned the use of Google document and PowerPoint with few teachers citing the application of simulation, Kahoot, and Mentimeter. All teachers reported using online forums for online teaching.

Infrastructure. The data collected on the school profile showed that all schools had a functional ICT laboratory. Table 4.5 shows other infrastructures that supported the delivery of lessons through use of ICT devices. All the sample schools have functional laptops and desktops. However, in some participating schools, the number was found to be inadequate. One of the interviewees said that an ICT lab with 30 computers is inadequate for 600 students (C1).

Table 4. 5

ICT Infrastructure Available in the School

Dzongkhag		Number of functional ICT infrastructure											
		L	D	P	Pr	Ph	G	T	SB	ST	S	WC	SS
Thimphu	Thimphu Dzongkhag	62	214	67	24	7	5	36	1	15	5	26	5
	Thimphu Throm	16	177	53	17	4	4	0	0	3	1	0	7
Zhemgang		10	87	29	9	1	2	0	2	3	2	12	4
Paro		10	260	30	23	6	1	0	5	6	7	0	3
Trashigang		27	166	8	23	5	0	0	4	13	6	20	3
Samtse		10	240	18	19	6	0	0	0	20	6	1	10

L=Laptop; D=Desktop; P=Projector; Pr=Printer; Ph=Photocopier; T=Tablet; ST=Smart TV; G=Generator/Inverter/UPS; SB=Smartboard; S=Scanner; WC=Web Camera, SS=Sound System

4.3 Internet connectivity and power

Table 4.6 shows the type of internet connectivity and availability of ICT infrastructure in the five Dzongkhag schools.

Table 4. 6

Internet and Power Connection

Dzongkhag		Type of Internet connection	Internet speed (Mbps)	Electricity available	Internet available	Computers available
Thimphu	Thimphu Dzongkhag	Fiber optics	11-20	Most of the time	Most of the time	Most of the time
	Thimphu Throm	Fiber optics	11-20	Most of the time	Most of the time	Most of the time
Zhemgang		Fiber Optic	6-132	Most of the time	Some time	Some time
Paro		Fiber Optic	5-23	Most of the time	Most of the time	Most of the time
Trashigang		Fiber Optic	7-14	Most of the time	Most of the time	Most of the time
Samtse		Fiber Optic	7-11	Most of the time	Most of the time	Most of the time

According to Table 4.6, all schools in the selected Dzongkhags had fiber optic broadband connections with varying speeds. All schools also had access to electricity, internet, and computers but Zhemgang Dzongkhag reported limited availability of internet and computers.

4.4 Digital equity and inclusion

Braille is the main method of teaching students with visual impairments at Muenselling Institute in Khaling. With the advancement of technology, screen reader is replacing braille. Education for the deaf relies heavily on visual teaching strategies. Technological interventions, such as projectors, British Sign Language (BSL) videos with English, and Dzongkha captions are used to facilitate learning for deaf students (MoE, 2019).

The DSE of MoE has received support from 'Save the Children', an NGO, for buying smartphones for 104 students in Wangsel Institute in Paro and 25 students in Muenselling Institute. All students are yet to receive the smartphones due to a supply shortage in the market. DSE was also successful in getting audiovisual books (Drukpa, 2020).

The teachers incorporate inclusive teaching approaches in their IEP so that children's educational needs are met. Various social media communication platforms, such as WeChat, WhatsApp, Telegram, and Google Classroom, are used to teach and learn in a meaningful way. Interview data, however, did not reveal any detailed information on digital equity and inclusion.

4.5 ICT in education initiatives

The Chiphen Rigpel Project (2010-2015) initiated with an objective to transform Bhutan to a modern IT-enabled and knowledge-based society was instrumental in providing basic ICT skills training to all teachers in Bhutan. During the 11th five-year plan (Write the years here), MoE developed and implemented its first-ever Education ICT Masterplan, iSherig-1 (Write the years). As a scale-up programme of Chiphen Rigphel, the iSherig-1 ICT Master Plan incorporated plans to provide digital pedagogy training to teachers.

Based on the emerging priority and progress made in the iSherig-1, the MoE developed its second Education ICT Masterplan, iSherig-2 (Write the years), to act as a road map while implementing Education in ICT in the 12th FYP. The major investments made are for providing adequate ICT infrastructure to all schools, curriculum development, and capacity development of teachers. All these investments are to be covered through the flagship programs funded by Project Tied Assistance (PTA) (MoE, 2019b).

Although the iSherig-1 Education ICT Master Plan was intended to provide digital pedagogy training to teachers but it could not be implemented due to the lack of teachers' professional standards and a dedicated coordinating body (MoE, 2014). MoE developed the Bhutan Professional Standards for Teachers (BPST) (MoE, 2019) keeping in line with the recommendation of the Bhutan Education Blueprint 2014-2024 and the National Education Policy. One of the focus areas of BPST is the Positive Use of ICT. The iSherig-2 Education ICT Master Plan (2019-2023) is implementing programs through concerted efforts to update the curriculum and upgrade infrastructure as per the changing ICT landscape. Equal priority is accorded to the capacity development of professionals delivering the curriculum and managing the ICT facilities and services.

CHAPTER 05: EQUITY AND INCLUSION IN EDUCATION

5.1 Attitudes and practices concerning equity and inclusion in education

The difference in the ability of students and accessibility of resources has a direct impact on the quality of education especially for learners with special educational needs. The quality of education received and resources made available determine the future of students. Catering for the diverse needs of students via the provision of appropriate and equitable resources in an enabling and learner friendly environment is imperative. Bhutanese students come from varying backgrounds including socio-economic status, special needs, gender, ethnicity, religious faith, geographical location, etc. Although the education system provides equal opportunities to all students irrespective of their backgrounds and abilities, it is also quite possible that a few categories of learners especially those with special needs could still miss a lot of educational opportunities because equal access to education does not address equity issues.

National education policy ensures opportunities that are equitable, fair, and accessible to all students. Clause 7.1 of this policy states, "All children of school-going age shall have equitable access and opportunity to free quality and inclusive basic education, as defined in the Constitution of the Kingdom of Bhutan" (MoE, 2019, p5). There is also a commitment to cater for the diverse needs of all students via curriculum, pedagogy, and assessment that are inclusive. This is also highlighted in Clause 9.1.10, which states that the curriculum and pedagogy shall be inclusive of gender, special educational needs, socio-economic circumstances, and geographic location. This is evident that the policy reassures the provision of a safe, supportive, inclusive, and learner-friendly environment that is conducive to holistic learning, intellectual engagement, and growth for all diverse learners.

The commitment of the Royal Government of Bhutan's (RGoB) to provide education to all by making it accessible without any forms of discrimination is explicitly pronounced in the Constitution of Bhutan (RGoB, 2008). Specifically, Articles 9.15 and 9.16 guarantee education as one of the fundamental rights. The BPST highlight the diversity of learners where teachers have to respond to diversity in the classroom. Teachers are expected to create settings that are suitably responsive to the learners' diverse needs (MoE, 2019).

There are 18 schools with Special Education Need (SEN) programs and two special institutes in Bhutan: Muenselling Institute in Khaling in Trashigang in the East and Wangsel Institute in Paro in the West. Muenselling Institute specialises in the provision of education for children with visual impairments, whereas Wangsel Institute provides specialised educational services for children with hearing impairment. In 2020, Drukpa (2021) reported that there were 777 students in 18 schools with SEN program and two special institutes. The schools with SEN programs assist students with mild to moderate disabilities. Students with mild to moderate learning disabilities are integrated into mainstream schools, whereas learning for students with severe needs and other categories of disabilities, such as those with visual and hearing challenges are offered facilities in Muenselling and Wangsel Institutes (MoE, 2020; Drukpa, 2014).

Since 2007, the ECCD and SEN Division of the MoE has been providing the expertise and mobilizing resources needed to improve the quality and reach of special education in Bhutan. Paro College of Education has started offering a two-year master's program in inclusive education for in-service teachers teaching students with special needs. Besides, the Royal Civil Service Commission sent teachers to other countries for pursuing masters in inclusive education through various scholarships to update their knowledge and practices. Bhutan has drafted a 10-year roadmap for inclusive and special education in 2019 with the vision to provide education to children with disabilities. According to the 10-year roadmap, the ECCD and SEN Division is mandated offer training programs on leadership in inclusive education for Principals. Schools with SEN programs will develop and deliver orientation programs for newly recruited teachers on inclusive education.

5.2 Inclusive access

Inclusive access to education in this study is understood at two levels. One where the school has the capacity for providing specialised inclusive education support services with required infrastructure and layout. Two, there is an inclusive education policy and teacher training programme.

During the COVID-19 pandemic period, when schools had to be suspended due to a series of lockdowns imposed to contain the rapid spread of coronavirus, teachers in schools with SEN programmes have depended on lessons telecasted by Bhutan

Broadcasting Service (BBS), an initiative adopted by the Ministry of Education. Other social media tools such as WeChat and phone have also been used to support and assist children with SEN and others affected by the lockdowns. In a few instances, schools and teachers have gone to the extent of making home visits to reach learning notes to the students and converted MP3s that suit individual learning needs of children with SEN. Teachers also had continued to develop individualised educational plan (IEP) to deliver lessons to ensure that the impact of COVID-19 pandemic on children with special needs were minimised. Students with special needs have also been able to learn from their homes with their family members' support wherever such support systems were available. Table 5.1 shows the school wise access to inclusive education.

Table 5. 1

School wise Access to Inclusive Education

School District		Name of the school	Inclusive Access
Thimphu	Thimphu Dzongkhag	Yangchen Gatshel MSS	Yes
		Kuzhugchen MSS	Yes
		Wangbama CS	No
		Khasadrapchu MSS	No
	Thimphu Throm	Babesa HSS	No
		Yangchenphu HSS	No
		Zilukha MSS	Yes
Zhemgang		Sonamthang CS	No
		Buli CS	Yes
Paro		Shari HSS	No
		Drukgyel CS	No
		Khangkhu	No
		Lamgong MSS	No
Tashigang		Gongthung MSS	No
		Dungtse CS	Yes
		Bartsham HSS	No
		Tashitse HSS	Yes
		Dungtse MSS	Yes

School District	Name of the school	Inclusive Access
Samtse	Yoeseltse MSS	Yes
	Peljorling HSS	No
	Gomtu HSS	Yes
	Tendruk CS	Yes
	Dorokha CS	No
	Samtse HSS	No
Total		10

The analysis of the principal survey questionnaire revealed that 10 out of 24 schools have access to inclusive education, as shown in Table 5.1. However, data analysis did not reveal the details of types of inclusive access available in the schools.

5.3 Education of children with SEN and marginalised socio-economic groups

During the COVID-19 lockdowns, students with SEN and other marginalised socio-economic groups primarily those situated in the far-flung remote communities without a reliable communication facilities including internet and television facilities were provided with self-instructional materials (SIM) with teacher visits to their homes for remedial learning support. For instance, C2a shared that 200 additional SIM materials were printed and made available to students who did not have television. He also said that 28 students were provided with MP3 speakers loaded with radio lessons. Similarly, C4 shared that the SIM was prepared and distributed to students who did not have access to internet facilities. it was further shared that this initiative has helped students who could not participate in online classes because of their parents' inability to buy smartphones.

Mobile classes were initiated to facilitate learning for students from class PP to III. One of the CDEOs (C2a) conducted a study in one of the urban areas of Bhutan and found that only 62% of parents provided academic support, such as helping children in completing assignments and homework activities. This study had revealed a little more than 8% of parents had not assisted their children.

Bhutanese students belong to different family backgrounds. One CDEO (C3) based in urban community expressed that students in the district come from different economic and family backgrounds. It was shared that many students had single parents, which adversely affected the quality of guidance and support received,

resulting in low academic performance. C4 added that students with special needs, coming from rural areas, and those with poor family backgrounds were affected more. Likewise, P3 pointed out other factors like poverty, distance from school, distractions in the town, lack of parental guidance, and family problems affect students' academic performance. P2a added that nutritional deficiency is an important factor contributing to low academic performance.

Table 5.2 shows the number of children with special needs and His Majesty's Kidu (Relief Support) students studying STEM.

Table 5. 2

Number of Special needs and Kidu Students Studying STEM

School district		Name of the school	Students with special needs		Kidu Students	
			Total	Taking STEM subjects	Total	Taking STEM subjects
Thimphu	Thimphu Dzongkhag	Kuzhugchen MSS	1	1	1	0
		Yangchen Gatshel MSS	36	36	12	12
		Wangbama CS	1	0	14	0
		Khasadrapchu MSS	17	17	5	5
	Thimphu Throm	Babesa HSS	0	0	7	7
		Zilukha MSS	0	0	13	0
		Yangchenphu HSS	1	1	5	3
Zhemgang		Sonamthang CS	0	0	21	12
		Buli CS	43	43	15	3
Paro		Drukgyel CS	3	0	16	6
		Khangkhu MSS	0		1	1
		Lamgong MSS	1		23	
Trashigang		Gongthung MSS	2	0	2	1
		Dungtse CS	37		2	
		Bartsham HSS	0	0	17	15

Samtse	Yoeseltse MSS			1	1
	Peljorling MSS	0	0	5	2
	Gomtu HSS	1	1	7	4
	Tendruk CS	79	56	16	10
	Dorokha CS	0	0	0	0
	Samtse HSS	0	0	0	0
	Total	222	155	183	82

*Blank indicates missing data

Table 5.2 shows 222 students with special needs out of which 155 students had opted to study STEM. There were 184 Kidu students, out of which 82 opted for STEM.

5.4 Initiatives for equity and inclusion in education

The Bhutan foundation started a special education program in 2008 in collaboration with Ministry of Education. The special education program increased the capacity of Bhutanese teacher to aid children with special needs and identified special educations schools. The program also established a US Special Education Advisory Committee. In same year, ministry of education drafted National Special Education policy for the country (Bhutan Foundation, 2008)

In 2017, UNICEF started a project titled 'A fair chance for every child in Bhutan' in collaboration with various stakeholders (UNICEF, 2018). One of the focus areas of the project was on strengthening the capacity of MoE and partners to provide inclusive education to the most marginalized children, through development and endorsement of Standards for Inclusive Education, modification of curriculum to suit the needs of children with disabilities (CWD), improvement of assessment systems and exchange of knowledge among practitioners of inclusive education. With UNICEF support, the Ministry of Education completed the first Knowledge, Attitude and Practices (KAP) study on CWD in Bhutan. The study confirmed that services for CWD have improved over the years, including in education and social services. However, it was found that there are significant knowledge gaps which lead to negative attitudes and lack of support for families with CWD. It is reported that this finding will inform the development of a comprehensive behaviour change communications strategy to address the challenges and gaps identified.

CHAPTER 06: STEM TEACHING AND LEARNING IN SECONDARY SCHOOLS

6.1 STEM education practices

Bhutan's emphasis in improving the quality of STEM education (REC, 2012), in particular since scientific knowledge and education, is critical for the development of any country. An overhaul of STEM curriculum, development of science laboratories, provision of equipment, and in-service training for teachers and laboratory assistants are some of the initiatives that are being undertaken. However, many students find it difficult to learn science and mathematics. For example, the Bhutan Council for School Examinations and Assessment (BCSEA, 2020) reported a mean scores of 46.8 in mathematics, 54.04 in physics, 54.88 in chemistry, and 50.67 in biology in the Class X high stakes national board examination. Mean scores of 64.18 in mathematics, 66.42 in physics, 66.15 in chemistry, and 69.18 in biology were reported in the Class XII board examination.

CL4STEM Project qualitative data mirror the lows academic performance of students in STEM. Students' performance in STEM was average in Thimphu (L2a, L2b), while it was reported below average in other Dzongkhags (L6, L1, L4). Result also indicated that economically disadvantaged and special needs students face more difficulties (A6, L3, L1, P2, C3, L6). Children with special needs, in particular those with visual impairment, have difficulty in STEM subjects, as they are unable to participate laboratory-based experiential learning (A6), which are visual in nature. Such challenges faced by this category of children get exacerbated when they come from families and homes where their parents are mostly uneducated and illiterate. As a result, these students hardly receive any motivation from their parents and community to focus and academically excel in STEM (L1) and pursue a dream and career related to STEM.

Teacher participants cited observations of students' lack of interest in STEM subjects (A2, L3, L1, P4, A5) and resource constraints to conduct practical classes (L1, P6, A2, L4) as some challenges that affect the effectiveness of STEM teaching and learning. Participants P3 and P6 alleged that students find it difficult to connect STEM concepts learned in the classroom to real situations. Lack of access to computers, poor net connectivity, and poor family background were also reported as challenges faced in learning STEM (L4, L1, P5).

The analysis of interview data revealed the schools making concerted efforts to help students perform better in STEM via interventions such as creating awareness through advocacy talk and constant reminding of constantly on the importance and future scope of studying STEM (P6, L1, A2); employing different teaching strategies (L2, L3 & A2); and equipping the science laboratories adequately (L3, P6 & P5). Participants reported schools in rural areas improvising laboratory equipment to facilitate the teaching of STEM subjects (L1). Data also showed the provision of remedial classes to help students weak in STEM (L2, L3 & L5).

6.2 Language

English and Dzongkha (Bhutan's national language) are the mediums of instruction in schools. Dzongkha is used in teaching Dzongkha as a subject, whereas English is used as a language of instruction to teach all other subjects across all levels of education. Though English is used in teaching right from pre-primary, children get to converse in English only in classrooms in most of the cases as most students come from rural areas and many have illiterate parents. The interview data revealed that some of the students have poor English language competency making it difficult for them to understand the concepts being taught in the classroom (L1). One of the Principals also expressed that teachers find it difficult to make concepts understandable to such students as it involves scientific procedures (P5). Hence, many teachers resort to explaining difficult concepts in the students' local language but this has other implications. Although such alternative approaches adopted by teachers help to make the teaching concepts clear to the students, the problem does not end there. Students still have to write their examinations and other modes of assessment in English language and the risk of performing poorly are still high for such students. Moreover, the use of alternative languages such as teaching in local languages is discouraged with the intention to improve students' English language proficiency. Explaining STEM concepts and terms is still a challenge as the local languages including Dzongkha, the national language does not always have an equivalent term to correctly explain scientific terms. Thus, Bhutanese students' English language

proficiency is seen as a potential barrier in the effective teaching and learning of STEM in secondary schools.

6.3 Curriculum

Schools in Bhutan follow a standardised common national curriculum. The Department of Curriculum and Professional Development (DCPD), earlier known as the Royal Education Council (REC), takes the burden of school curriculum development and is mandated to review, innovate, and keep the curriculum for school education current and relevant.

As per the old Science Curriculum Framework (REC, 2012), science learning experiences are organized into four strands based on process strand (Strand 1) and conceptual strands (Strands 2, 3, and 4) as reflected in Table 6.1. The four strands run across all classes.

Table 6. 1

Strand and Learning Experiences for STEM in Bhutan

Strand	Learning experiences
One	Working scientifically
Two	Life processes
Three	Materials and their properties
Four	Physical processes

In order to set the standards, the learning experiences are organized into five key stages as shown in Table 6.2. Each key stage is elaborated with learning outcomes for all strands.

Table 6. 2

Key Stages and Classes

Key stage	Classes
One	Classes PP-III
Two	Classes IV-VI
Three	Classes VI-VIII
Four	Classes IX-X
Five	Classes IX-XII

As per the old Mathematics Curriculum Framework (MoE, 2005), mathematics learning experiences are organized into seven strands (See Table 6.3)

Table 6. 3

Strand and Learning Experiences for Mathematics in Bhutan

Strand	Learning experiences
A	Numeration
B	Operations
C	Patterns and Relations
D	Measurement
E	Geometry
F	Data
G	Probability

Each of the strands is spread across the Key Stages: Classes III, VI, VIII, X, and XII.

A New Normal Curriculum (NNC) was initiated in 2021 by the erstwhile REC, now DCPD as an education in emergency curriculum during the COVID-19 pandemic period. The strands and key stages in science and mathematics are still retained in the new curriculum. The selection of topics for teaching is not flexible because a common curriculum is followed across schools (C3, C4, P5, P4, P2b).

6.4 Assessment

The NNC mandates science teachers to adopt five pedagogical practices to help students learn as personal and social enterprises. The pedagogical practices are:

i. Active hands-on learning
ii. Assessment for learning
iii. Classroom environment
iv. Effective use of ICT
v. Gender-sensitive

Teachers are also expected to use role-playing, games, simulations, talking, reading, writing, and experimentation to enhance students' learning.

Similar to science, the NNC mandates mathematics teachers to adopt the following pedagogical practices to achieve the expected competencies by students, as they complete their school education.

i. Establishing a safe and positive learning environment
ii. Designing lessons that focus on knowledge construction and transfer

iii. Making provisions for mathematical connections, representations, and communication
iv. Encouraging divergent thinking
v. Encouraging differentiated instruction, design thinking, inquiry-based learning, etc.
vi. Encouraging reflective practices
vii. Embedding assessment and feedback into the lesson
viii. Adopting competency-based education and learning approaches, location-based education approaches, pedagogies for developing and advanc ing 21st-century skills, blended learning approaches to use both face-to- face teaching as well as electronic and online media.

The Lead Teachers and Academic Heads who participated in this study reported of a variety of pedagogical practices adopted by teachers in teaching to enhance students' learning. Some of the examples are as follows:

i. Demonstration, problem-solving, and lecture method (L4)
ii. Active learning practices, such as concept mapping, flipped classrooms, and peer instruction practices (L3)
iii. Project-based experiments (L2b)
iv. Experiential learning, activity-based learning, demonstration, 5E model,
scientific inquiry methods and differentiated instruction (A2a)
v. Inductive, deductive, project method, demonstration, activity-based method, questioning, problem-solving, and creative teaching method (A2b)
vi. Inquiry-based learning, reflective learning, integrative learning, collabrative learning, and constructivist learning (A5)

6.5 Assessment

Assessment of a STEM subject in school has two components i.e., continuous assessment (CA) and summative assessment (SA). Table 6.4. shows the old weighting for each of these assessment components.

Table 6. 4

Old Assessment Framework

Curriculum	Subjects	Classes	CA (%)	SA (%)	Remarks
Old	Physics, Chemistry, Biology	IX	20%	80%	SA is Board Exam
		X	20%	80%	
		XI	20%	80%	
		XII		100%	
	Mathematics	IX	30%	70%	
		X	30%	70%	
		XI	40%	60%	
		XII		100%	

The assessment in the NNC for science and mathematics is reflected in Table 6.5 and Table 6.6.

Table 6. 5

Science Assessment Practice

Subject	Key stage	Assessment						CA weighting and Breakup for Each Term
		Term I			Term II			
		CA	Mid Term Exam	Total	CA	Mid Term Exam	Total	
Science	II	35	15	50	35	15	50	Term I: CA breakup: Assignment = 8, Class Activity=13, Test=4, Project=6, Scrap=4
								Term II: CA breakup: Assignment = 8, Class Activity=13, Test=4, Project=6, Scrap=4
	III	30	20	50	30	20	50	Term I: CA breakup: Assignment = 8, Class Activity=12, Test=2, Project=4, Journal=4
								Term II: CA breakup: Assignment = 8, Class Activity=12, Test=2, Project=4, Journal=4
	IV	20	30	50	20	30	50	Term I: CA breakup: Assignment = 6, Class Activity=8, Test=2, Pro-ject=4
								Term II: CA breakup: Assignment = 6, Class Activity=8, Test=2, Pro-ject=4
	V	15	35	50	15	35	50	Term I: CA breakup: Assignment = 4, Class Activity=5, Project=3, Practical=3
								Term II: CA breakup: Assignment = 4, Class Activity=5, Project=3, Practical=3

Note: CFA means continuous formative assessment

Table 6. 6

Mathematics Assessment Practice

Subject	Key stage	Assessment						CA weighting and breakup for each Term
		Term I			Term II			
		CA	Mid Term Exam	Total	CA	Mid Term Exam	Total	
		CFA			CFA			
Mathematics	II	35	10	40	30	30	60	For both Term I and Term II assess each competency through appropriate performance tasks and assessment tools
	III	20	25	45	20	35	55	Performance Tasks: Quiz, question and answer, presentation, making models, small projects, etc. Assessment Tools: Checklist, rating scale or rubrics.
	IV	15	35	50	15	35	50	Assessment Areas: Formulating situations mathematically. Applying concepts, facts and procedures, and interpreting mathematical results
	V	10	40	50	10	40	50	Obtain CA marks using the relation given in the curriculum framework and the instructional guide

6.6 Academic calendar and assignment of teaching responsibilities

The school curriculum is expected to be delivered in 180 instructional days totaling 1080 hours in an academic year. For instructional hours, English, Dzongkha, and Mathematics are given more time than Science and Humanities in Middle Secondary Schools (MoE, 2014). All teachers are engaged in professional duties from 8.20 am to 3.40 pm, including one-hour lunch break and 30 minutes recess. Some teachers are engaged in co-curricular programs that are conducted regularly besides teaching. Teachers in boarding schools have additional responsibilities than teachers in day school (Kaka, 2017).

Regarding school timing, instructional days, and time per subject, all schools follow the same opening, examination, vacation, and closing time in an academic year, except for a few schools in higher altitudes. The academic session happens in two terms. The first term is from mid-February to June end. The second term is from the first week of August to November end. However, schools situated in the extreme north remain open only from April to September.

Table 6.7 shows the average individual teacher time spent in classroom teaching, planning, assessing students' assignments, and administrative activities (co-curricular) or parent-teacher meetings.

Table 6. 7

Dzongkhag wise STEM Teacher's Time spent on Activities

Dzongkhag		Hours spent in:		
		Classroom teaching	Planning, teaching, and assessing students' assignments	Administrative activities / Parent meetings
Thimphu	Thimphu Dzongkha	18.4	18.6	6.07
	Thimphu Throm	18.4	43.8	16.8
Zhemgang		16.3	10.4	3.6
Paro		16	22.5	3.83
Tashigang		18.16	13.85	3.98
Samtse		19.3	18.2	4.6

Table 6.7 indicates that urban teachers especially Thimphu Throm spent more hours

(43 in a week) in planning, teaching, and assessing students' assignments when compared to other Dzongkhag teachers. Other Dzongkhag teachers spent around 10-18 hours on an average. Besides teaching, STEM teachers spent 3-16 hours a week on administrative activities, such as parent-teacher meetings and co-curricular activities. According to the principals, individual STEM teachers spent an average of 16-19 hours per week in classroom teaching.

6.7 Teacher proficiency in STEM education

This section presents a discussion of related to proficiency of STEM teachers in terms of their competencies, training and ongoing support, learning infrastructure and resources, and STEM education initiatives.

6.7.1 Teaching experience and teacher qualification

Table 6.8 shows the number and percentage of STEM teachers teaching different STEM subjects in the participating schools. It is to be noted that some teachers would be teaching more than one subject as all teachers with B. Ed and most teachers with PGCE/PgDE would have specialised in two subjects during their pre-service teacher training.

Table 6. 8

Percentage of Teachers Teaching STEM Subjects

Subject taught	Number of Teachers	Number of Teachers (%)
Mathematics	47	28.7
Physics	40	24.4
Chemistry	45	27.4
Biology	48	29.3
General Science	48	29.3

The three science subjects namely Physics, Chemistry and Biology are taught as a single subject from Classes IV to VIII. It is named as General Science. The bifurcated science is taught from Class IX onwards.

The teaching experience of STEM teachers in five Dzongkhags is as reflected in Table 6.9. For instance, more than 50% of the respondents have taught STEM subjects for more than ten years, followed by 29% with a teaching experience between 5 and 10 years, and 19% with less than 5 years.

Table 6. 9

Number of years of Teaching STEM Subjects

Number of years	Number of Teachers	% of Teachers
Less than 5 years	32	19.4
5 to 10 years	48	29.1
More than 10 years	85	51.5

Teaching experience of STEM teachers in the participating schools suggest that the majority of teachers have more than a decade of experience in teaching in school.

Table 6. 10

STEM Teachers' Professional Qualification

Qualification	Number of Teachers	% Of Teachers
B. Ed	68	41.2
PgDE/PGCE	51	30.9
M. Ed	31	18.8
PhD	1	0.6

Professional qualification of STEM teachers in the participating schools is as given in Table 6.9. While some STEM teachers have a Master's Degree in Education (M. Ed), a large majority (72%) have taught with the first initial pre-service teacher education qualification i.e., B. Ed and PgDE/PGCE, which are pre-service teacher education programmes offered at SCE. If concerns and issues related to STEM education need to be addressed, it will be important to review the educational/professional qualifications of STEM teachers in the school system. Opportunities to upgrade STEM teachers' qualification with a focus on both professional (M. Ed) and academic content focus (MSc) might serve well in the long run.

Table 6. 11

Dzongkhag wise Number of Teachers with Qualification and Teaching Experience

Dzongkhag		Qualification				Teaching Experience (yrs)		
		B. Ed	PgDE/ PgCE	M. Ed	PhD	< 5	5-10	> 10
Thimphu	Thimphu Dzongkhag	5	3	9	1	0	5	11
	Thimphu Throm	15	12	3	0	2	15	22
Zhemgang		4	8	3	0	5	10	1
Paro		3	4	2	0	0	2	10
Trashigang		13	8	5	0	9	5	15
Samtse		28	16	9	0	16	11	26

Survey data reveals that NQTs (less than 5 years) are fewer in schools in some Dzongkhags. For instance, Thimphu and Paro Dzongkhags have zero NQTs, whereas Samtse has a maximum of 16 NQTs, as shown in Table 6.11. This difference in the number of STEM NQTs in Thimphu in particular maybe because of the Ministry of Education's teacher deployment policy of sending NQTs to other Dzongkhags and remote schools for the initial placement. This is done to also avoid teacher congestion and concentration of teachers in urban schools such as Thimphu, which becomes the choice of many teachers for variety of reasons.

In terms of years of teaching experience, Samtse Dzongkhag has more teachers with teaching experience of more than ten years (26), followed by Thimphu Throm and Trashigang with 22 and 15 years, respectively. Zhemgang has only one teacher with teaching experience of more than 10 years. The reason why Samtse has the highest number of teachers with teaching experience of more than 10 years probably could be attributed to the geographical location of the Dzongkhag, which shares its border with the State of West Bengal and its proximity to Siliguri, one of the popular shopping and destination for business for the Bhutanese. Especially during the pre- COVID-19 pandemic period, for the Bhutanese living in Samtse, Siliguri is the most desired shopping destination and place for family weekends considering the availability of multiple high-end shopping complexes and access to cheaper and affordable items of varying sorts.

6.7.2 Teacher training and ongoing support

Opportunities to attend and participate in regular ongoing professional development programmes are critical to enable teachers to continuously update their academic content knowledge and enhance pedagogical practices. Survey data from the teachers of five Dzongkhags indicated that the status of PDs attended by teachers from 2018-2020 is less than the required number of 80 hours, mandated by the Ministry of Education. Table 6.12 shows this clearly. Only 3% of the school teachers have attended PD for 80 hours. This is far from the Ministry's mandate.

Table 6. 12

Percentage of Teachers who Attended PD on STEM (2018-2020)

Hours of PD attended in a Year	% of STEM teachers who had attended PDs		
	2018	2019	2020
80 hours and above	3	3.6	3.6
At least 1	13.9	15.8	16.4
Not Attended any	86.1	84.2	83.6

Analysis of the Dzongkhag wise PD programs attended by teachers in the last three years (2018 2020) reveal that teachers in Thimphu and Paro had more opportunities to attend PD when compared to teachers in other Dzongkhags. For instance, for the last three years, teachers from Thimphu and Paro have attended an average of 15 hours and 10 hours of PD respectively, when compared to other Dzongkhags (See Table 6.13). Zhemgang Dzongkhag has the least average number of hours of PD attended by teachers.

The greater opportunities that STEM teachers of Thimphu and Paro seem to have had in attending PD compared to other Dzongkhags could possibly be due to their proximity to the headquarters of the Ministry of Education, other government and non-governmental organisations, and easy access to business entities that provide PDs and refresher courses. For instance, it is quite understandable that STEM teachers in Zhemgang had the least PD attendance because Zhemgang is one of the remotest and least developed Dzongkhags in the country.

Table 6.13

Number and hours of PD Attended by STEM Teachers (2018-2020)

Dzongkhag		2018		2019		2020		Average number of PD	Average hours of PD
		No. of PD	Hours of PD	No. of PD	Hours of PD	No. of PD	Hours of PD		
Thim-phu	Thimphu Dzongkhag	0.38	5.63	1.00	13.38	1.31	26.00	0.90	15.20
	Thimphu Throm	0.31	8.03	0.36	7.33	0.36	7.15	0.34	7.50
Zhemgang		0.06	1.25	0.06	1.25	0.13	0.69	0.08	1.06
Paro		0.58	10.67	0.50	6.67	0.83	12.17	0.64	10.00
Trashigang		0.34	1.90	0.52	1.72	0.31	4.28	0.39	2.63
Samtse		0.36	6.85	0.38	8.49	0.17	2.17	0.3	5.84

6.7.3 STEM education learning infrastructure and resources

Effective teaching and learning of STEM involve observing, handling, and manipulating real objects and materials. Several scientific theories and concepts are difficult for the teachers to explain directly from the books. For the students, the theory learnt in classrooms may not be easily understandable unless they observe and execute the process practically. Students must get a first-hand learning experience by performing various experiments on their own or with guidance from their teachers. Therefore, schools must have adequate infrastructure to make STEM learning hands-on and experiential to make learning more durable and long lasting. Infrastructure facilities that support laboratory or experiments-based learning also make learning interesting and effective for students. It also encourages and motivates them to develop a scientific mindset to learn with a strong sense of scientific discovery and inquiry. Infrastructure facilities such as well equipped science laboratories and well-resourced library with adequate collection of textbooks and supplementary reading and learning materials are sine qua non – an absolute necessity to advance STEM learning in school.

Survey data of School Principals revealed that most of the participating schools had functional STEM laboratory and library as reflected in Table 6.14.

Table 6. 14

Dzongkhag wise Functional Laboratories

Dzongkhag		Number of functional laboratories				
		Physics	Chemistry	Biology	Library	Mathematics
Thimphu	Thimphu Dzongkhag (n=4)	3	4	4	4	1
	Thimphu Throm (n=3)	3	3	3	3	0
Zhemgang (n=2)		2	2	1	2	0
Paro (n=4)		4	4	4	4	0
Trashigang (n=5)		5	4	4	5	0
Samtse (n=6)		5	5	6	6	0

*n represents the number of schools

Table 6.14 shows that all schools from Paro and Thimphu Throm have functional science laboratories, while other schools lack one or more functional laboratories. Except for one school in Thimphu Dzongkhag, no other participating schools had a mathematics laboratory. Qualitative data confirmed that the participating schools in Paro Dzongkhag had separate laboratories for Biology, Physics, and Chemistry (C3). Interview participants of other schools opined that despite the availability of science laboratories, budget provision was required to replenish laboratory chemicals, equipment, and consumables on a timely basis which was lacking at present (A2B, P4 & A5). There were reports and instances where teachers sometimes had to improvise resources themselves (A1, A2a).

All participating schools reported having adequate facilities and well-furnished libraries. They also use guidebooks, reference books, past question papers, and instructional guidelines (A2b). The participants reported the use of online resources to support teaching (A2a, C3, A2b).

6.7.4 STEM education initiatives

In pursuit of developing STEM education, MoE initiated a number of activities such as overhauling the science and mathematics curriculum, upgrading the qualification of STEM teachers to the masters' level, organizing STEM Olympiad, etc. The National STEM Olympiad is aimed to improve the quality of STEM education. It is expected to spark students' interest in STEM-related areas, instill positive attitude and values, and provide recognition for outstanding achievement in STEM education. STEM Olympiad is a competition that consists of team events and individual scholastic works, which students and teachers prepare on a given theme. These challenging and motivational events are well balanced among the various disciplines of Science, Technology, Engineering, and Mathematics (REC, 2019). STEM Olympiad is organised by the curriculum division of the Ministry of Education once annually. The National STEM Olympiad held at Paro 2019 was organised on the theme Artificial Intelligence for Sustainable Farming.

The importance of STEM education is echoed in the Education Blueprint 2014-2024. It mentions that students with deep knowledge and understanding of STEM will succeed in higher education or function effectively in a competitive economy (M0E, 2014). Recognising STEM as the future of the country, the Royal Society for STEM, which is an office under His Majesty's Secretariat, has been established to strengthen Bhutan's participation in scientific and technological innovations.

CHAPTER 07: READINESS OF SCE TO TAKE CL4STEM PROJECT FORWARD

7.1 SCE - CL4STEM synergies

The Royal University of Bhutan consists of ten colleges spread across the country. Samtse College of Education is one of them. RUB provides tertiary education in Bhutan. Its vision is to be an internationally recognised university steeped in GNH values. The mission of RUB is to:

a) Provide relevant and good quality study programs at the ter tiary education level, which will fulfil the country's needs for an educated, skilled, and humane population;

b) Promoteandconductresearchtocreaterelevantknowledgefor students of Bhutan; and

c) Provide training and professional services for the enhance ment knowledge, capacity building, and community devel opment.

The programs and activities developed and offered are based on the university's core values, which include: creativity and innovation, community services, and professionalism. As a constituent college of RUB, SCE beside training secondary school teachers is also expected to continually offer relevant PD to enhance school teachers' pedagogical and content knowledge.

The overarching aim of the CL4STEM project is to strengthen STEM education globally by building capacities of middle and higher secondary schools' Newly Qualified Teachers (NQTs) in science and mathematics. This is achieved by fostering higher-order learning in classrooms where no child is left behind. The STEM faculty of SCE are engaged in developing Open Educational Resources (OERs) in STEM discipline that are aligned to achieve the aim of the CL4STEM, which is in synchrony with RUB's vision to provide professional services for the enhancement of knowledge, capacity building, and community development and Bhutan's current emphasis in the improving the standard of STEM education.

The College also has a good pool of experienced STEM faculty. All STEM faculty have more than five years of teaching experience. They have the experience of developing curriculum for STEM education both in teacher education and school STEM curriculum. SCE has 5 STEM faculty with PhD qualifications in different subject backgrounds that might serve as a strength in the successful implementation of the CL4STEM project.

7.2 ICT preparedness

STEM faculty of SCE integrates various ICT tools like Camtasia, Jamboard, Mentimeter, Poll everywhere, Slido, etc., in teaching, learning, and assessment. They use Moodle, an online learning management system known as VLE, in sharing, teaching, and learning resources, uploading reading materials, preparing lessons, conducting quizzes, discussing collaboratively on forums, assessing peers through workshops, designing interactive PowerPoint, and preparing interactive video using H5P.

Faculty competencies to integrate ICT in teaching and learning processes vary from individual to individual. Some STEM faculty members have an advanced knowledge and skills in integrating ICT in teaching, learning, and assessment. They even facilitate in-house PD on ICT tools, such as the use of Jamboard, Padlet, Slido, and online quizzes in the College. Some of the STEM faculty have attended a weeklong training program on advanced python. The College has two ICT faculty members providing technical support in the CL4STEM project.

The College also provides various professional development training on ICT for school teachers whenever possible. The STEM Education Research Centre at SCE organized a webinar titled "The Promise of ICT-izing Education: Making Online Teaching and Learning Engaging, Interactive, and Immersive" where two senior teacher educators shared their knowledge and expertise of using a variety of digital tools and platforms for teaching, learning, and assessing to support online or remote learning during the COVID-19 pandemic period when schools across the country were closed.

7.3 Professional development of STEM teacher educators

The College organises a series of in-house PD for the STEM faculty similar to other faculty members for continuous professional development. The PD facilitators are either experts within or from outside the College. Although a mix of in-house and ex-country PD would have been desirable, opportunities for ex-country PD programmes

are a rare opportunity considering the limited budget available to support such capacity development initiatives. Any ex-country faculty capacity building activities if at all available are primarily funded through projects that are externally funded. Given this limited opportunities of ex-country PD, the College over the COVID-19 pandemic period had initiated webinars and virtual PDs with academics, teacher educators, researchers and scholars from reputed institutions abroad in different disciplines including STEM. Recently, many STEM faculty members in the College have completed a certificate course on place-based education organized by Teton Science School in Wyoming, Colorado in the United States of America.

The College also encourages teacher educators in the College to enroll in free courses on Coursera, Udemy, Udacity related to their subject of specialisations whenever possible and also use online resources such as Khan Academy, Wolfram Alpha, and other available online resources freely available. For instance, beginning from the 2022 Autumn Semester, the College has made it mandatory for all faculty members to enroll in one freely available online course related to their respective subjects of specialisation to model continuous professional learning and development.

7.4 Technology readiness to offer NQT online modules

The CL4STEM team of SCE is well coordinated and determined to take the project activities forward. The team headed by the President, country project coordinator, has formed different working teams with Research Team Leaders for different research activities and Subject Leaders to lead the development of OERs and their implementation in the participating schools.

Samtse College of Education has an added advantage in terms of online teaching, learning, and assessment because all STEM teacher educators have experience in developing curriculum at both College and school levels. In addition, STEM educators at SCE have a good experience of conducting online or virtual classes because of their prior experience of using Moodle as the LMS, popularly known as VLE across all colleges of RUB. Most of the STEM faculty members are confident of using VLE features like resources, uploading, making lessons, conducting quizzes, discussing collaboratively on the forum, assessing peers through a workshop, designing interactive PowerPoint, and preparing interactive video using H5P. They also participated in an in-house PD organised by the College on ICT tools like Jamboard, H5P, workshop, Slido, etc.

Physics and Biology have a faculty with advanced knowledge, skills, and practical experience of using ICT in the class. Such expertise within the group will help the team to design the module using ICT. Mathematics and Chemistry do not have ICT experts. However, the College has a strong ICT team that can design OERs for online classes. The two ICT faculty will help all STEM faculty, but some of them are especially designated to support the Mathematics and Chemistry groups.

The project team from Tata Institute of Social Science (TISS) in Mumbai, India has introduced the STEM faculty of SCE on how OERs are developed and implemented over a period of more than three months. Further, they provided a five day 'Universal Design for Learning' workshop. This workshop enhanced the knowledge and skills of the STEM faculty at SCE to design OERs by incorporating ICT tools in teaching, learning, and assessment. Further, the TISS team is closely working with each subject discipline to develop the OERs. SCE has the capacity and capability to implement the OERs.

7.5 Relationships with stakeholders

SCE, a teacher education college that used to be under the administration of the Ministry of Education, has a well-established partnership with various stakeholders under Ministry of Education who are directly or indirectly involved in the implementation of the CL4STEM project.

The Ministry of Education and the schools are the key stakeholders that SCE will need to work closely with for a successful implementation of the CL4STEM Project activities and future scalability of this project. Besides the common educational vision and mission that guides SCE and the stakeholders in the development of STEM education and the general education system in the country, the following are some of the special advantages we see for this project:

- The Director General of the Department of School Education, who is also serving as the Officiating Secretary of MoE has been providing an uncondi tional support in granting the approval to undertake the need analysis of this project and implement other activities of this project in the participat ing schools.

- Most of the secondary teachers, Principals, and CDEOs currently serving in the schools and Dzongkhags in Bhutan are graduates of SCE and they have been always supportive of any initiatives we have taken so far.
- One of the STEM faculty at SCE is a member of the Science Subject Com mittee responsible for developing, reviewing, and studying the relevance and effectiveness of science curriculum across the whole education system in the country. Many STEM faculty in the College somehow get actively in volved in anything related to STEM curriculum development in the country. The President of SCE is a member of the Teacher Education Development Board (TEDB) and Curriculum Technical Advisory Board (CTAB) of the MoE and also shares an excellent professional and personal working rapport with all agencies at MoE.

CHAPTER 08: RECOMMENDATION FOR INTERVENTION

8.1 CL4STEM in Bhutan: A SWOT analysis

The conclusion from the findings is presented in the form of Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis.

8.1.1 Strengths

The strengths, weaknesses, opportunities, and threats are presented in relation to SCE's relation to the key stakeholders that will be involved in this CL4STEM Project.

Samtse College of Education

Policy level support at the government level and the recognition of the importance of technology-enhanced educational practices

- The Royal Decree for Reform in Education with a special emphasis on improving ICT facilities to align with a 21st-century education
- Support from MoE, CDEOs, Principals and teachers
- ICT technical experts both at the college and university level
- RUB's emphasis on prioritising technology as a primary tool for teaching, learning and assessment in preparing teachers for the system
- Good working relation with stakeholders who are directly or indirectly related to CL4STEM project implementation

  STEM faculty at SCE have:

  - prior experience of developing STEM and other general education curriculum development both at the college and school level including textbook writing for school curriculum
  - required qualification with many years of teaching experience in respective subjects
  - experience in offering online teaching
  - ICT knowledge to model technology-enhanced teaching, learning and assessment practices
  - undertaken numerous ICT related PD to enhance teaching, learning, and assessment
  - experience in organising and facilitating PD, workshops, and training at the school, college, and national levels School

- Most of the secondary teachers, principals, and CDEOs currently serving in the schools are graduates of SCE
- English is one of the medium of instruction and the issue of having to translate the training materials into local languages will not be required unlike in other countries where English is not the primary medium of in struction in schools
- Students with mild to moderate learning disabilities are integrated into mainstream schools
- All the teachers have a teaching qualification
- Majority of teachers either own personal laptops and smartphone or have access to computer facilities in the school
- Increasing number of teachers in schools use CT devices in teaching
- Teachers use social media apps such as WeChat, WhatsApp, Telegram, etc. for communication and for teaching and learning, which could also be used for building communities of practice (CoP) for professional ex changes, sharing of resources, etc.
- Schools enjoy a good community feeling without any major issues of exclusion in terms of gender, LGBT, and regional differences.

8.1.2 Weaknesses

Samtse College of Education

- Some faculty may need support in ICT knowledge on customisation of simu-lation
- Faculty lack prior knowledge in developing OERs
- Faculty time management skills and inability to prioritise tasks could pose challenges

School

- Many school teachers and students have minimal ICT knowledge
- Most schools lack resources (devices, software)
- Teachers are mostly overworked because of multitasking responsi bilities in addition to teaching
- Some school students have no access to smart phones while a good number as minimal access
- Not all teachers are competent and knowledgeable in using ICT in their professional practice

- Opportunities for capacity development on ICT and STEM is minimal
- English as the primary medium of instruction although not an issue in general, still poses a challenge in students' learning
- Lack of reliable official database regarding the actual population of learners with special needs and the categories of educational services provided
- Schools follow a 45-60 minute teaching period system. This may have an implication on carrying out STEM activities that may require more than an hour to complete. Schools follow prescribed syllabus, which tend to make the teachers believe that the curriculum is rigid and inflexible although a lot of innovation and creativity can still be introduced via the kind of pedagogy and instructional methods adopted.

8.1.3 Opportunities

- Strengthening collaboration and linkages with schools and other stake holders
- TISS expertise in developing and offering OERs
- Support from principals and teachers in the implementation of project activities
- STEM faculty and teachers' capacity development in using ICT integrated teaching, learning, and assessment through the use of OERs
- Strengthening collaboration and professional relationships between SCE STEM faculty and school STEM teachers
- Developing STEM Community of Practices (CoPs) amongst STEM teacher educators and STEM teachers in schools for professional support and sharing of good practices
- Building new institutional linkages with partner institutions outside Bhutan to improve the quality and standard of STEM education in Bhutan
- Knowledge enhancement via joint collaborative research with partner institutions outside Bhutan in areas of the integration of ICT in STEM teaching Publication of research reports to inform the government of the day for formulation of new policies and decisions based on empirical research evidence
- Increased emphasis and priority in making investments for the promotion of technology-enabled educational practices in the Bhutanese education system

8.1.4 Threats

ICT infrastructure and connectivity especially in schools

- COVID-19 situation (frequent lockdowns) and movement restrictions
- Commitment of school teachers and school principals in implementing the OERs due to other competing priorities in school such as the activities related to the nationwide education reform that has just been initiated
- STEM laboratory resources in the schools which are mostly ill-resourced and under-equipped
- Deployment of STEM NQTs in all schools are not balanced, which might affect the selection of schools for participation in this project which need schools with STEM NQTs.

8.2 Recommendations

The recommendations suggested here are in connection to the implementation of the CL4STEM project activities only and should not be seen as recommendations to address the issues or problems related to STEM education in general. With this understanding, the scope of the recommendations proposed has been intentionally kept narrow and focused to fit within the scope of this project. The recommendation for intervention is based on the SWOT analysis carried out as a result of the situational analysis and they are as follows:

- Support from school principals will need to be sought to let teachers make some timetable arrangement to accommodate the intervention plans in the class.
- The number of NQTs is very less in the five Dzongkhag schools. In view of this, it is suggested that teachers with more than five years teaching experience be included in the intervention phase of implementing the innovation.
- Schools will need to explore and mobilise resources to make specific laboratory equipment and apparatus required for the interventions available for teachers and students so that the project activities are implement ed successfully making the desired impact in students' learning outcomes.
- Internet connectivity is an issue across many schools. The CL4STEM project at the College might have to explore the possibility of providing

data package to teachers so that the teachers' participation in this project do not cost them financially.

- Schools follow a prescribed curriculum based on a centralized national curriculum where teachers often are conscious and concerned of covering the given syllabus within a stipulated time. Therefore, interventions planned in the form of modules will need to be aligned and finetuned to fit the school curriculum.
- Some teacher may need awareness and support about ICT and STEM related content. Therefore, some plans towards this additional support may be considered in advance.
- The PISA-D 2017 reported the weaknesses of STEM students (BCSEA, 2019). In mathematics, they had difficulty in formulating situations mathematically, and solving tasks related to content area. In science, they faced challenges in interpretation of data. Further, in the participating schools, students' performance in STEM disciplines from 2018 to 2020 is just above average (Table 3.6 of Chapter 3). Hence, in the designing and implementation of OERs, additional support especially in the areas identified may have to be considered.
- Students ICT knowledge and access to ICT equipment may need to be considered as the computer laboratories in many schools are not well resourced.
- School teachers and SCE STEM faculty time may need to be considered as they will have their own share of usual teaching workload in the school and College. Some ways of compensating their time devoted to this project may be useful.
- Suggest for some contingency plans to ensure that the project activities are not affected if COVID-19 pandemic continues because the project is a timebound project with budget to support only activities that have been initially approved by the funding agency.

- Many schools in Bhutan have a school level policy that forbids students to carry their phones to school. When the whole world makes conscious efforts to harness and optimize the benefit of technology to enhance the quality and effectiveness of education, such regulations can have conflicting effect on the government's aspiration and vision of promoting

technology/ICT enabled teaching, learning, and assessment practices in the education system. The efficiency and effectiveness of the successful implementation of the CL4STEM Project activities that aim to primarily integrate ICT into teaching of STEM subjects could face some setbacks due to such regulations in school. Therefore, it is suggested that the Ministry of Education review such practices to avoid any contradictions between policy initiatives (i-Sherig I & II) and practical realities in the school setting.

8.3 Conclusion

The implementation of CL4STEM project activities is in line with the Royal Decree for Reform in Education where emphasis is also placed on using ICT facilities to support teaching-learning. The whole education fraternity in Bhutan recognise the importance of technology-enhanced educational practices and hence the unwavering support for CL4STEM project activities at the policy level as well as the implementation level. At the college level, Samtse College of Education with support from TISS expertise has the capacity to provide professional support and share good practices with STEM teachers in schools especially in technology supported teaching learning practices. Hence, the Connected Learning Initiative (CLIx) as an innovative STEM teaching practice in Bhutanese schools is seen as a worthwhile initiative to enhance STEM learning thereby leading to achieving the Bhutan's national vision of realizing a GNH state.

References

Alazam, A., Bakar, R., Hamzah, R., Asmiran, S. (2021). Teachers' ICT skills and ICT in tegration in the classroom: The case of vocational and technical teachers in Malaysia. *Scientific Research Publishing*, 3 (8), 70-76. DOI: 10.4236/ ce.2012.38B016

Bhutan Council for School Examinations and Assessment. (2019). *Pu pil performance report 2019*. https://www.bcsea.bt/uploads/publications/ PPR%22019_1626325664.pdf

Bhutan Council for School Examinations and Assessment. (2020). *Pupil peformance report 2020*. https://www.bcsea.bt/uploads/publications/PPR%20 2020_1626324345pdf

Bhutan Council for School Examinations and Assessment. (2021). Pupil peformance report 2021. https://www.bcsea.bt/uploads/publications/PPR%20 2021_1626324248.pdf

Bhutan Canada Foundation. (2021). *Politics and education policy.* https:// bhutancanada.org/politics-and-education-policy/

Bhutan Council for School Examinations and Assessment. (2019). *Education in Bhu tan findings from Bhutan's experience in PISA for development.* http://www. education.gov.bt/wp-content/downloads/publications/other/Bhutan-PI SA-D-National-Report.pdf

Bhutan Council for School Examinations and Assessment. (2021). Pupil perfor mance report. School Examination Division. Thimphu.

Bhutan Special Education Foundation. (2009). Special education needs schools. http://bhutansped.org/projects/sen-schools/

Creswell, J. W. (2019). *Qualitative, quantitative, and mixed methods approaches*. New Delhi.

Drukpa, U. (2021). *1,800 class X-pass students to enroll in private schools of their choice*. https://thebhutanese.bt/1800-class-x-pass-students-to-enroll-in-privat-schools-of-their-choice/

Dorji, J. (2005). *Quality of education in Bhutan*: The story of growth and change in the Bhutanese education system. Thimphu.

Gelmo, D. (2020). The third pole. https://www.thethirdpole.net/en/livelihoods/pho to-story-abandoned-houses-haunt-rural-bhutan/

Gross National Happiness Commission. (2016). Guidelines for preparation of the 12th five-year plan. https://www.gnhc.gov.bt/en/wp-content/up loads/2017/05/Finalized-Guideline.pdf

Kaka (2017). *Teacher workload in Bhutan: An analysis and proposal*. https://www. researchgate.net/profile/Kaka-Kaka-3

Ministry of Education. (n.d.). *Standards for inclusive education.* Thimphu. http:// www.education.gov.bt/wp-content/downloads/publications/publication/ Standards-for-Inclusive-Education-in-Bhutan.pdf

Ministry of Education. (2014). *Bhutan education blueprint.* Thimphu. https://www. globalpartnership.org/sites/default/files/bhutan_education_blue print_2014-2024.pdf

Ministry of Education. (2019). *National education policy.* Thimphu. http://www. education.gov.bt/wp-content/downloads/publications/publication/ National%20Education%20Policy%202019%20(Draft).pdf

Ministry of Education. (2014). *isherig-1 education ICT master plan*. Thimphu. https://tinyurl.com/ybhv4vzu

Ministry of Education (MoE). (2014). *Education blueprint 2014-2024*. https://www. globalpartnership.org/sites/default/files/bhutan_education_blue print_2014-2024.pdf

Ministry of Education (MoE). (2019). Bhutan professional standard for teachers. https://tinyurl.com/3humxte3

Ministry of Education. (2019). *Ten-year roadmap for inclusive and special education in Bhutan.* https://education-profiles.org/sites/default/files/2020-03/Ten%20Year%20Roadmap%20for%20Inclusive%20and%20Special%20Education%20in%20Bhutan.pdf

Ministry of Education. (2019a). i*sherig-2 education ICT master plan*. Thimphu. https://tinyurl.com/5nd9j35z

Ministry of Education. (2019b). Transforming ICT in education for future blueprint of education ICT flagship programme. Thimphu. https://tinyurl.com/bum f4zbm

National Statistics Bureau. (2018). *Statistical yearbook of Bhutan*. Thimphu Bhutan.

National Statistics Bureau. (2020). *Statistical yearbook of Bhutan.* Thimphu Bhutan.

Palden T. (2019). T*he long walk to school. Kuensel – Bhutan's National Newspaper*. https://kuenselonline.com/the-long-walk-to-school/

Royal Education Council. (2021) *National science curriculum framework.* https://rec.gov.bt/curriculum-frameworks/#56-56-wpfd-curriculum-framework-p2

Royal Education Council. (2012). *Science curriculum framework*. Thimphu, Bhutan.

Royal Education Council. (2020). *Education in emergency (EIE).* http://www.education.gov.bt/wp-content/uploads/2020/03/FINAL-EIE-Curriculum-Implementation-Guidelines.pdf

Royal Education Council. (2010). *Teacher quality enhancement project policy guidelines and strategic plan*. Thimphu, Bhutan.

Royal Government of Bhutan. (2006). N*ational adaptation programme of action.* http://unfccc.int/resource/docs/napa/btn01.pdf

Royal Government of Bhutan. (2008). *The constitution of the Kingdom of Bhutan*. https://www.nab.gov.bt/assets/templates/images/constitution-of-bhutan-2008.pdf

Royal Government of Bhutan. (2009). Strategizing climate change for Bhutan. National environment commission and United Nations environment programme. http:/www.rrcap.unep.org/nsds/uploadedfiles/file/bhutan.pdf

National Statistics Bureau of Bhutan. (2018). R*ural-urban migration and urbanization in Bhutan*. https://www.nsb.gov.bt/rural-urban-migration-and-urbanisation-in-bhutan-2/

Tamang, R. S., Tshering, & Rinchen, S. (2021). The impact of educational technology tools on the learning achievement of B.Ed science students in Ecology class at Samtse College of Education. *Contemporary Education and Teaching Research*, 2(1),1–11. https://doi.org/10.47852/bonviewCETR2021020101

United Nations International Children's Emergency Fund. (2018). *Annual report 2017: A fair chance for every child in Bhutan*. https://www.unicef.org/bhutan/media/301/file/UNICEF%20Bhutan%20annual%20report.pdf

Utha, K. (2015). *Formative assessment practices in Bhutanese secondary schools and its impact on quality of education*. Unpublished PhD dissertation, Aalborg University, Denmark.

Utha, K., Subba, B. H., Mongar, B. B., Hopwood, N., & Pressick-Kilborn, K. (2021). Secondary school students' perceptions and experiences of learning science and mathematics: the case of Bhutan. *Asia Pacific Journal of Education, 1-18*

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