SITUATION ANALYSIS - TANZANIA

United Nations
Educational, Scientific and
Cultural Organization

UNESCO Chair on
Teacher Education and Curriculum
Open University of Tanzania
Dar es Salaam, Tanzania

The Open University of Tanzania

The Connected Learning for Science, Technology, Engineering, and Mathematics (CL4STEM) project aims to pilot an innovation and research its effectiveness and potential scaling for building capacities of secondary school teachers in Science and Maths for fostering higher-order thinking with inclusion and equity in their classrooms. The CL4STEM pilot engages teachers in curated OERs based modules in Science and Maths and participation in online communities of practice. It is a South-South collaboration among higher education institutions to adapt and pilot the Connected Learning Initiative (CLIx, https://clix.tiss.edu) in Tanzania, Nigeria, and Bhutan. CLIx has been successfully implemented at scale in India.

The associated research studies focus on two broad areas. First, the Impact Study, analyses the impact of innovation on teachers Knowledge, Attitudes, and Practice for higher-order teaching and learning of science and maths in an inclusive and equitable manner. 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 would 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.

This study is funded by IDRC under the Global Partnership for Education Knowledge and Innovation Exchange (https://www.gpekix.org). Centre for Applied Sciences and Technology Research, Ibrahim Badamasi Babangida University, Lapai, Nigeria, is the lead of the CL4STEM project consortium which includes Samtse College of Education, Bhutan and Open University of Tanzania as the country partners. Tata Institute of Social Sciences, India is the technical consultant to the project.

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Report is available for download at https://www.connectedlearningforstem.org/

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

ACSEE	Advanced Certificate of Secondary Education
ADEM	Agency for Development of Educational Management
ADSI	African Digital Schools Initiative
CASTER	Centre for Applied Sciences and Technology Research
CETE	Centre of Excellence in Teacher Education
CFIT	China Funds-in-Trust
CoL	Communities of Learning
CoP	Communities of Practice
CPD	Continuous Professional Development
CSEE	Certificate of Secondary Education
DEO	District Education Officers
DPD	Direct Professional Development
EFA	Education for All
EQA	Education Quality Assurers
ESR	Education for Self-Reliance
ESRF	Economic and Social Research Foundation
ETP	Education and Training Policy
FSTES	Faculty of Science, Technology and Environmental Studies
GER	Gross Enrolment Ratio
GeSCI	Global E-Schools and Communities Initiative
IAE	Institute of Adult Education
IBBUL	Ibrahim Badamasi Babangida University, Lapai
ICS	Information and Computer Studies
ICT	Information and Communication Technology
IICD	International Institute for Communication and Development
KAP	Knowledge, Attitudes, and Practice
LMS	Learning Management System
MoE	Ministry of Education
MoEST	Ministry of Education, Science and Technology

NACTE	National Council for Technical Education
NECTA	National Examinations Council of Tanzania
NER	Net Enrolment Ratio
NFCPD	National Framework for Continuous Professional Development
NPD	National Policy on Disability
NQT	Newly qualified teachers
NSGRP	National Strategy for Growth and Reduction of Poverty
OER	Open Education Resources
OUT	Open University of Tanzania
PCM	Physics, Chemistry, and Mathematics
PD	Professional development
PDP	Professional development programme
PGDCDD	Post Graduate Diploma in Curriculum Design and Development
PSLE	Primary School Leaving Examination
REA	Rural Energy Agency
RELI	Regional Education Learning Initiative
SAIDE	South African Institute for Distance Education
SCE	Samtse College of Education
SDG	Sustainable Development Goals
SEQUIP	Secondary Education Quality Improvement Program
SIDA	Swedish International Development Agency
SSB	Secondary school board
STEM	Science, Technology, Engineering, and Mathematics
TBC	Tanzanian Broadcasting Corporation
TCLSS	Tanzania Computer Literacy for Secondary Schools
TCU	Tanzania Commission of Universities
TDMS	Teacher Education Development and Management Strategy
TEN	Tanzania Education Network
TESSA	Teacher Education in Sub-Saharan Africa
TIE	Tanzania Institute of Education
TLSB	Tanzania Library Services Board
TPACK	Technological Pedagogical Content Knowledge
TTPB	Tanzania Teachers' Professional Board
TVET	Technical and Vocational Education and Training

TVTE	Technical and Vocational Teacher Education
UDP	Universal Design Principles
UNESCO	United Nations Education, Science and Culture Organization
VETA	Vocational Education and Training Authority

1 Introduction

This document provides country-specific background information to plan, design, and execute the activities of the Connected Learning for STEM (CL4STEM) pilot in Tanzania. This report is collated from secondary literature and through key informant interviews with education functionaries. Participant information was collected through a survey of participating districts, secondary schools, and teachers in the country.

1.1 About CL4STEM

CL4STEM aims to pilot an innovation and research its effectiveness and potential scaling for building the capacities of newly qualified teachers (NQTs) of middle and 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), which is already developed and scaled in India, to new contexts in Bhutan, Nigeria, and Tanzania.

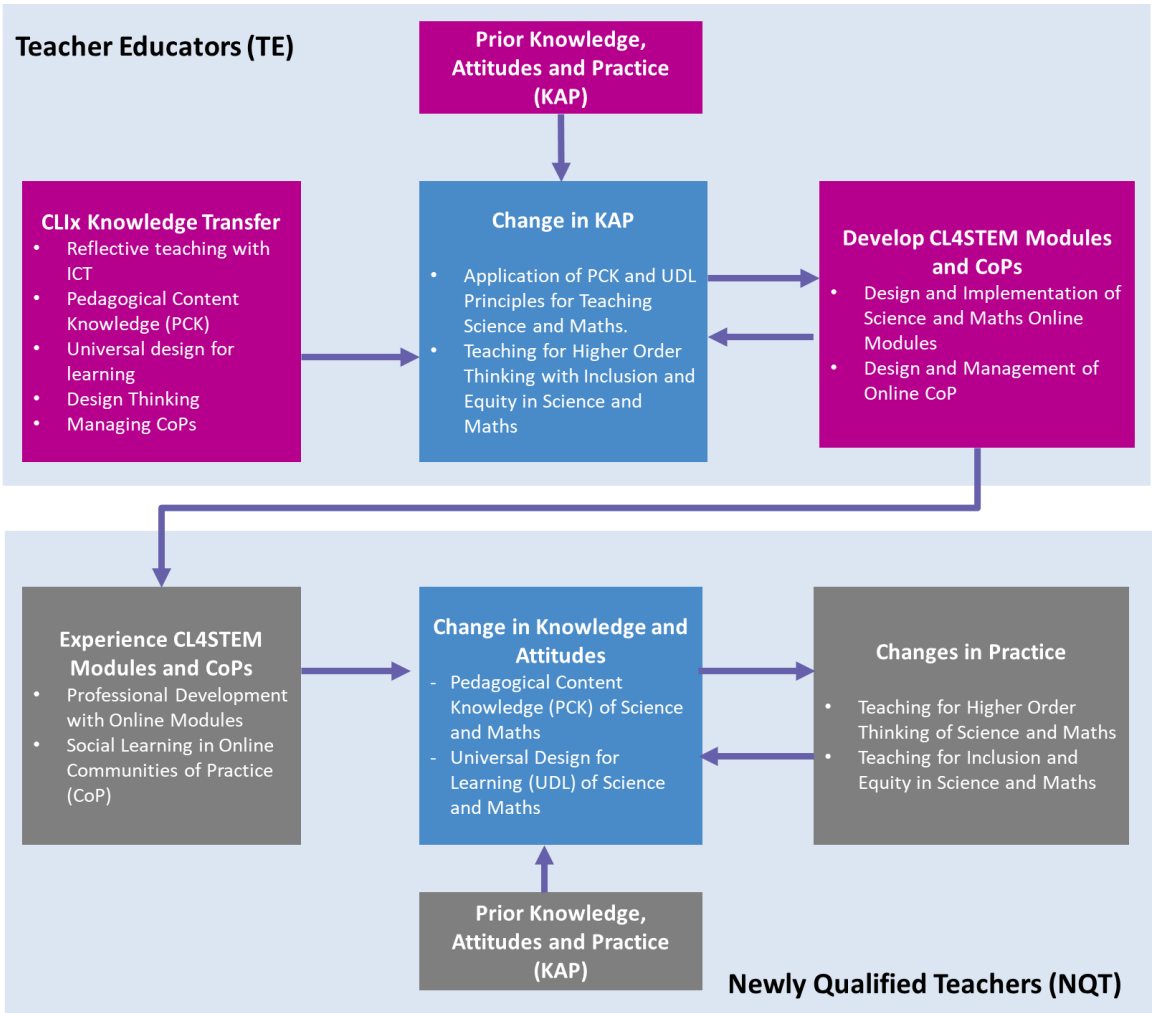

Figure 1.1: Theory of Change

The pilot involves the building of teachers' professional capacities through their engagement with curated modules based on Open Education Resources (OER) and through 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 for higher-order teaching and learning of science and maths 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 would 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.

1.2 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). Centre for Applied Sciences and Technology Research (CASTER), Ibrahim Badamasi Babangida University, Lapai (IBBUL), Nigeria is the lead of the CL4STEM project consortium, which includes Samtse College of Education, Bhutan (SCE) and 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) is 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 the 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 trains 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 to brace 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, and 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 teachers' 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, Mumbai, 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 it 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'.

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: Prof. 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.

1.3 Importance Of CL4STEM In Tanzania

IDRC and OUT jointly funded and run a research project with TISS, IBBUL, and SCE on CL4STEM aims at developing Technological Pedagogical Content Knowledge (TPACK) for strengthening the capacities of newly qualified teachers (NQTs) of Science and Mathematics in secondary schools. The teacher professional development involves the adoption and use of high quality and locally relevant OERs to develop pedagogical content knowledge of teachers. Teachers' support via mobile-based Communities of Practice (CoPs) is important in Tanzania for advancing teachers' capacity sustainably in offering quality STEM-related education.

This is achieved because OUT Science and Mathematics academicians, who are involved through this project, will have knowledge and capacities to create and adapt OERs using Universal Design Principles (UDP) and they will foster teachers' capacity building through the Technological Pedagogical Content Knowledge (TPACK) approach. Furthermore, OUT participants will have knowledge and capacities to form and nurture mobile-based CoPs, and both the former and the latter will contribute to the required capacity building in the country through secondary school NQTs or INSET for STEM. This will happen through capacity building by the lead consultant, TISS, which would adopt and adapt the CLIx innovation (successful in India) to the Tanzanian context. TISS would use high quality locally relevant OERs that will be selected, curated, adapted, and integrated into a professional teacher education curriculum that will be created in this project. Localised, module based and inclusive OERs for physics, chemistry, biology, and mathematics would be expectedly developed through this project in the form of a professional certificate. Associated teacher support mobile-based Community of Practice (CoP) platform would be used to exchange knowledge, skills, and experience sustainably during and after

the project and the usefulness of this intervention will be captured by innovation diffusion and impact studies.

The project is in line with Tanzania education and training policy 2014 that emphasizes the STEM and Sustainable Development Goals (SDGs), especially SDG 4 that emphasizes having an improved quality of education by 2030. It will be achieved together with the University network of stakeholders in the education sector including basic education levels, such as Tanzania Institute of Education (TIE), responsible for designing and developing secondary education curriculum that will be engaged in the contextualization of modules and orientation of teachers to participate in this CL4STEM project process effectively. Moreover, teacher education would be involved in secondary schools' sections of the Ministry of Education (MoE), Science and Technology. The MoE provides policy and monitors the implementation. The President's Office – Regional Administration and Local Government (PO-RALG) are responsible for the administration and management of the basic education sub-sector in the country, which among others deal with secondary schools in more than 184 local government authorities.

The locally developed professional certificate indicated the collaboration and ascertained that innovation diffusion and impact studies would uplift the weak technological pedagogical content knowledge of some pre- and in-service teachers, because it is one of the central problems of teacher development in Tanzania, particularly in the STEM subjects. Therefore, Knowledge, Attitudes, and Practice (KAP) would be enabled for higher-order teaching and learning of science and mathematics in an inclusive and equitable manner. This also applies to competency-based and sustainable teachers' professional development of NQT INSET and would contribute to increasing quality to the teaching of STEM in secondary schools that are vital in achieving 2025 vision-related socio-economic development in the country.

1.4 CL4STEM In Tanzania: A SWOT Analysis

SWOT analysis is conducted to identify strengths, weaknesses, opportunities, and threats, regarding the implementation of CL4STEM in the context of Tanzania through The Open University of Tanzania (OUT), as presented below next:

Strengths

- OUT has STEM subject expertise and pedagogical teacher educators: The faculty of Science, Technology and Environmental Studies (FSTES) and the faculty of Education (FED) are among the five faculties at OUT. The FSTES teaches several subjects which include Physics, Chemistry, Biology, Mathematics, among other subjects. Currently, there are 10 Physics experts, 14 Chemistry experts, 10 Biology experts and 9 Mathematics experts. On the other hand, the Faculty of Education has 10 Sciences and 5 Mathematics pedagogical experts, respectively (PROSPECTUS-2020-2021_MAIN.pdf)). These teacher educators are crucial in the implementation of the CL4STEM project from knowledge transfer to innovation diffusion and impact.
- OUT has academic staff with skills and experiences in developing learning materials: OUT offers a number of Senate approved programs, which have been accredited by Tanzania Commission for Universities (TCU). Most of the teaching and learning materials of these programs have been developed by OUT academic staff and are based on the principles of learning theories to

create desirable conditions that facilitate effective learning. These teaching materials differ from normal textbooks and lecture notes because they are pedagogically sound, interactive, hands-on and experimental oriented as well as self-testing thus learner-centred oriented. Therefore, the availability of STEM subject matter expertise with such skills and experiences are very important in the project implementation specifically in modules creations.

- OUT has reasonable Internet connectivity: To take the advantage of the technology, OUT has invested a lot in ICT infrastructure including improving internet accessibility. Currently, the total internet bandwidth for both HQ and regional centres is 505 Mbps. In addition, OUT has installed several wireless access points at HQs as well as different regional centres that allow internet access to students while in our centres. Furthermore, plans are in progress to ensure that by June 2023 the internet bandwidth is increased to 1Gbps. Therefore, the availability of reliable internet connectivity at OUT contributes to the smooth implementation of the CL4STEM project especially during knowledge transfer (for both teacher educators and NQTs).
- OUT has a learning management system (Moodle): ICT has become a major tool that supports teaching and learning at OUT. The university has in place an e-learning platform (Moodle) where most of the courses' content has been uploaded and interaction between educators and students taking place. In addition, academic staff have been trained on how to create content, upload them, facilitate students online, evaluate and grade. This experience of managing the OUT e-learning platform will be of great value in enrolling NQTs, uploading developed Technological Pedagogical Content Knowledge (TPACK) modules and orienting NQTs on how to use the modules.
- OUT has ICT expertise to support online teaching and learning: The Open University of Tanzania has a special institute (Institute of Educational and Management Technologies, IEMT) which is responsible for integrating ICT in teaching, learning and research. This institute has six instructional designers, whose major roles include building capacity to academic staff in instructional design, graphics, and multimedia, providing opportunities to students with special needs to enrol for programs and study as distance learners, editing, publishing, and printing various OUT documents including study materials. These staff will help OUT in the implementation of the CL4STEM project by providing support to teacher educators, NQTs and during the module creation process.
- Support of OUT Management: The OUT management is aware that academic staff from FSTES and FED are participating in the CL4STEM project. Therefore, staff involved in this project are granted chair office to use and time to implement all the planned activities including permissions to travel to various regions during data collection and beyond.

Weaknesses

- *Newly STEM teacher educators lack module writing skills while others need upgrading:* Newly STEM teacher educators at OUT have inadequate module writing skills while the rest need to upgrade their skills to match with the current requirements of developing online, inclusive, competence, and technological pedagogical content knowledge-based teaching materials. However, this challenge has been solved because all subject matter experts have been trained on how to design localized modules based on modules to strengthen the capacities of newly qualified ordinary level secondary school teachers of Science and Mathematics.
- *Inadequate ICT knowledge including OERs to schoolteachers, students, and leaders:* The lower ICT related knowledge and skills might slow down the project. Well encompassing awareness and training may reduce the problem.

- Faculty time constraint: This could be problematic due to the presence of many other University obligations and personal carrier development.

Opportunities

- Existence of smartphones and social media for CoP: In January 2021, Tanzania had a population of 60.61 million. Of this, 5.40 million were social media users (TCRA, 2021). The common social media that are used in Tanzania are Twitter, Facebook, Instagram, WhatsApp, and Telegram. The sampled data collection also indicated teachers use them mostly WhatsApp even for school/professional purposes. Also, collected data indicated that over 85% of teachers have a smartphone of some kind. The availability of these social media and smartphones will provide access to each NQT regardless of geographic distance. This will accelerate the professional development of STEM NQT.
- Government policies and other documents support STEM subjects: Tanzania Education Policy (2014) put emphasis on improving the performance of STEM subjects and their importance in the digital and industrialized economy. A similar emphasis has also been narrated in Tanzania Vision 2025 document (TZ-Vision, 2025) and the last 5 years development plan 2020-25. Therefore, the Government of Tanzania will consider the implementation of the CL4STEM project as one of the initiatives that aim at improving the performance of Science and Mathematics students at the ordinary secondary schools' level through strengthening the capacity of NQTs.
- Existence of many OERs for each subject: Open Education Resources (OERs) allow others to modify the materials to suit the specific context. As a result, OERs save time, duplication of effort and build on best practices by experts in the specific subject area across the globe. Therefore, the availability of OERs in each STEM subject will accelerate the cost-effective creations of quality modules for Physics, Chemistry, Biology and Mathematics.

Threats

- Covid-19 pandemic: Strict measures taken to contain the pandemic such as movement restrictions, banning of gatherings to social and physical distancing, if happens again, may slow down the implementation of the project because some activities may require rescheduling. This re-arrangement of the work plan may delay the project completion or add extra cost to the project implementation.
- Lack of adequate and up to date ICT infrastructure: Most secondary schools in remote areas have limited access to electricity and ICT infrastructure such as computers, laptops, internet, TV screen, smart phone, etc. This may affect the implementation of some of the activities of the project especially during module implementation to NQTs. However, we see obvious efforts to end up electricity issue by REA that so far have covered more than 10,000 villages while the available ones are about 12,000.
- School timetable: For ordinary level secondary school, the year begins in January and has two terms (January to June and July to December). This is mean that June to July and December to January are two long holidays for both teachers and students. In addition, there are two short breaks (April and September) for both teachers and students. Both short breaks and long holidays may delay the implementation of the project if some activities fall under those periods.

1.5 Brief Background On Data Collection

The situation analysis is based on the data collected from secondary sources, such as published reports and papers, as well as primary sources, such as surveys and interviews. Education-wise, Tanzania mainland has 26 regions and 185 district councils that are geographically distributed in 11 school quality assurance zones, namely, Dar es Salaam, Eastern (Morogoro & Pwani), North Eastern (Kilimanjaro & Tanga), North Western (Manyara & Arusha), Central (Dodoma & Singida), Highlands (Mbeya, Songwe, Rukwa & Katavi), Southern Highlands (Iringa, Ruvuma, & Njombe), Southern (Mtwara & Lindi), Western (Tabora, Shinyanga, & Simiyu), Lake (Mwanza, Mara, & Geita), and Western Lake (Kagera & Kigoma) (www.moe.go.tz/sw/menu-item/school-quality-assurance-office-contacts). These 11 zones of school quality assurance were consolidated into six representative geographical areas for this situational analysis study. The six representative geographical areas were (1) Eastern comprising Dar es Salaam and Eastern zones; (2) Northern comprising North-Eastern and Western zones; (3) Central comprising Central and Western zones; (4) Highlands comprising Highlands and Southern Highlands zones; (5) Southern comprising Southern zone, and (6) Lake comprising of Lake and Western Lake zones. These six regions were represented by Dar es Salaam, Arusha, Dodoma, Iringa, Mtwara, and Mwanza, respectively.

The regions and subsequently the district councils selected in each representative area and respective zone/s considered the presence of zonal education/school quality assurance main office to facilitate logistics during the data collection visits that also included the latter. The data was collected at the district council level in this project and thus one district council was selected per region, as shown in Table 1.1, followed by the brief description of each selected district council (www.tamisemi.go.tz).

Table 1.1. District councils where data was collected for the situational analysis study

No.	Representative geographical areas/school quality assurance zones	Region	District Council
1	Eastern	Dar es Salaam	Dar es Salaam City Council
2	Northern	Arusha	Arusha District Council
3	Central	Dodoma	Dodoma City Council
4	Highlands	Iringa	Iringa District Council
5	Southern	Mtwara	Mtwara Municipal Council
6	Lake	Mwanza	Mwanza City Council

Dar es Salaam City Council: Dar es Salaam City Council is among the five councils of the Dar es Salaam region. It was originally known as Ilala Municipal and was established in 2000. It was transformed into Dar es Salaam city council in February 2020. Out of the 102 secondary schools, 54 are public schools and 48 are private schools.

Arusha District Council: Arusha district council is among the seven councils of the Arusha region. It was established in July 2007 by the former Arumeru district council. Arusha district council is currently having a population of 323,198 where 154,301 are males and 168,897 females. Arusha district council has 58 secondary schools, out of which 33 are public and 25 are private. The total number of students is 26,805, out of which 22,702 are in public secondary schools and 4,103 are in private schools. The council has 1,063 teachers (public schools), whereby the number of female teachers is 512 (48%) while the number of male teachers is 551 (52%).

Dodoma City Council: Dodoma city council is one of the eight councils in the Dodoma region, and it is the capital city of Tanzania. Dodoma city council has 57 secondary schools, out of which 39 are public schools and 18 are private schools. By 2021, 550 science-related subject teachers are required in public secondary schools wherein 347 teachers are available, and 204 teachers are in deficit. The higher deficit is in Mathematics (88), Physics (43), Biology (28), and Chemistry (23). The situation is different in an arts subject, as there 627 subject teachers are required, and 1006 teachers are available with 379 teachers being extra. Swahili (111) and History (103) are the leading arts subjects with more additional teachers.

Iringa District Council: Iringa district council is among the five councils of the Iringa region and has 36 secondary schools out of which 28 schools are public and 8 schools are private. The number of students is 17,727 in public secondary schools and 1,695 in private secondary schools. There are 940 secondary schoolteachers in the council, whereby 195 teachers teach Science and Mathematics subjects.

Mtwara Municipal Council: Mtwara municipal council is among the nine councils of the Mtwara region and has 21 secondary schools of which 13 are public schools and 8 are private schools.

Mwanza City Council: Mwanza city council is one of the eight councils in the Mwanza region. The council has 60 secondary schools, wherein 30 are government secondary schools and 30 are private secondary schools.

1.5.1 Socio-economic profile of students and teachers of the schools in sited districts

Each council had a government public school, a community school, and a private school. Totally, 17 schools participated in this study from the six district councils with the number of STEM teachers being 76 (Table 1.2). Of these, 58 (76.3%) were male teachers and 18 (23.7%) were female teachers. The age of most teachers (40.8%) was between 30 and 39 years and more than 84% were aged below 50 years, as illustrated in Table 1.3. Thus, it is evident that any capacity building provided can be useful for long. One DEO (secondary school) from each of the six councils and four school quality assurers from each zone/council participated in the study through interviews. Furthermore, 17 heads of schools (one per school) were interviewed, and they filled a school profile.

Table 1.2. Secondary schools and STEM teachers who participated in the situational analysis study

No	Name of the Council	Name of the school (Government, Community, or Private)	Total number STEM Teachers	Percentage (%)
1	Mwanza CC	Mwanza Secondary	6	7.9
		Igelegele Secondary	4	5.3
		Lake Secondary	2	2.6
2	Iringa DC	Kalenga Secondary	6	7.9
		Isimani Secondary	4	5.3
		St. Dominic Secondary	4	5.3
3	Dar es Salaam CC	Mchikichini Secondary	4	5.3
		Pugu Secondary	4	5.3
4	Arusha DC	Iliboru Secondary	6	7.9
		Enyoito Secondary	3	3.9
		Enaboishu Secondary	3	3.9
5	Dodoma CC	Msalato Secondary	7	9.2
		Chinangali Secondary	5	6.6
		Maria de Mattias Secondary	6	7.9
6	Mtwara MC	Naliendele Secondary	4	5.3
		Mtwara Sisters Secondary	4	5.3
		Shangani Secondary	4	5.3
		Total	76	100

Table 1.3. Age distribution of STEM teachers

Age (years)	Number of teachers	Percentage (%)
Below 30 years	17	22.4
30-39 years	31	40.8
40-50 years	16	21.1
Above 50 years	12	15.8
Total	76	100

1.5.2 Organization chart of the district council in relation to secondary schools

A district council consists of administrators, educators, education quality assurance officers, and logistic officers who are responsible for ensuring students' academic success and social growth. A generic district council organization structure in relation to secondary schools' management is intended for the effective provision of quality education, as shown in Figure 1.2.

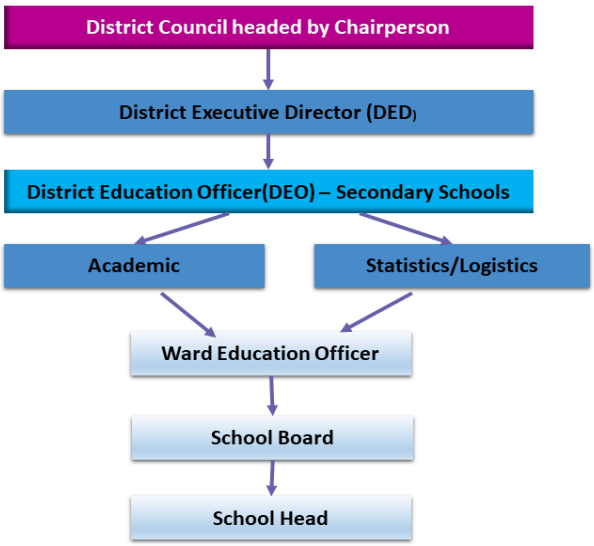

Figure 1.2. Organization chart in the district council with respect to secondary schools

1.5.3 Brief on ICT in education, STEM teaching, equity/inclusion in school district

Number and percentage of the newly qualified STEM in the participating districts

According to the situational analysis study, 76 STEM teachers participated in the survey, whereby 23 teachers (30.3%) had an experience below five years (NQTs) and 44 (57.9%) teachers had an experience below ten years. Table 1.1 summarizes the number of STEM teachers and their respective teaching experiences.

Table 1.4. Teaching experience

	Frequency	Per cent
Less than 5 years	23	30.3
5-10 years	21	27.6
More than 10 years	32	42.1
Total	76	100

1.5.4 Interventions in the past three years

According to the situational analysis study, district educational officers, heads of schools, and school quality assurance officers indicated that different interventions were made to solve or minimize the challenges associated with teaching and learning.

Intervention around STEM teaching and learning - Various training about STEM teaching and learning have been reported. Some of them were organized at the school, district, and ministry levels. Seminars were conducted on competency-based teaching and learning and managing practical sessions. Teachers' subject day was started for each subject in the secondary school curriculum with a priority for Physics, Chemistry, Biology, and Mathematics. All teachers of a particular subject exchanged knowledge via presentations and discussed issues that could improve knowledge and its delivery to

students. This included the participation of Education Quality Assurers (EQA) who presented the issues and opined based on their quality assurance visits/interventions that teachers did not perform as expected. No interventions were made in some districts about training. However, science laboratories were constructed in schools that did not have such facilities, old science laboratories were rehabilitated, and the necessary equipment and chemicals were supplied. In addition, some STEM books were bought along with other subjects from capitation grants.

Intervention to address dimensions of inequities and marginalization - A number of interventions about the issues of inequities and marginalization were mentioned, though no intervention was made in some districts for the past three years. The ministry has been requested to build houses for teachers and the government has been trying to address this issue, but it is time consuming due to the several challenges posed in the education field. Some schools have managed to organize transport for teachers from home to schools and vice versa, and the fare for public transport is used for fuel. During the COVID-19 pandemic, radio and stationaries were used to reach those from marginalized communities as an alternative to website access or through WhatsApp to reduce urban and rural inequities. Marginalization of ICT use in education was used to access lectures, assignments, and other learning materials.

Intervention around ICT in Education - According to the study, many reported that they did not attend or organize training on ICT in education. Instead, teachers used ICT knowledge obtained from self-effort or colleges/universities. One school reported that it allowed its STEM subjects teachers to attend seminars on e-learning (facilitated by Americans and Germans) and how to improve the deliverance of STEM subjects. Some teachers reported having attended ICT training on the use of instructional devices like projectors, search engines, etc. On the other hand, some interventions used ICT to teach; for instance, each STEM subject in Dodoma has a CoP that uses WhatsApp as a platform. The random sharing includes professional development in the subject area regarding questions, possible solutions, and other related matters of interest that can improve subject knowledge and delivery. Students are encouraged to use computers to find solutions to questions that are fed in school computers.

Key learnings from the interventions

The key learnings from the interventions are as follows:

- Teachers improved after attending seminars/training
- An improvement was observed in teaching and challenges were solved
- The examination setup was competency-based

Improvisation was observed in the usage of the current environment to facilitate e-learning and in the usage of technology to solve daily learning problems.

2 Mapping The Context

2.1 Country Context

2.1.1 Geography, demography, politics, and administration

Tanzania is a country located in Eastern Africa and it lies between 6.369° south of the equator and 34.889° east of the Greenwich Meridian. It is bordered by the Indian Ocean to the east, Kenya and Uganda to the north, Rwanda, Burundi, and the Democratic Republic of the Congo to the west, and Zambia, Malawi, and Mozambique to the south, as shown in Figure 2.1 (TzMap, 2018). Tanzania was formed as a sovereign state in 1964 through the union of the theretofore-separate states of Tanganyika and Zanzibar. Thus, Tanzania is also known as the United Republic of Tanzania, due to the union of Tanganyika and Zanzibar. Tanzania is administratively divided into two parts, namely, Tanzania mainland and Zanzibar. Tanzania mainland has 26 regions and Zanzibar Island has five regions. Each region is subdivided into districts and councils. The capital city of Tanzania is Dodoma located about 450 km from Dar es Salaam. Dar es Salaam is the country's commercial capital whose port serves the neighbouring land-locked countries of Malawi, Zambia, Burundi, Rwanda, and Uganda as well as the Eastern Democratic Republic of Congo. The six sampled districts and respective regions (blue) are shown in Figure 2.1.

Figure 2.1. Map of Tanzania showing administrative regions

Source: Annamap.com

Tanzania is the biggest among East African countries covering an area of 945,000 km^2, wherein Tanzania mainland covers 881,000 km^2 and the Islands of Zanzibar and Pemba cover 2,000 km^2 (URT, 2018). The current population of the United Republic of Tanzania is 61,846,647 as of October 1, 2021 (Worldometer, 2021). The Tanzanian population consists of people from about 120 different tribes, each with its own language. However, Swahili is spoken by all tribes, and it is the national and the official language, while English is the second official language. Swahili is the medium of instruction in public primary schools while English is used as the medium of instruction in secondary schools and post-secondary educational institutions.

Tanzania is a land of geographical extremes that houses the highest peak (Mount Kilimanjaro), the lowest point (the lakebed of Lake Tanganyika), and a portion of Lake Victoria, the largest lake (shared with Uganda and Kenya) on the African continent. Tanzania is home to world-famous Serengeti, Ngorongoro Crater, Tarangire, Lake Manyara, Mikumi, Arusha, Ruaha, Saadani, and Udzungwa mountains and national parks. Tanzania is home to game reserves like Selous, Gombe Stream, and Mkomazi Game Reserve, Amani Nature Reserve, Kigosi, Lukwika-Lumesule, Maswa, Monduli Mountains, Msangesi, and Ugala. Totally, Tanzania has 12 national parks, one conservation area, 13 game reserves, 38 game-controlled areas, and about 120 national cultural heritage sites.

Tanzania has a tropical climate with temperatures ranging around 10°c and 20°c during the cold and hot seasons in the highlands, respectively. However, the rest of the country has temperatures above 20°c. The months of November and February record the warm and humid seasons (25°c - 31°c), while the months of May and August record the cold season (15°c - 20°c). Tanzanian agricultural economy is dependent on rainfall, which falls between October and May every year. Unimodal and bimodal are the two rainfall regimes that exist between December and April and between October and December, respectively.

In Tanzania, CL4STEM project situation analysis was carried in six (out of 11) education quality assurance zones that were grouped in a geographical representation. In each zone, a district council was selected and, in each council, three secondary schools (public, community, and private) were selected. Each sampled district council is briefly introduced in Part A, Section 1.6.

2.1.2 Country-specific project risks

Tanzania prioritizes embracing emerging methodologies and technology for quality and equitable education. Thus, CL4STEM project activities will be implemented according to a plan. However, some minor risks may deter the project's success.

COVID-19

If another COVID-19 wave hits the country and strict measures, such as banning gatherings and travelling, are instituted, then the implementation of the CL4STEM project may be affected. This risk can be minimized by rescheduling some project activities. However, this rearrangement may delay the project completion or might add extra cost to the project implementation.

Availability of NQTs due to school breaks

Another challenge that can affect the project implementation is the availability of NQTs, due to school breaks. The academic calendar of Tanzanian secondary schools begins in January and has two terms: January to June and July to December (TIE, 2007). Project implementation might be delayed due to the two long breaks from June to July and from December to January and two short breaks in April and September if some activities are scheduled during such breaks. To address this issue, all activities related to NQTs' engagement including orientation and learning experience through online modules must not be scheduled during the vacations.

NQTs not having access to ICT devices

Project implementation can be affected because of NQTs not having access to ICT devices, such as desktops, laptops, or smartphones. Data collected from 76 science and mathematics teachers in 17 secondary schools (where this project will be piloted or implemented) revealed that the majority of teachers (87%) do not have laptops or desktops, but most of them (82.9%) owned smartphones. In addition, most Tanzanian secondary schools, especially community public schools, did not have ICT infrastructure (Ngeze, 2017) and ownership of the individual smartphone is not allowed at this level. To address this issue, orientation programs for using computers and related digital facilities must be conducted for NQTs at schools having such facilities or at OUT ICT labs present in centres of the piloting regions. In addition, project activities including content delivery and envisaged CoP should leverage the widespread use of smartphones among teachers and administrators across all sample districts and schools.

Teacher workload

According to the guidelines of the ministry of education, a teacher is required to teach about 24 periods a week, which results in 16 hours per week (Monday to Friday) and 3.2 hours per day, which is about 5 periods of 40 minutes every day, thereby facilitating time for preparation of classes and marking assignments. The survey and interview analysis revealed that the average mean workload of STEM teachers in the sampled schools was high due to the shortage of science and mathematics teachers. This risk must be considered while implementing the CL4STEM project to ensure that the timings for the modules would be balanced and appropriate for teachers.

2.1.3 Impact of the COVID-19 pandemic

In Tanzania, the first COVID-19 case was reported in March 2020. Like many other disastrous situations, COVID-19 has tremendously affected all sectors in Tanzania. However, six key sectors have faced the highest risks. The six affected sectors are the tourism and hospitality industry, transportation and storage industry, agriculture, wholesale and retail trade, finance and insurance, and social services sectors of health and education (ERSF, 2020). For example, in the tourism and hospitality industry, the COVID-19 pandemic has reduced the number of tourists from different countries, thereby reducing the amount of expected foreign currency significantly. Furthermore, a reduction in the number of tourists caused a decline in economic activities and a fall in income, due to the strong backward and forward economic linkages.

The Tanzanian education sector was affected negatively by the COVID-19 pandemic. The government closed all physical contact activities on 17th March 2021 and classroom teaching became unviable in secondary schools. However, teaching activities were launched through television and radios by Tanzanian Broadcasting Corporation (TBC) and students could attend classes from their locations. The disadvantage of this arrangement was that only students with access to televisions or radios were able to learn. Similarly, online learning was initiated by some private schools, but most of the public schools did not provide online teaching. Instead, assignments were sent to students through parents' WhatsApp groups. In some cases, parents collected hardcopies from schools or a nearby stationary. This was found in community government schools, where most of the students were from neighbourhoods. After the reopening of schools, teachers had to teach under pressure to complete the syllabus on time; however, some teachers could not complete it. In some schools, teachers contracted the virus and had to stay under quarantine for 14 days and this affected the teaching and learning processes. To compensate for the lost teaching time, remedial classes were established in some schools. Data collected from interviews with 6 District Education Officers (DEOs) (secondary schools), 17 Heads of secondary schools, and 24 Zone Quality Assurance Officers of Science and Mathematics subjects highlighted the students' obstacles, namely, lack of ICT devices, poor/nil Internet connectivity, and unsuitable home learning environment, in the midst of school shutdowns.

The COVID-19 pandemic is not yet over in Tanzania; however, the rate of its spread has significantly reduced. In case of a resurgence of COVID-19 in Tanzania, a cut in the budget would be the main challenge in implementing education. This could jeopardize the gains made in recent years in terms of access to education and an improved teaching and learning environment. In case of a resurgence of Covid-19, the main challenge in implementing the CL4STEM project could be the unavailability of NQTs and the re-closure of all schools.

2.2 Education System

2.2.1 Education administration

Management of the education system

The education system in Tanzania is broadly organized into three segments, namely, formal education, professional training, and adult and non-formal education. Formal education comprises pre-primary to university/higher education, while professional training provides pre-service and in-service teacher development programs for pre-primary, primary, and secondary teachers. Technical and Vocational Education and Training (TVET), which include formal and non-formal alternatives for primary school leavers, is provided under professional training. In addition to short vocational courses, adult and non-formal education provides options for alternative learning for the youth and adults. This is to mainstream back into formal education, acquire basic and functional literacy, and continue education.

Management of the education system is vested in two ministries, namely, the Ministry of Education, Science and Technology (MoEST) and the President's Office-Regional Administration and Local Government (PO-RALG). MoEST is entrusted with the responsibilities of formulating and implementing appropriate educational policies, training, and producing qualified teachers and other educational experts, supervising the development of community colleges, consolidating, and coordinating national

technical education and supervising, evaluating, and ensuring quality and accountability of the education system (Figure 2.3).

Other functions of MoEST are improving the use of science, engineering, technology and mathematics, promoting and supervising research in science and technology, developing human resources in the education sector, developing and overseeing teachers' professional, moral, and ethical standards, setting assessment and evaluation standards for primary, secondary, and teacher educational levels, overseeing quality assurance matters, and overseeing educational organizations, agencies and programs (URT, 2019b). These functions are outlined in the ministry organization chart, as indicated in Figure 2.2.

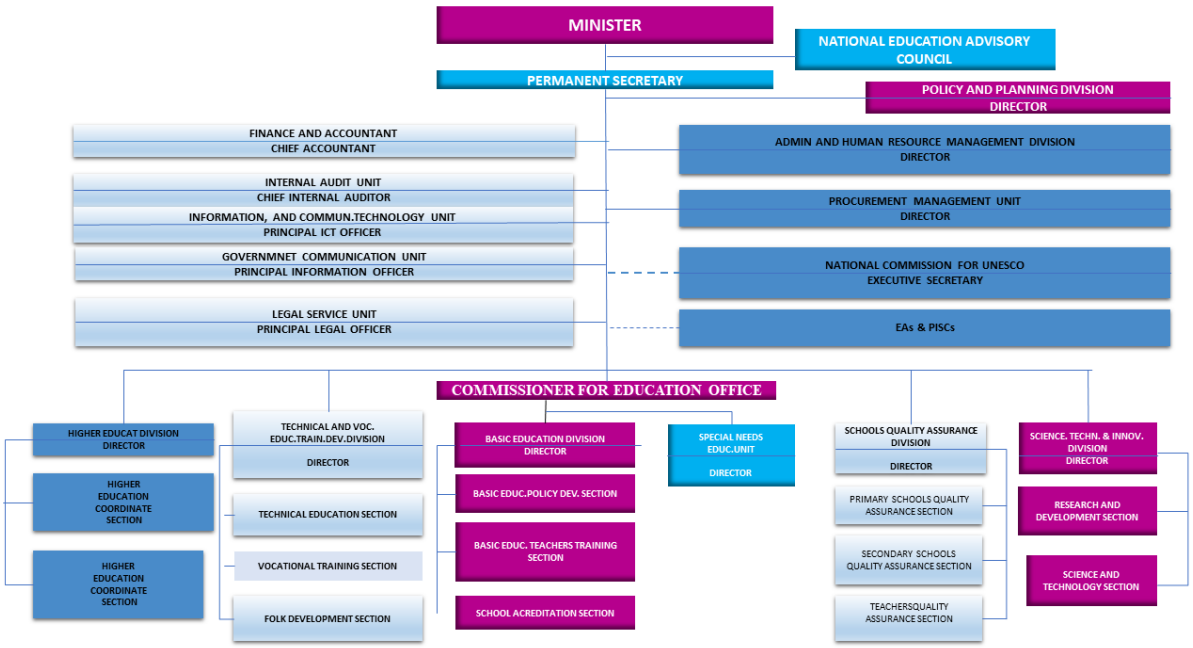

Figure 2.2. MoEST organization structure

Likewise, PO-RALG, among other non-education functions, manages basic education by providing pre-primary, primary, and secondary education including student enrolment, retention, and completion, and ensuring the availability of teaching-learning resources, such as books, furniture, and infrastructure. PO-RALG oversees the recruitment and deployment of teachers and their social/remuneration needs, oversees parental and community participation in the education of their children, and supervises the conduct of teachers and other educational personnel in the respective regions. A deputy minister deals specifically along with a complete division/directorate with sections of pre-primary and primary education, secondary education, adult and non-formal education, and special needs education.

Other bodies in basic education management include the National Examination Council of Tanzania (NECTA), Tanzania Institute of Education (TIE), National Council for Technical Education (NACTE), Vocational Education and Training Authority (VETA), Institute of Adult Education (IAE), and Agency for Development of Educational Management (ADEM). These bodies operate under MoEST jurisdiction (URT, 2019b).

Roles of NGOs, CSOs, and CBOs in education

Several Non-Governmental Organizations (NGOs), Civil Society Organizations (CSOs), and Community-Based Organizations (CBOs) function in the Tanzanian education sector. The Tanzania Teachers' Union is the main representative body for teachers. Tanzania Education Network (TEN) is a national network of over 200 NGOs and CBOs that promote education and influence policies for providing basic and quality education in Tanzania. NGOs play different roles in delivering services in the Tanzanian education system. Some NGOs, CSOs and CBOs are primarily involved in advocacy aimed at pressurizing governments to ensure that children have access to education of acceptable quality. Other organizations provide education directly to the excluded and 'hard-to-reach' students. Such students include street children, orphans, child soldiers, demobilized children in post-conflict areas, pastoralists, child labourers, and children belonging to indigenous groups, language, faith, disability, and gender. These forms of exclusion may be due to income-related poverty but can also result from children not attending school for socio-cultural and other demand-side related reasons. Inadequate supply of schooling in remote and rural areas can further exacerbate these constraints. NGOs, CSOs, or CBOs may provide school uniforms and pay other related costs, such as transport and books, or provide education on crosscutting issues, such as HIV/AIDs, as observed during this study.

Typical school organization structure

A school consists of administrators, teachers, and supporting officers, who ensure students' academic success. A school in the district council needs to be structured organizationally for providing quality education, as summarized in Figure 2.3.

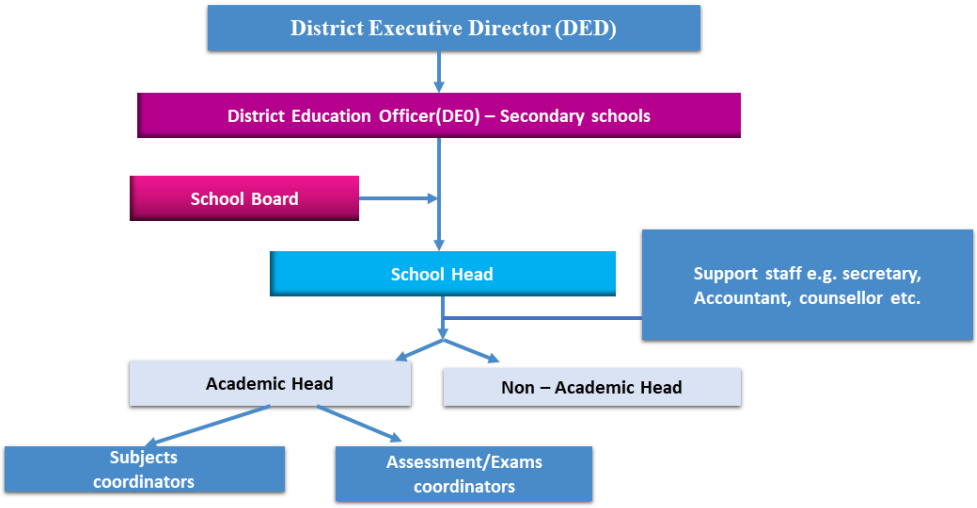

Figure 2.3. Organization chart of secondary schools in the district council

Management of secondary schools

A secondary school is managed by the school board and the head of the school. The secondary school board (SSB) is a team established for the management, development, planning, discipline, and financing of government secondary schools (URT, 1978). According to the Education Act of 1978 No.25, SSB works on behalf of communities to execute the school activities. In addition, communities

are involved in managing the school during parents' meetings where various issues related to school developments are discussed. Furthermore, a secondary school is managed by the school head person, who is responsible for the supervision of all academic and administrative activities. The main activities include supervision of teaching and learning activities, supervision of teachers' attendance and students' attendance in classes, implementation of education policy and circulars, and management of all other non-human resources (funds, school infrastructure, teachers' welfare, students' welfare, etc.) In terms of supervision, secondary school teachers are supervised by academic teachers, zonal education quality assurers, District Education Officers, and ward education officers.

2.2.2 Education policy and funding

Main documents of education policy

From the independence of Tanzania in 1961 until 2014, three major turning points are evident in its educational policy-making. The turning points are marked by the 1967 Arusha Declaration, which introduced Education for Self-Reliance (ESR); the 1980s' macro policies, which emphasized rationalization of investment, liberalization, and cost-sharing; and when Vision 2025 was launched in 1999 to mould knowledgeable and skilled populace capable of dealing with development challenges competently and competitively (URT, 2019b). In tangible education policy documents, such turning points are evident through ESR, the 1995 Education and Training Policy I (ETP I) (1995) and the 2014 Education and Training Policy II (ETP II) (2014). Self-reliance, competency-based, and decentralized basic education have been the dominant characteristics in the formulation of educational policy objectives to achieve access, equity, and quality in the provision of education in Tanzania.

ETP II of 2014 expanded compulsory basic education in Tanzania to include one year of pre-primary education, six years of primary education, and four years of secondary education. Six years of primary education is yet to be accommodated in the Education Act and to be made a Tanzanian law. As a measure to expand access, free pre-primary, primary, and lower secondary education was introduced, which is managed by the President's Office-Regional Administration and Local Governments (PO-RALG).

Policy in use of ICT for teaching and learning in schools

The Tanzanian Information and Communication Technology (ICT) Policy for Basic Education (URT, 2007a) incorporates the integration of ICTs in pre-primary, primary, secondary and teacher education, as well as non-formal and adult education. The policy considers issues of infrastructure; curriculum and content; training and capacity development; planning procurement and administration; management, support, and sustainability, and monitoring and evaluation. In general, references to ICTs were prominent in all the three policy documents that governed the education sector in Tanzania. The policy documents were the Education and Training Policy of 2014 (UTR, 1995), the Primary Education and Development Plan (PEDP) 2002-2006 (UTR, 2001), and the Secondary Education Development Plan (SEDP) 2004-2009 (UTR, 2004). All the three documents emphasized the need for access to quality education for all, despite the increasing number of enrolments, which is emphasized further in the education and training policy of 2014 such that it contributes to competency-based graduates.

STEM teaching and learning in secondary schools

Students from Form I and Form II study Science (Physics, Chemistry and Biology) and Mathematics at the ordinary level of education. However, students in Form III and Form IV take six core subjects, namely, Mathematics, English, Kiswahili, Biology, Civics, and Geography. They also include one or more elective subjects selected among Chemistry, Physics, Bookkeeping, Commerce, History, and ICS, in their study programs. These subjects fall under the following categories: Sciences, Social Sciences, and Commercial subjects. Therefore, from the perspective of STEM or Science, students of ordinary level education study Biology and Mathematics as compulsory subjects, while Physics and Chemistry are optional in Form III and IV (TIE, 2007).

The number of STEM subjects studied at the advanced level of education depends on the learning areas with corresponding combinations. Subject combinations are organized according to learning areas, which fall under two main categories, namely, a combination comprising subjects drawn from one learning area and a combination comprising subjects drawn from more than one learning area (TIE, 2007b). The list of STEM subject combinations offered at the advanced level of secondary education is shown in Table 2.1, providing various possibilities to those who want to proceed with STEM subjects.

Table 2.1. STEM subjects combinations for advanced level secondary school

Areas of Study	Principal Subjects	Combination Acronym	Supplementary Subjects
Natural Sciences	Physics, Chemistry, Mathematics	PCM	GS and ICS
and Mathematics	Physics, Chemistry, Biology	PCB	GS and BAM (ICS-optional)
(I) All three Natural Science Subjects	Chemistry, Biology, Mathematics	CBM	GS and ICS
	Physics, Mathematics, Computer Science	PMCs	GS and BAM
	Physics, Chemistry, Agriculture	PCA	GS and BAM (ICS-Optional
	Chemistry, Biology, Computer Science	CBCs	GS and BAM
	Chemistry, Biology, Agriculture	CBA	GS and BAM (ICS-Optional)
	Chemistry, Biology, Nutrition	CBN	GS & BAM (ICS - Optional)
(II) Two natural Science Subjects and one different subject.	Physics, Geography, Mathematics	PGM	GS and ICS
	Chemistry, Biology, Geography	CBG	GS and BAM (ICS-Optional)
	Physics, Computer Science, Geography	PCsG	GS and BAM
	Chemistry, Biology, Fine Arts	CBFa	GS and BAM (ICS-Optional)
	Chemistry, Biology, Physics Education	CBPe	GS and BAM (ICS-Optional)
	Physics, Biology, Physics Education.	PCPe	GS and BAM (ICS-Optional)
	Physics, Computer Science, Music	PCSMu	GS and BAM
	Physics, Comp. Science, Fine Arts	PCsFa	GS and BAM
	Mathematics, Computer	MCsC	GS and BAM
	Science, Commerce		(ICS-Optional)
	Agriculture, Chemistry, Geography	AgCG	GS and BAM (ICS-Optional)
	Agriculture, Biology, Economics	AgBE	GS and ICS
	Physics, Mathematics, Music	PMMu	GS and BAM (ICS-Optional)
	Physics, Chemistry, Textile Technology and Clothing	PCTe	GS and BAM (ICS-Optional)
	Biology, Nutrition, Home Management	BNHm	GS and ICS
(III) One natural science, two different subjects	Physics, Geography, Economics	PGE	GS and BAM (ICS-Optional)

***Note**: GS = General Studies, BAM = Basic Applied Mathematics, ICS = Information and Computer Studies (Source: TIE, 2007b)*

Education financing

The Tanzanian government implemented the Education and Training Policy, 2014 on 27 November 2015 and directed the public bodies to ensure that primary and secondary education is free for all children. This policy included the removal of all forms of fees and contributions. However, whilst most fees including exam fees are covered and many students can join, some indirect costs remain. For example, students from poor families may require stakeholders' assistance regarding school uniforms, sports uniforms, and learning materials. This leads to a substantial budget that includes basic education. The overall national budget for the past five years has been consistent at about 4% (Table 2.2). However, this study identified some challenges faced by the sector including teachers regarding learning materials and ICT facilities and such challenges could be overcome through the allocation of more budget.

Table 2.2. Education versus overall national budget

Sl. No.	Financial Year (Tanzanian Currency)	Total Budget (Tanzanian Currency)	Ministry of Education & Vocational Training (Tanzania Currency)	Percentage of Higher and Basic Education Budget
1	2017/2018	31,711,986,000,000.00	1,366,685,241,000.00	4.30%
2	2018/2019	32,475,950,000,000.00	1,407,136,481,000.00	4.33%
3	2019/2020	30,539,965,494,338.00	1,388,664,740,272.00	4.54%
4	2020/2021	34,879,802,956,148.00	1,348,563,375,000.00	3.86%
5	2021/2022	36,329,739,565,000.00	1,387,093,874.000.00	3.82%

The procedure of monitoring and evaluating projects

To implement projects in the education sector, monitoring and evaluation activities are conducted periodically and reports are provided to all concerned parties and stakeholders. Routine and periodic measurements of project inputs, activities, and outputs are undertaken during monitoring to track continually and indicate shortcomings regarding the delivery of inputs and execution of activities. However, project inputs, activities, and results are analysed during evaluation and assessed to determine the effectiveness, impact, and relevance of projects considering the stated objectives. Furthermore, rules and regulations are adhered to in the event of procurements by the government through public procurement laws. Therefore, the goal of monitoring and evaluation is to assure that funds have been utilized effectively and to the expected standards.

2.2.3 Academic structure

Education in Tanzania is provided by both public and private sectors and operates on the '2-7-4-2-3+' system, i.e., 2 years of pre-primary school, 7 years of primary school, 4 years of ordinary secondary school, 2 years of advanced secondary school, and at least 3 years of higher education (TIE, 2007; Nuffic, 2015). A summary of the academic progression of education and training in Tanzania is

illustrated in Figure 2.4. Compulsory education in Tanzania starts at the age of 7 and ends at the age of 14. Swahili is the language of instruction for primary education and English is the language of instruction for both secondary and higher education (TIE, 2007; Nuffic, 2015).

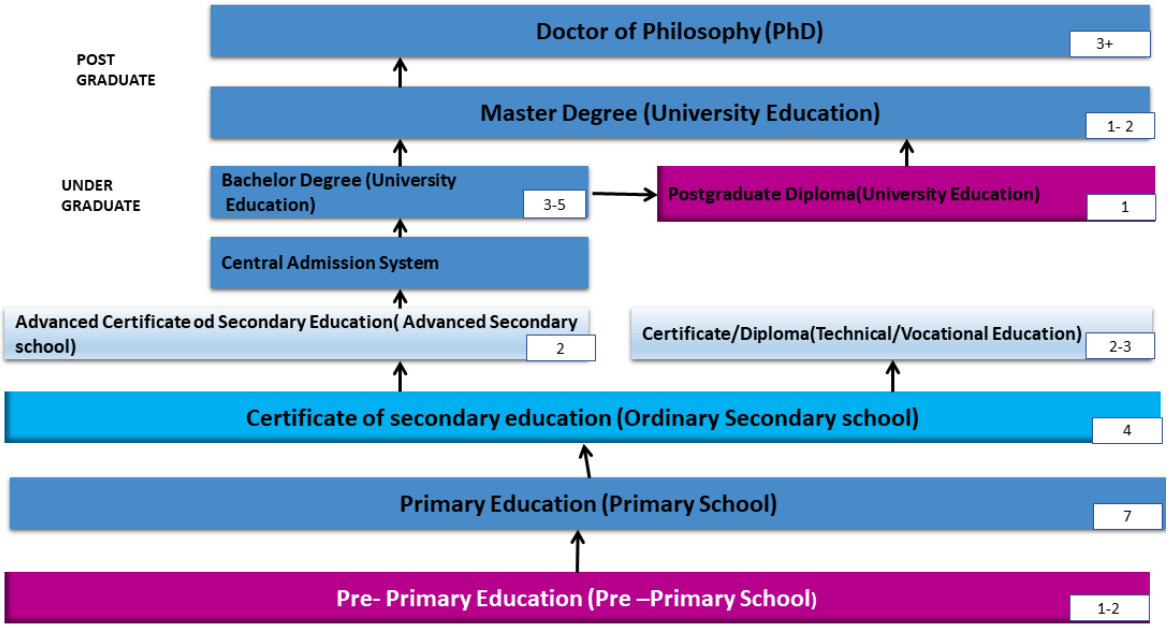

Figure 2.4. Academic progression of education and training in Tanzania

Source: Nuffic, 2015

The education policy of 2014 mandates the provision of a compulsory one-year pre-primary education to children aged between three and five years. Pre-primary education is provided prior to joining standard one (URT, 2016), after which children join primary education. Primary education is compulsory for children aged from 7 to 14 years and it is provided free in public schools. However, parents/guardians must bear the costs of school uniforms, school supplies, and minor school overheads. Primary education lasts for 7 years and is divided into two sections. The first section involves the first two years of primary education, namely, Standards I and II (URT, 2019a). In these two years, the curriculum focuses on developing the pupils' competencies in Reading, Writing and Arithmetic (3Rs). The second section is for Standards III to VII and it focuses on developing competencies in the following eight subjects: Kiswahili, English, Mathematics, Civic Education, Moral Education, Science and Technology, Social Studies, and Vocational Skills, and optional subjects, such as French and Arabic (URT, 2019a). At the end of 7 years, all pupils appear for a final examination called Primary School Leaving Examination (PSLE), which is conducted by the National Examinations Council of Tanzania (NECTA). PSLE is a test through which entrants for secondary schools are selected by the government.

Secondary education is provided through two levels, namely, ordinary, and advanced. The ordinary level comprises standards I to IV and the advanced level comprises standards V and VI. Students in standards I to IV (ordinary level) study Civics, English, Kiswahili, History, Geography, Physics, Chemistry, Biology, and Mathematics, and Information and Computer Studies (ICS) where infrastructure is available. To obtain the Certificate of Secondary Education, students must take examinations in at least seven subjects. Students in standards V and VI (advanced level) are subjected

to general studies and they specialize in Commerce, Arts, and Social Sciences or Natural Sciences (URT, 2019b).

2.2.4 Teacher education and service conditions

Teachers' professional qualifications

The National Framework for Continuous Professional Development (NFCPD) for practising Tanzanian teachers was formulated in 2017 as a guide for teachers' learning to enhance their teaching skills and develop them into competent and effective practitioners (URT, 2017a). The framework reiterated the four years (2007/8 - 2010/11) Teacher Education Development and Management Strategy (TDMS), which among other things had sought to address the issues related to teaching and teacher development during the primary and secondary education reforms of the early 21st century in Tanzania. TDMS stipulated a period of four years to identify and recruit teacher trainees (one year), train them for a minimum of two years, examine and post them to schools (one year), and monitor their performance, especially during induction and confirmation. NFCPD focuses on the provision of continuous professional development to practising teachers aiming to improve the quality of education in the country. This would occur through training and development programs that transformed the serving teachers rather than transmission models that dominated the previous strategies.

The framework identifies three major types of continuous professional development programs, which could be either optional or compulsory, namely:

- *School Level Professional Development Communities of Learning (CoL)*: Teachers work to improve their own learning to ensure all students learn and achieve the intended outcomes. Adequate support needs to be garnered from administrative leaders and performance managers to ensure the effectiveness and sustainability of CoL at the school level. Heads of schools should give time to teachers to meet, share, reflect, and learn from each other.
- *Direct Professional Development (DPD) for In-Service Teachers*: Sessions consisting of the provision of engaging, interactive, and hands-on workshops and seminars introduce new knowledge and skills to teachers, encourage them to share, solve problems, reflect, and innovate. The duration of DPD can be as short as a one-day activity or as long as a five-day activity, at least thrice a year. By policy, the framework encourages short, brief, and intensive sessions of no more than five days.
- *Ward Cluster Level Professional Development*: The District Education Office consults educational administrators at ward and school levels and creates professional development ward clusters in each district. The size of each cluster should be determined by distance and ease of access to the agreed cluster sites and should not exceed 30 teachers and head teachers. Ward cluster sites could be schools, teachers' resource centres, training colleges, or other sites chosen by the educational administrators. Teachers meet at ward clusters at least twice a year. However, the number of sessions is determined in consultation with educational administrators and the District Education Office.

However, by practice, teachers in Tanzania acquire professional development from teacher education colleges or higher education institutions. Teacher education colleges provide training at the certificate and diploma levels, while universities and other higher education institutions provide training at the

bachelor's degree level and beyond. Teachers graduating from both avenues serve in schools and colleges where they need to access any three indicated Continuous Professional Development (CPD) for enhancing knowledge, skills, and competencies relevant to issues emerging in their routine professional engagement and practices.

Professional bodies and standards governing teacher professional conducts

Tanzania Teachers' Professional Board (TTPB) was established in 2018 to deal with the registration of teachers, regulation of standards, professional conduct, and management of other related matters (URT, 2018). The functions of TTPB are:

- advise the minister on matters pertaining to the teaching profession.
- establish and maintain the register of professional teachers.
- establish and promote the teachers' professional standards.
- promote, regulate, and control continuing professional development for teachers.
- inquire into complaint, charge, or allegation of improper conduct against any registered teacher.
- oversee the teaching of education ethics and professionalism within the teachers' training programs.
- formulate and enforce a comprehensive code of professional conduct and ethics of the teaching profession.
- undertake and commission appropriate research into teaching and matters related to the teaching profession.
- issue certificate of registration or licenses for teachers; and
- perform any other function as may be required under this Act or under any other written law.

Organization of initial teacher education system (pre-service education)

In Tanzania, teachers are trained in either teacher education colleges or higher education institutions. Teacher education colleges train teachers at the levels of certificate and diploma, while higher education institutions (including universities and university colleges) train teachers at the level of bachelor's degree and beyond. Graduate teacher education programs are offered by universities and university colleges (URT, 2019b). The curriculums for certificates and diplomas are designed by the Tanzania Institute of Education while the curriculums of postgraduate diplomas and other degrees (Bachelor, Masters, & PhD) are prepared by universities under the guidelines of the Tanzania Commission of Universities (TCU). The National Council for Technical Education (NACTE) is a regulatory body established to oversee technical education and training in Tanzania. One of the statutory functions of NACTE is to award certificates and diplomas in technical education and training, which are consistent in standard and are comparable to related awards nationally and internationally (URT, 1997).

Apart from pre-service education teachers training, in-service teacher professional development (PD) is also imparted. The in-service PD focuses on orienting teachers on matters related to the curriculum for basic education, i.e., pre-primary, primary, and secondary education as well as teacher education. TIE collaborates with various stakeholders and organizes and provides PD education to teachers.

Professional teachers are employed in public and private schools. Public school teachers are recruited either through campus or through advertisements posted to PO-RALG; however, screening-interview is not conducted (Massima, 2018). Birth certificates, valid academic certificates of secondary school (ordinary and advanced), and teaching profession certificates are the main criteria considered in recruiting new teachers for public secondary schools (Massima, 2018). Moreover, recruitment practices determine the quality of teachers in terms of commitment, mastery of subject contents, pedagogical skills, professional code of conduct, experience, and physical fitness.

Community of Practice (CoP) and secondary school teachers' professional development

Social media can facilitate the professional development of teachers by helping them share knowledge, skills, and resources. Studies have indicated that social networks can support teachers' professional development in Tanzania (Manyama & Ndibalema, 2017). In addition, data collected from situation analysis in the six district councils indicated that most secondary school teachers use social media, namely, WhatsApp (88.2%), followed by Facebook (40.8%), Messenger (26.3%), Instagram (25.0%), Telegram (17.1%), Forums (13.1%), and Twitter (7.9%). Interviews with sampled respondents indicated that these social media are used for various purposes. For example, most teachers use social media for teaching, obtaining news and updates, and communicating with friends and families. In addition, it was found that teachers use social media to share information with fellow teachers and parents (67.1%), for professional networking (40.8%), and for watching movies, sharing information with students, and shopping online (less than 30%). Thus, the usage of WhatsApp would be viable for planned CoP in this project. This is because teachers are already involving themselves in CoP, where knowledge, skills, and expertise are exchanged. The extent of CoP happening in schools is evident from the interview data collected from DEOs (secondary school) and the relevant heads of schools. According to one of the DEOs, CoP is being organized per subject and carried out at a district council level, where teachers meet and thereafter share subject content via Whatsapp group. In addition, one of the heads of schools expressed that CoP happens where teachers help each other and learn through school-based in-service program, which includes sharing expertise and peer learning, and STEM progress might be made if such practice is done effectively in all subjects and schools.

2.2.5 Education Indicators

Summary of tables on enrolment, school infrastructure and teaching staff

Quantitative indicators of different levels of basic education (pre-primary, primary, ordinary secondary, and advanced secondary), school ownership, and the number of teachers in each school for all regions in Tanzania are indicated in Table 2.3 (BEST, 2020). Other quantitative education indicators in terms of enrolment per district, ward, student age and sex per class, pupil-teacher ratio (PTR), school infrastructure (books and ICT devices), pupil-book ratio (PBR) and other important education indicators can be accessed online at https://www.tamisemi.go.tz/en/singleministers/basic-education-data-2021 (URT, 2021).

Table 2.3. Summary of statistics in basic education sub-sectors as of 2020

Level of Education	Ownership	Enrolment			Teaching Staff			No. of Schools
		Male	Female	Total	Male	Female	Total	
Pre-Primary	Government	647,609	631,277	1,278,886	2,226	5,327	7,553	16,355
	Non-Government	50,558	47,965	98,523	696	4,981	8,574	1,803
	Total	698,167	679,242	1,377,409	2,922	10,308	16,127	18,158
Primary	Government	5,211,409	5,249,376	10,460,785	84,673	85,896	170,569	16,406
	Non-Government	232,505	232,606	465,111	14,214	9,953	24,167	1,746
	Total	5,443,914	5,481,982	10,925,896	98,887	95,849	194,736	18,152
Secondary (FORM 1-6)	Government	1,045,557	1,126,700	2,172,257	54,221	30,393	84,614	3,863
	Non-Government	143,853	157,396	301,249	16,758	4,634	21,392	1,280
	Total	1,189,410	1,284,096	2,473,506	70,979	35,027	106,006	5,143
Secondary (FORM 1-4)	Government	983,351	1,079,366	2,062,717				3,801
	Non-Government	120,459	139,083	259,542				1,271
	Total	1,103,810	1,218,449	2,322,259				5,072
Secondary (FORM 5-6)	Government	62,206	47,334	109,540				401
	Non-Government	23,394	18,313	41,707				385
	Total	85,600	65,647	151,247				786
Non-Formal Education-COBET	Government	31,724	24,826	56,550	1,783	1,406	3,189	2,376
	Non-Government	4	6	10	6	1	7	4
	Total	31,728	24,832	56,560	1,789	1,407	3,196	2,380
Adult Education-ICBAE	Government	58,565	89,649	148,214	2,868	2,253	5,121	2,762
	Non-Government	496	907	1,403	19	27	46	32
	Total	59,061	90,556	149,617	2,887	2,280	5,167	2,794
Non-Formal Education-IPPE	Government	2,743	2,297	5,040	296	169	465	117
	Non-Government	61	110	171	14	21	35	9
	Total	2,804	2,407	5,211	310	190	500	126
Adult Education-ODL	Government	3,228	4,200	7,428	874	339	1,213	160
	Non-Government	1,449	2,009	3,458	309	100	409	38
	Total	4,677	6,209	10,886	1,183	439	1,622	198

Note: COBET = Complementary Basic Education in Tanzania; ICBAE = Integrated Community Based Adult Education; IPPE = Integrated Post Primary Education; ODL = Open Distance Learning.

Source: BEST, 2020

Analysis of teachers by professional qualifications and years of experience

The minimum academic qualification for a secondary school teacher is a diploma in education obtained from a recognized institution. If necessary, graduates without any teacher training may be employed but they must possess a teaching license issued by the education ministry (TIE, 2007). Table 2.5 provides a summary of the number of teachers by qualification in government and non-government schools by region and sex, as of 2020 (BEST, 2020). The number of teachers by qualification in secondary schools shows that a majority are holders of bachelor's degree (67.1%). In addition, the present study data indicates that most teachers (73.7%) hold a bachelor's degree, followed by diploma holders (18.4%). In terms of years of experience, most STEM teachers had experience of fewer than 10 years (57.9%) and about 42.1% of STEM teachers had the experience of more than 10 years.

Table 2.4. STEM secondary school teachers' professional experiences

Teaching experience	Frequency	Per cent
Less than 5 years	23	30.3
5-10 years	21	27.6
More than 10 years	32	42.1
Total	76	100

Table 2.5. Number of secondary school teachers by qualification in government and non-government schools by region and sex as of 2020

Region	Teachers' Qualifications														Total	
	PhD		Masters		PDGE		Bachelor		Diploma		Licensed Teachers		Others			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	Number of Teachers	Qualified Teachers
Arusha	3	1	167	102	38	16	2646	1813	1016	644	4	0	47	10	6507	6446
Coast	1	1	83	74	19	8	2245	1574	620	423	3	1	32	4	5088	5048
Dar es Salaam	7	15	225	301	37	54	3455	3457	1023	1098	5	1	71	18	9767	9672
Dodoma	4	0	101	67	17	12	1762	1172	734	345	1	1	34	5	4255	4214
Geita	0	0	55	14	13	2	1530	586	744	223	8	0	17	2	3194	3167
Iringa	1	2	119	54	26	13	1905	970	673	339	3	0	23	2	4130	4102
Kagera	4	1	114	31	7	3	2369	831	1033	376	27	3	45	11	4855	4769
Katavi	0	0	5	3	1	1	386	113	239	56	2	2	13	1	822	804
Kigoma	0	0	56	10	12	3	1311	437	846	239	16	1	43	2	2976	2914
Kilimanjaro	7	1	167	109	38	9	2997	1753	1110	712	7	1	43	12	6966	6903
Lindi	0	0	16	9	1	0	766	319	382	107	1	0	10	2	1613	1600
Manyara	1	0	53	19	12	6	1410	516	824	326	8	2	27	2	3206	3167
Mara	0	0	68	22	10	3	1919	604	920	262	21	1	40	4	3874	3808

Region	Teachers' Qualifications														Total	
	PhD		Masters		PDGE		Bachelor		Diploma		Licensed Teachers		Others			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	Number of Teachers	Qualified Teachers
Mbeya	0	1	110	53	26	10	2837	1379	1066	525	5	0	36	0	6048	6007
Morogoro	1	1	157	107	26	11	2449	1518	933	495	11	0	31	8	5748	5698
Mtwara	0	0	35	29	5	1	1159	470	597	176	3	0	15	5	2495	2472
Mwanza	0	1	217	102	16	12	3343	1577	1390	461	13	0	61	8	7201	7119
Njombe	0	0	65	19	15	5	1243	517	700	324	7	2	15	1	2913	2888
Rukwa	2	0	25	12	3	0	872	258	478	108	11	0	16	5	1790	1758
Ruvuma	2	1	67	21	16	1	1714	690	812	317	12	3	14	4	3674	3641
Shinyanga	0	0	36	13	5	4	1226	550	661	219	19	0	30	12	2775	2714
Simiyu	0	0	39	8	12	1	1118	279	632	198	4	0	9	1	2301	2287
Singida	1	0	36	17	6	3	1042	479	600	226	5	1	22	2	2440	2410
Songwe	0	0	30	14	5	1	1106	486	510	165	1	0	7	0	2325	2317
Tabora	0	0	63	14	17	5	1515	635	813	296	13	1	28	4	3404	3358
Tanga	35	27	2231	1283	400	194	46871	24214	20471	9155	218	23	753	131	106006	104881

Source: BEST, 2020

2.2.6 National assessments of literacy, numeracy, and STEM Skills

In Tanzania, secondary school education is divided into two categories, namely, ordinary level (Form I-IV) and advanced level (Form V-VI). Students take examinations administered by the National Examinations Council of Tanzania (NECTA) at the end of each education level. However, Tanzania does not provide standardized tests for STEM literacy and numeracy. Two official examinations are conducted on a national scale for Form II and Form IV students in the ordinary level secondary education cycle. Students passing the Form II examination are promoted to Form III. The results of this examination are used as a part of continuous assessment in the Form IV examinations. No certificate is awarded for the Form II examination (TIE, 2007). To mark the completion of ordinary level secondary education, Form IV students take an examination called Certificate of Secondary Education Examination (CSEE). This examination is used to select students for further education training and direct employment. Students in ordinary level secondary education are subject to STEM-related study that includes Physics, Chemistry, Biology, and Mathematics, and ICS where ICT infrastructure and human resources are available. Biology and Mathematics are compulsory subjects up to Form IV, while Physics, Chemistry, and ICS are optional subjects.

Similarly, students appear for examinations at the end of the advanced secondary school level to obtain an Advanced Certificate of Secondary Education (ACSEE). At the advanced secondary school level, STEM students mostly specialize in natural sciences by combining three subjects selected among Physics, Chemistry, Biology, Agriculture, Mathematics, and recently Computer Science, an example being Physics, Chemistry, and Mathematics (PCM). Students also take a general studies subject (URT, 2019b).

Examinations in both secondary school levels consist of questions, which measure all levels of learning domains, i.e., cognitive, affective, and psychomotor (TIE, 2007). However, STEM subjects are examined in theory and practical papers, whereby each paper carries 50% of the total marks of the respective final examination for the subject (TIE, 2007).

Grading systems are used to evaluate a student's educational performance. In Tanzania, the grading system varies according to the overall performance of candidates in subjects that are examined to mark the end of the education cycle. Tables 2.6 and 2.7 present the grading system, division, and points for the Certificate of Secondary Education Examination (CSEE) and Advanced Certificate of Secondary Education Examination (ACSEE), respectively (URT, 2019b).

Table 2.6. Grading system in ordinary and advanced secondary school education

Education Levels	Grade	Point	Remarks
Certificate of Education Examination (CSEE)	A	1	Excellent
	B	2	Very Good
	C	3	Good
	D	4	Satisfactory
	F	5	Failure
Advanced Certificate of Education Examination (ACSEE)	A	1	The highest-level principal pass of achievement
	B	2	Very good principal pass
	C	3	Good principal pass
	D	4	Average principal pass
	E	5	Weak principal pass
	S	6	The lowest level principal pass
	F	7	Failure

Table 2.7. Division classification and points

Education Levels	Division	Points	Remarks
Certificate of Education Examination	I	17-Jul	Excellent
	II	18-21	Very Good
	III	22-25	Good
	IV	26-33	Satisfactory
	0	34-35	Fail
Advanced Certificate of Education Examination	I	9-Mar	Excellent
	II	12-Oct	Very Good
	III	13-17	Good
	IV	18-19	Satisfactory
	0	20-21	Fail

Student performance for STEM subjects

The total number of secondary schools in the country is 5,072, out of which 3,801 (74.94%) schools are owned by the government and 1,271 (25.06%) schools are owned by non-government organizations (URT, 2020).

Table 2.8. Secondary school enrolment in Tanzania- Form I-IV (Grade 9-12), 2020

Ownership	Male	% Male	Female	%Female	Total
Government	983,351	47.67	1,079,366	52.33	2,062,717
Non-Government	120,459	46.41	139,083	53.59	259,542
Total	1,103,810	47.53	1,218,449	52.47	2,322,259

The percentage of females (52.47%) enrolled in secondary schools is slightly more than that of males (47.53%), as shown in Table 2.16. The Gross Enrolment Ratio (GER) for Forms I-IV increased from

43.9% in 2019 to 46.0% in 2020. The Net Enrolment Ratio (NER) increased from 34.8% in 2019 to 36.0% in 2020.

Table 2.9. Certificate of Secondary Education Examination (CSEE) results by subject and sex for school candidates, 2018-2019

Sl. No.	Subject	Year	% Of Male Passed	% Of Female Passed	Total
1	Civics	2018	62.2	51.8	56.9
		2019	69.4	59.3	64.2
2	Kiswahili	2018	86	91.5	88.8
		2019	89.7	92.5	91.3
3	English	2018	67.8	64.1	65.9
		2019	69	62.9	65.8
4	History	2018	66.5	47.7	57
		2019	61.7	41.6	51.2
5	Biology	2018	65.9	55.3	60.5
		2019	62.4	48.7	55.3
6	Geography	2018	59.9	45.8	52.7
		2019	60.8	46.2	53.2
7	Basic Mathematics	2018	24.1	15.8	19.9
		2019	24.7	15.7	20
8	Physics	2018	54.1	34.7	45.2
		2019	56.9	38.2	48.4
9	Chemistry	2018	68.4	54.4	61.8
		2019	81.5	71.5	76.8

Source: NECTA - CSEE Results, 2018-2019

It was found that subject-wise pass rates in the Form 4 examination were higher in Kiswahili (91.3%) and Chemistry (76.8%) in 2019, as shown in Table 2.9. The lowest pass rate was in Basic Mathematics (20.0%) and Physics (48.4%). The performance of boys in science subjects is higher than that of girls. However, the performance of girls in Kiswahili is higher (92.8%) than that of boys (89.7%) (NECTA-CSEE_Results, 2019).

The candidates' performance in Basic Mathematics was the lowest, which shows that four topics, namely, Statistics (50.3%), Sequence and Series (39.9%), Accounts, Ratio, Profit and Loss (39.6%), and Rates and Variations (31.5%) had an average performance in CSEE 2020, while two topics, namely, Statistics and Circles (53.4%) and Rates and Variations (33.9%) had an average performance in CSEE 2019. None of the topics performed well in both years and the main reasons were the candidates' failure to apply correct formulae, rules, theorems, properties, and procedures, formulate expressions, inequalities, and equations from word problems, perform correct mathematical operations, draw diagrams and graphs, and interpret figures correctly (BEST, 2020).

Both primary and secondary data on the performance of all marginalized groups in STEM subjects were not readily available. Data were available on gender bases, males, and females (Table 2.9). Standardized tests for STEM literacy and numeracy were found to be non-existent in the country.

Performance of students in STEM subjects

The performance in STEM subjects was felt by many to be poor when one quality assurance officer was interviewed about the performance of STEM subjects.

The performance of students in STEM subjects was between poor and very poor and it was as follows:

- Physics: poor
- Chemistry: poor
- Biology: poor
- Maths: very poor – because almost all students failed form IV exams.

The analysis of performance in the final examination of Certificate of Secondary Education (CSEE) in the year 2020 indicates the following general performance:

Physics - Optional subject in Forms III and IV and 18,906 candidates appeared for the examination out of which 16,768 (89.13%) passed the examination and 2,138 (10.87%) failed (NECTA, 2020).
Chemistry - Optional subject in Forms III and IV and 154,881 candidates appeared for the Chemistry exam in 2020, wherein 12.91% failed (NECTA, 2020).
Biology – Compulsory subject for all in Forms I to IV and 423,887 candidates appeared for the examination out of which 232,960 (55.26%) passed and 190,927 (45.74%) failed (NECTA, 2020).
Mathematics - The number of candidates who sat for the examination in CSEE 2020 was 435,345 out of which 87,582 (79.88%) failed (NECTA, 2020).

The above data support the observation of the education quality assurance officer that the performance of mathematics is very poor for 20.12% of the students who passed the exam.

2.3 ICT In Education

2.3.1 Attitudes and practice concerning ICT in education

Teachers' and students' experiences in using ICT in learning and teaching activities

The government is willing to support and promote the use of ICT in different sectors including education. The National ICT Policy (NICTP) of 2003 and the revised one of 2016 suggest the recognition of ICT by the Tanzanian government as one of the important components of development (URT, 2016).

The recognition of ICT in education can be traced back to the ICT Policy for Basic Education, 2007, where ICT was indicated as instrumental in enhancing access, equity, quality, and relevance of basic education while stimulating and improving teaching and lifelong learning. Education and Training Policy (ETP) was launched in 2014 and it consolidated different levels of education policies, thereby replacing the existing policies including ICT Policy for Basic Education, 2007. Policy statement 3.3.5 of ETP (2014) advocated the government's emphasis on the use of ICT in teaching and learning at all

levels of education including the basic level. The importance of integrating ICT in education is not a Tanzanian matter but a global one, as demonstrated by the UNESCO-related Qingdao Declaration (2015) number nine on quality learning, which states that "We recognize that the ability to leverage ICT for learning is no longer a specialized skill; it is foundational to success in today's societies. We, therefore, acknowledge the need to integrate basic ICT skills and information literacy into primary and secondary education curricula. We support the adaptation of learning assessments to reflect the use of ICT and its impact on learning and outcomes" (UNESCO, 2015).

According to the National ICT Policy 2016, the implementation and access of ICT are challenging, as most secondary schools lack the ICT infrastructure and only a few schools and higher learning institutions in urban areas have ICT facilities. In recent years, significant improvement has been made in equipping secondary schools with ICT facilities. However, despite many efforts, the available ICT resources at schools are not effectively exploited. According to Malekani (2018), a study of selected secondary schools in Morogoro municipality on the access, use, and challenges of ICT in Tanzanian secondary schools revealed that despite the awareness of students and teachers on ICT, most schools do not have enough ICT facilities and those available were not adequately utilized.

Users of computers and smartphones have gradually increased in Tanzania. According to BEST statistical reports for the years 2019 and 2020, the number of desktop computers in all government and non-government secondary schools was 22,587 in 2019. The number increased by about 5% in one year to 23,735 in 2020. In addition, the number of laptops in 2019 (7,442) increased by 3% in 2020 (8,429). The increase in computers indicates the increase in awareness of the use of ICT and promises a bright future.

The first outbreak of the COVID-19 pandemic resulted in a new experience for secondary school teachers, as they strategically used ICT to reach out to students during the lockdown. This study revealed that all the 17 schools involved used some sort of ICT tools, such as websites, radio and television programs, and WhatsApp, to deliver teaching. Despite the advantages accrued during COVID-19 and despite the teachers' computer/smartphone literacy, the pedagogic integration of ICT in teaching and learning is challenging.

Benefits of using ICT in teaching and learning STEM subjects in secondary schools

ICT has proved beneficial in various sectors including education in improving access, efficiency, productivity, and decision-making. Difficult subjects, especially Science and Mathematics, can be explained better by using ICT. According to Uhomoibhi (2006, p.9, as cited in Suryani, 2010), e-learning allows students to get information faster from everywhere and anytime. E-learning content is learner-centred and helps students to engage in their learning through active interaction (Suryani, 2010). Learning through the utilization of ICT is more effective than learning through memorization. ICT allows learners to experience the process, interact, and enjoy technology. The digital curriculum employs several e-learning patterns through links with educational sites. Such sites contain simulation programs of scientific concepts and phenomena, such as celestial bodies, earthquakes, and volcanoes, which cannot be displayed or observed inside classrooms (Ismail, 2010 as cited in Al-Rsa'i, 2013).

Challenges of using ICT in teaching and learning in STEM subjects at the secondary school level

Various challenges, such as lack or shortage of computers, lack of technological and pedagogical skills in integrating ICT, lack of ICT-related support, lack of internet connectivity, digital illiteracy, and lack of infrastructure, can be found in using ICT in teaching and learning. Ghavifekr et al. (2016) indicated that lack of training in digital literacy, lack of pedagogic and didactic training in using ICT in classrooms, and lack of training on using technology in specific subject areas, hindered the utilization of new technologies in education. Mtebe and Raphael (2017) identified limited electricity distribution, resistance to change among instructors, insufficient Internet bandwidth, and inadequate funds to implement e-learning initiatives, as the limiting factors, among others. Furthermore, Swarts and Wachira (2010) pointed out that unsupportive mindsets of decision-makers, which is more pronounced among the older generation, were one of the limiting factors in ICT uptake.

NQTs' participation value in this intervention

According to the present study, heads of schools and DEOs believe that NQTs' participation in CL4STEM will be valuable because content developed will be shared through computers, which will subsequently improve their ICT skills. Those with inadequate ICT skills would have to learn to access and use the relevant materials. On the part of improving STEM skills, they believed that their participation would be valuable because the aim is to provide inclusive and competency-based education. However, it is still at a staggered stage, as teachers have not been able to acquire and practice so effectively and they need more knowledge and practice on these aspects. Thus, if the project content is competency-based and on inclusive education, the teachers will prepare themselves and would do the needful to teach effectively.

Self-perception of STEM teachers on skills and ability to use ICT for teaching

It was found that some teachers own and use ICT tools to facilitate teaching. This evidence suggests that the frequency of using ICT in teaching will increase if it is availed with ICT tools and related infrastructure. Ismail (2010) as cited in Ngeze (2017) on teachers' perception of the use of technology in teaching languages showed that teachers' use of ICT in teaching can improve their own teaching practices, which in turn may promote students' learning. However, lack of training and teachers' computer knowledge is evidenced in pedagogical practices in the integration of ICT in teaching in colleges/Universities. Mwalongo (2012) examined teachers' perceptions about ICT for teaching, professional development, administration, and personal use, and indicated that while the frequency of ICT usage was influenced by access, the competence of ICT use was influenced by training. Teachers used ICT for teaching, administration, professional development, and personal use. However, teachers did not use ICT to change their pedagogical practices radically but to sustain their traditional practices. Kafyulilo et al. (2015) indicated that even though teachers are learning to use and integrate technology into their teaching, they are not yet using technology as a pedagogical tool per se to enhance teaching and learning in their subjects.

2.3.2 Teacher proficiency in ICT in education

Different technical supports regarding the use of ICT in teaching and learning exist from the government to school levels. The Tanzanian government came up with revised ICT competency standards for teachers (ICT-CST) in 2015 through the ministry of Education, Science and Technology.

The government sought the support of the UNESCO-China Funds-in-Trust (CFIT) project to have harmonized standards of ICT training for all teachers. These standards are drawn from the UNESCO ICT competency framework for teachers. Such standards are to be used with technology literacy and knowledge deepening components with the premise that teachers need to be capacitated with those components and be resourceful in enhancing access, equity, quality, and relevance of basic education delivery. Different trainings of teachers in ICT have been conducted through different programs initiated by the government and in collaboration with non-government organizations, both inside and outside the country (URT, 2015).

In 2017, the Global E-Schools and Communities Initiative (GeSCI) based in Kenya introduced a project known as the African Digital Schools Initiative (ADSI) with an aim to develop digital schools of distinction focused on quality STEM teaching and learning and 21st-century skills. The ADSI involved 40 secondary schools drawn from two regions of Morogoro and Coastal in Tanzania, whereby 10 STEM teachers from each school (totally 400 teachers) were capacitated in three cycles, namely, technology literacy, knowledge deepening, and knowledge creation, as per the UNESCO ICT competency framework for teachers, customized for Tanzania. Each school involved was given five laptops, two routers for Internet connectivity, and two projectors for presentations.

According to the situational analysis study, all heads of schools and District Educational Officers (DEOs) must support and create a conducive environment that can improve academic performance. Several examples of support were organizing seminars on ICT in education, conducting competency-based training/seminars outside schools, and seeking the support of school or district management for the provision of food and transport.

For example, laptop loans were provided to teachers in some schools and school management endorsed them. Moreover, capacity building on ICT was initiated at school and district levels and was conducted regularly. School teachers were encouraged to use ICT tools. For example, teachers were asked to type exam questions and were discouraged to submit handwritten questions. In some schools, teachers used wireless cellular routers to connect online teaching and learning resources and an ICT staff provided the technical support.

It was found that most STEM teachers were literate, as many teachers had smartphones (more than 85% in this study), done online transactions, and used social media for their professional activities. Tables 2.10 and 2.11 indicate that more than 80% of teachers use the internet and social media to get news and updates and more than 67% of teachers use of internet and social media to share information with teachers and parents. It can be inferred that teachers used online content and the associated CoP. Thus, it is evident that teachers can use online content, use social media-based online communities of practice (CoP), make photos/videos, fill online survey forms, and use the developed and piloted OERs-based modules and established CoP after the end of projects. However, the level of using digital literacy is minimal, as most teachers do not use digital knowledge in teaching or content delivery per se, an aspect that may be enhanced in subsequent interventions.

Table 2.10. Use of internet and social media to get news and updates

	Frequency	Percent %
Yes	61	80.3
No	15	19.7
Total	76	100

Table 2.11. Use of internet and social media to share information with teachers and parents

	Frequency	Percent
Yes	51	67.1
No	25	32.9
Total	76	100

2.3.3 ICT in education: infrastructure and resources

Secondary schools have access to electricity, ICT infrastructure, Internet, and other digital teaching and learning resources

The government of Tanzania in partnership with other stakeholders, such as NGOs inside and outside Tanzania, embarked on various endeavours to provide secondary schools with the necessary infrastructure, improve access to quality education, and improve performance. Several digital infrastructure-related projects have been implemented by the government of Tanzania and other stakeholders for the education sector.

UNESCO-China Funds-in-Trust (CFIT): Equipped two teachers' colleges with servers installed with Moodle LMS at Monduli and Tabora. The same project enabled the development and uploading of e-content for STEM subjects in the installed Moodle LMS in collaboration with the Open University of Tanzania.

Secondary Education Development Program Phase 2 (SEDP II): In July 2010, the government of Tanzania launched the Secondary Education Development Plan-Phase 2 (SEDP II) with an objective to improve the quality of secondary education in underserved areas. One of the four components of the objective was dealing with upgrading the existing school infrastructure, such as furnishing of classrooms, science laboratories, teachers' residences, and latrines, providing water, and providing electricity through the grid or solar power (URT, 2010).

The implementation of ICT in Teacher Colleges (TCs): A report by Swarts and Wachira (2010) shows the MoEVT's priority for deploying ICT in teacher education colleges. The implementation of ICT in Teacher Colleges (TCs) started in 2005 as a joint venture between MoEVT and the Swedish International Development Agency (SIDA) to improve the quality of pre-service and in-service teacher education through ICT. All 34 public TCs were equipped with client solutions and VSAT connectivity, tutors were trained in computer literacy, and tutor technicians were trained to provide technical maintenance support and networking essentials.

Distance Education Learning Services (DILES): This project took the support of the International Institute for Communication and Development (IICD) and aimed to improve the quality of and access to educational materials for secondary school children through the usage of the internet. The DILES

project developed teaching and learning materials for secondary school students (URT, 2015). IICD supported other projects, such as Tanzania Computer Literacy for Secondary Schools (TCLSS) (URT, 2015).

The Tanzania Computer Literacy for Secondary Schools Trust Fund (TCLSS): The Tanzania Computer Literacy for Secondary Schools Trust Fund (TCLSS) was an initiative that procured computers and set up computer laboratories for secondary schools in the country. Computer literacy and computer maintenance were taught to students and teachers through the project, which was implemented in about 20 schools in the country (URT, 2015).

Rural Energy Agency (REA): Rural Energy Agency (REA) is a government body formed to promote and facilitate improved access to modern energy services in rural areas of Mainland Tanzania. REA projects include electrification of primary and secondary schools, health facilities, district headquarters, and villages. In general, with the onset of connectivity to electricity (both solar and grid), teachers are motivated to stay in their workstations when compared to the previous situation. The respective schools have an attractive working environment that motivates teachers and students to stay in school and work hard. The schools have the necessary infrastructure and base for accessing and using digital teaching and learning resources (URT, 2018). In addition, electricity is available in almost all secondary schools in rural and urban areas; however, there is little or no power backup. A study revealed that all 17 secondary schools had access to reliable electricity, three schools (17.6%) had power backup, and 12 schools (70.6%) had no generators. Only two schools (11.8%) had inverters.

Internet: The Internet is a major challenge in a majority of the secondary schools in Tanzania. It was found that 10 schools (58.8%) lacked internet connectivity. Nonetheless, many secondary schools were in a better situation regarding equipment, such as computers, copiers, printers, projectors, etc., especially in central government-managed secondary schools, such as those in Pugu, Tosamaganga, Iliboru, and Msalato. It was found that 10 schools (58.8%) had a computer room equipped with either laptops or desktop computers. Projectors were found in 13 schools (76.5%), and printers and copiers were found in 14 schools (82.4%).

ICT tools included in the curriculum as teaching and learning resources

Although the ordinary level curriculum specified Information and Computer Studies (ICS) as one of the optional subjects in ordinary secondary school (I-IV) with two periods per week, there was no specific mention on the usage of tools, software, or online resources. However, onsite information about Microsoft Word, Microsoft Excel, and Microsoft PowerPoint featured in many places. In addition, 28 teachers (about 40%) used videos, while 32.9% used Microsoft Word for teaching and professional development. Less than 15% of teachers used simulations, Google forms, Google drive, Zoom, Moodle, GeoGebra, and Google classroom for teaching and professional development.

Furthermore, the situational analysis report showed that about 54% of teachers (n=41) owned laptops and smartphones; 9.2% (n=7) had laptops; and 3.9% (n=3) had iPads/tablets. The laptops were used for teaching through videos (42.1%) and simulations (57.9%). The smartphones were used for emails (63%) and for staying connected with friends (96.1%). Only 11.8% (n=9) used desktops, 23.7% (n=18) of teachers used projectors, and 2.6% (n=2) used smart boards during teaching. In addition, 21.1% (n=16) of teachers used printers. Majority of teachers used WhatsApp (88.2%), followed by Facebook

(40.8%), Messenger (26.3%), Instagram (25.0%), Telegram (17.1%), Forums (13.1%), and Twitter (7.9%). Most teachers (80.3%) used social media to get news and updates and stay connected with friends, 67.1% of teachers used social media to share information with teachers and parents, 40.8% used social media for professional networking, and less than 30% used social media for watching movies, sharing information with students, and shopping online.

Secondary school teachers have access to teaching resources

According to the study, teachers get teaching resources, especially textbooks, which are prepared, distributed, sold by the Tanzania Institute of Education (TIE). Most of the textbooks are available online and accessible through TIE's e-library (www.tie.go.tz); however, awareness needs to be spread among people. An application that can simplify access to such e-libraries is required. In some cases, Oxford textbooks, past examinations' review books, and materials searched on the internet are found in other related sites to complement TIE's efforts.

2.3.4 ICT in education initiatives

Despite the several initiatives to exploit the ICT potential to enhance teaching and learning, a high student to computer ration poses a challenge to ICT access from the perspective of ICT in education projects. However, with the emerging technologies especially with the promising mobile phone penetration in Tanzania, the increase in mobile phones and internet users promises a huge potential to increase access to digital content, especially for teachers as secondary school students are not allowed to own them. Emerging ICT technologies and an increase in the number of digital literate teachers necessitate the capacitation of teachers in secondary schools through guidelines. One of the examples of such guidelines is the UNESCO's ICT competency standards for Teachers' Framework on technology literacy and knowledge deepening. Furthermore, pedagogic approaches in integrating ICT in teaching and learning should be emphasized and awareness of TIE'e-library, OERs, and CoP usage should be spread among secondary school teachers.

2.4 Equity And Inclusion In Education

2.4.1 Attitudes and practices concerning equity and inclusion in education

Factors affecting the inclusion of secondary school students from marginalized communities

Attempts have been made to achieve equity and inclusion in Tanzania over several years, but more pronounced movement in education practices is a recent phenomenon (Kuluchumila, Philip & Ntazoya, 2016). Tanzania is not exceptional from other developing countries, as it is struggling in terms of practising and attaining a high level of equity and inclusion in education. The history of its struggles can be traced back to when Tanzania signed the world declaration on Education for All (EFA) in Jomtien, Thailand in the 1990s and later reaffirmed it at the World Education Forum in Dakar Senegal in the 2000s (UNESCO,2015).

Some marginalized groups like hunters and gatherers, fishing communities, pastoralists' societies, orphans, and street children are out of school. In the year 2020, students living in vulnerable environments were 10.6% of the total number of students who were in secondary schools. The inequity of access and learning outcomes continues to present a major challenge. For example, girls

have higher enrolment and retention rates in both primary and lower secondary education, but they lag boys in the transition rate from primary to secondary education, as indicated in Table 2.12. Girls underperform in exams when compared to boys.

Table 2.12. Lower secondary survival rates, 2016-2019

Year	2016	2017	2018	2019
Boys	70.76%	72.71%	75.90%	72.18%
Girls	73.93%	75.77%	77.71%	75.72%
Total	72.33%	74.25%	76.83%	74.00%

Girls' access to higher secondary and higher education lags that of boys. Large variations are found in enrolment and retention rates and academic performance across the country, with remote rural areas lagging far behind the urban areas. For example, some schools in urban areas use ICT in teaching and learning, which is rare in rural areas. A significant number of children remain out of school, although the introduction of free basic education has reduced this number significantly.

Improving access and learning achievement for children with disabilities and other special needs requires more attention and resources. According to BEST (2019 & 2020), the number and type of students with disabilities in secondary schools are indicated in Table 2.13.

Table 2.13. Students with disabilities in secondary schools 2019-2020

S No.	Type of Disability	2019			2020		
		Boys	Girls	Total	Boys	Girls	Total
1	Albinism	629	572	1,201	388	359	747
2	Autism	27	15	42	16	10	26
3	Deaf				577	612	1189
4	Deaf blindness	71	46	117	15	12	27
5	Intellectual Impairment	63	35	98	50	26	76
6	Physical Disability	1,913	1343	3,256	1904	1480	3384
7	Low Vision/ Visual Impairment	1,948	2309	4,257	1555	2036	3591
8	Blind				220	133	353
9	Hearing Impairment	900	878	1,778	314	463	777
10	Multi-Impairment				103	52	155
Total		5,551	5,198	10,749	5,142	5,182	10,325

Source, BEST, 2020

The rate of dropouts in secondary schools is higher in lower grades than in upper grades. Form 2 has the highest number of dropouts (39.8%). The major reason for dropouts is truancy (91.6), followed by pregnancy (5.5%), and death (0.7%) (BEST, 2020).

Even though Tanzania has made major advances in providing education to its people since 2009, access to education needs to be improved for the most vulnerable learners, including those with disabilities (URT, 2017). During interviews with stakeholders, it was found that poverty, long distance

to school, school infrastructure, parents 'education level, culture and customs tied up with occupations, and other teacher factors were the barriers in the achievement of equity and inclusion. These factors were linked with each other. For example, long-distance families can afford to hire hostels near schools or pay for school transport, whereas poor families cannot afford to pay such costs. Thus, students from such families either drop out or do not attend school regularly. Poverty contributes to food deficits. It is difficult for a hungry learner to focus and gain the benefits of schooling. Parents' occupation linked with traditions is another factor that contributes to achieving equity and inclusion in education. For example, female students belonging to pastoralist households lack familial support, as girls' education is not considered important.

Poor infrastructure of school buildings proves to be a barrier to school children, especially those with special needs. Classes, laboratories, halls, toilets, etc., built a long time ago, may require renovation. Normal students' and teachers' stigma on students and teachers with disabilities was another factor that negatively impacted equity and inclusion. This factor has been linked with discouraging students with special needs to continue with their studies.

Wangio (2014) conducted a study in Kenya, a neighbouring country of Tanzania, and found that teachers' age and gender, academic and professional qualifications, teaching experience, teaching styles, and their perceptions towards inclusive education affected the implementation of inclusive education in public schools. Undoubtedly, these factors affect the teaching and learning of science subjects in Tanzania.

Shortage of teachers, especially in mathematics and science subjects, teachers' poor motivation, lack of learning and teaching materials, and inadequate library facilities were found to affect students' academic performance (Mhagama, 2015). Usage of unauthorized books, inadequate mentors, fewer STEM teachers, and reluctance in coping with the real-life situation in schools were some of the problems faced by teachers.

Students in Tanzania are currently not allowed to own or use mobile phones while in school. However, most of the students are day scholars and they may access ICT devices when they are at home or out of school. Students belonging to a marginalized category find it difficult to access ICT devices in their homes. Subsequently, marginalization culminates into a number of problems. If electronic devices are not available at school and if the school infrastructure is not supportive, then marginalized students can hardly access ICT devices for learning.

The situation gets worse when students from marginalized families and with special needs face the issue of the layout of infrastructure and facilities at their schools, apart from the aforementioned problems.

Factors influencing the performance of students from marginalized backgrounds

Undoubtedly, the factors affecting equity and inclusion of students from marginalized communities are likely to influence their performance. Secondary data reveals a number of factors that influence the performance of students from marginalized backgrounds. For example, Nyalusi (2013) conducted a study on factors affecting girls' performance in community secondary schools in Mbeya, Tanzania. Her study findings lead to the conclusion that lack of matrons and shortage of female teachers as role

models, lack and poor provision of physical facilities, hostels, social practices, and school timetable contributed to the poor academic performance among girls in community secondary schools.

Findings from the current study show that only 18 (23.7%) were females, whereas 58 (76.3%) were males, as shown in Table 2.14. Data collected from the field supports the findings of Nyalusi (2013) that female teachers are short in numbers to play as role models to female students.

Table 2.14. STEM teachers' gender

Gender	Frequency	Percent
Male	58	76.3
Female	18	23.7
Total	76	100

In general, school infrastructure, home environment, and teacher factors have a negative effect on children's self-confidence and positive attitude to learning. Factors, such as include lack of awareness on the part of teachers and school management, poor teaching approaches, budgeting, facility planning, and culture and traditions restrict equity and inclusion and lead to stigmatization of marginalized communities and people with special needs.

Challenges faced in teaching and learning for inclusion of students from marginalized backgrounds

Poor school infrastructure and facilities - Most school buildings are not structurally good, especially for teachers and students with special needs. Currently, the government has issued directives to all schools to take care of people with special needs, such as including stairs for people with disabilities to access all school facilities and look into possibilities of modifying the old buildings.

Teacher factors – Factors, such as inadequate teacher preparedness, were identified from the collected data. Table 2.15 and Table 2.16 show the time consumed for planning to teach, wherein 60.5% of the STEM teachers used five and fewer hours in planning to teach, while 52.6% used 12 and fewer hours in classroom teaching. This suggests that teachers are inadequately prepared.

Table 2.15. Average in planning teaching and assessing assignments (hours)

Hours	Frequency	Percent %
0	3	3.9
1	4	5.3
2	14	18.4
3	3	3.9
4	12	15.8
5	10	13.2

Table 2.16. Average classroom teaching workload per week (hours)

Hours	Frequency	Percent %
0	1	1.3
2	2	2.6
4	7	9.2
5	1	1.3
5	1	1.3
6	1	1.3
7	1	1.3
8	12	15.8
9	1	1.3
10	1	1.3
12	12	15.8

Other teacher factors, such as lack of punctuality, inadequate teaching approaches, inefficient teaching styles, reluctance to use technology in teaching and learning, and teachers' perceptions towards inclusive education, were the barriers to the implementation of inclusive education in secondary schools. All challenges fall under three main categories, namely, teacher factors, school factors, and student factors.

In order to overcome the challenges, teachers should plan their lessons for inclusive education, address competency-based aspects, and use technology to make teaching more interactive and meaningful for students. The government, private school owners, school management, and teachers should ensure learner-friendly teaching and learning environments, pay attention to people with special needs, and use ICT suitably. Teachers should be sensitized and trained about handling students from marginalized communities. Teachers should be trained on improvising contextualized competency-based teaching and use the available ICT optimally to maximize learning among students, including those from marginalized communities.

2.4.2 Educationally marginalized socio-economic groups

Official recognition of students and teachers from marginalized backgrounds

Students and teachers from marginalized backgrounds require official recognition because the country's constitution specifies that citizens have the right to be respected and developed to the maximum of their capacities. This is also emphasized in sections 3.3.1 and 3.3.2 of the Education and Training Policy (ETP) of 2014, which state that:

> *"3.3.1. Serikali itaendelea kuongeza fursa anuwai za elimu na mafunzo kwa usawa kwa makundi yote ya kijamii katika ngazi zote ikiwemo watoto wenye mahitaji maalumu."*

It means "the government will keep on increasing equal education and training opportunities to all social groups at all levels including children with special needs."

3.3.2. Serikali itaondoa vikwazo vinavyozuia fursa ya wanafunzi kuendelea na masomo na kukamilisha mzunguko wa elimu katika ngazi husika.

It means "the government will remove all barriers to students' opportunities in developing academically and completing all cycles of formal education at all levels."

Most of the secondary school students in Tanzania are living and studying in ward-based secondary schools, which are located in rural areas where access to electronic devices is relatively limited. Although not officially recognized, students living in rural areas may be considered marginalized in this stage of the country's development.

Categories of marginalization and the distribution of students and teachers

The categories of marginalization and the distribution of students and teachers across these backgrounds include hunters and gatherers, fishing communities, pastoralists' societies, orphans, and street children, who are out of school. Girls are also treated as a group that needs special attention due to social, cultural, and historical backgrounds.

Certain aspects, such as drop-out, non-enrolment, and repetition rates, have remained high, as indicated in Table 2.17. For example, drop-out was recorded at 25% in 2019 despite education being free.

Table 2.17. Number of dropouts in government/non-government schools by reason, grade, and sex, 2019

Grade	Reason										Total			% Of Total
	Death			Indiscipline			Pregnancy	Truancy						
	M	F	T	M	F	T		M	F	T	M	F	T	
Form 1	95	65	160	196	115	311	880	17,953	13,533	31,486	18,244	14,593	32,837	33.2
Form 2	117	95	212	458	239	697	1,536	19,494	17,400	36,894	20,069	19,270	39,339	39.8
Form 3	81	59	140	505	210	715	1,527	8,104	8,031	16,135	8,690	9,827	18,517	18.7
Form 4	50	44	94	288	91	379	1,331	2,799	2,979	5,778	3,137	4,445	7,582	7.7
Form 5	9	10	19	57	17	74	81	108	71	179	174	179	353	0.4
Form 6	13	10	23	94	26	120	43	88	47	135	195	126	321	0.3
G. Total	365	28	648	1,598	698	2,296	5,398	48,546	42,061	90,607	50,509	48,440	98,949	100
	0.4	0.3	0.7	1.6	0.7	2.3	5.5	49.1	42.5	91.6	51	49	100	

Source: BEST, 2020

Equity considerations for participants

Challenges faced by NQTs from marginalized communities while participating in this project and the solutions are discussed in this section. As previously stated, it is not easy to identify teachers from all categories of marginalization in Tanzania, wherein marginalization categories of gender and special needs could be easily noted. No teachers with special needs were found from all STEM teachers, who filled the questionnaire for situational analysis. Issues of marginalization among teachers in Tanzania

can be explained by gender, where only 23% of the teachers who filled the questionnaire were females (Table 2.12). All NQTs are likely to face similar problems in the context of Tanzania. The identified problems were a shortage of ICT devices and facilities in schools, overloaded timetable, lack of proper training on the integration of ICT in teaching, and lack of reliable internet connection at workplace and home. Most teachers owned smartphones though several devices were limited in functions, were of reasonable size for comfortable reading, and adequate storage capacity.

Therefore, the challenges faced may include devices with inadequate capacity to handle teaching and educational applications, unreliable connections in some areas, shortage of funds to buy internet bundles and stationeries, and overloaded school schedules. The marginalized NQTs can minimize these challenges by receiving support from their schools, projects, and well-wishers. Devices, such as desktops, laptops, tablets/iPads, internet connections/bundles, and training sessions, should be made available to marginalized NQTs. The CL4STEM innovation needs to be adapted to meet the needs of teachers with special needs.

Equity and digital inclusion

Data collected from interviews with quality assurers, school heads, and district education officers indicated mixed observations. Some participants said all NQTs were relatively good at using electronic devices at colleges/universities if they are to be compared with old teachers, irrespective of their socio-economic statuses. The category of teachers from marginalized families was not identified by the respondents; however, all NQTs were observed. All STEM teachers were considered the same, all were ICT literate, and therefore used the available facilities.

With regard to digital devices ownership, one school head said,

> *"Yes, our schools have no ICT devices such as computers for teachers but most teachers especially this dot.com generation (NQTs) for them better to miss meals rather than smart phones or tablets, and they are fast at using them. If there is any training which demands the use of the smart phones or tablets, I hope no NQT will miss it because of lack of these devices ..... they may miss training because of other reasons, such as lack of enough bundles and other personal factors"*

Findings from the situational analysis survey indicated that most STEM teachers owned smartphones (83%) and were computer literate. STEM teachers used WhatsApp (88%) mainly to communicate with friends and 53% of the sampled NQTs used smartphones for professional and teaching purposes.

Some schools and some NQTs, especially in rural areas, were living in houses without electricity. Some NQTs lived in rooms without electricity in urban areas, due to financial constraints. They were unable to hire good rooms to stay due to their family background and status and because they had many dependents. Some teachers were fortunate because their workstations were near their homes, and they were therefore not paying for rooms. The cost of living of such teachers was relatively lower, irrespective of their family and socio-economic background.

Measures for equitable participation

Since the criteria to identify marginalized students and teachers in Tanzania situation is contextual, it would be better to find ways of assisting all teachers and students. However, special attention should be paid to some people who can be identified as marginalized.

The usage of a holistic approach may be advantageous over other approaches in such situations. Students and teachers can be supported by improving school ICT infrastructure to suit all categories and they could be trained to learn the digital way of working and integrate ICT in teaching and learning.

Employers must find ways of supporting teachers and students to make use of ICT in a meaningful way. Government, communities, and other education-related stakeholders should put in efforts to ensure the availability of ICT equipment, facilities, and internet connectivity for teaching and learning in schools.

In order to control the challenges of equity and inclusion, some schools have designated counsellors to handle gender and other related problems in schools. In addition, school committees deal with challenges that may impede students' progress and academic performance.

Some NGOs, foundations, and good Samaritans assist marginalized groups in districts. For example, WELA deals with food and nutrition. Such NGOs should be identified and requested to collaborate with the CL4STEM project where necessary.

Internet service providers and electronic device dealers should be requested to provide service at an affordable price, as it would be beneficial to higher learning institutions, students, and communities.

2.4.3 Initiatives for equity and inclusion in education

Tanzania has signed several international agreements regarding children's rights to education, but few have been successfully achieved. The agreements include the Sustainable Development Goals (SDGs) and Education for All (EFA). Opini and Onditi (2016) maintain that the agreements have led to the establishment of a new policy that safeguards the interests of students with disabilities when it comes to the accessibility of secondary education. For example, government documents like the National Strategy for Growth and Reduction of Poverty (NSGRP) of 2005 and the National Policy on Disability (NPD) of 2004 stressed the government's commitment to ensure students with disabilities have access to secondary education (URT, 2010). Since then, various steps have been taken to improve the situation of equity and inclusion in education. One of such steps is the several versions of National Strategies for Inclusive Education.

Previous projects focused on equity and inclusion, and these were carried out in secondary schools across the country. Such projects include:

i) Tanzania Secondary Education Quality Improvement Program (SEQUIP)- March 2020-January 2026

The main goal of the project is to provide Tanzanian children with better, safer, and more accessible secondary education to build the country's human capital. Specifically, the project keeps children in

school and helps all secondary school dropouts, including pregnant girls, in pursuing their secondary education, and provides a formal public education system in the next cycle. Key CL4STEM-relevant learning from the SEQUIP project is to get NQTs to develop and implement the modules and benefit students retained in classes and dropouts (particularly marginalized ones).

ii) The Regional Education Learning Initiative (RELI) began in 2017 as a member-led initiative with a network of over 70 member- organizations in Kenya, Uganda, and Tanzania, with the sole aim of addressing the challenges that affect the education of children in East Africa. RELI since it aims to address the challenges that affect the education, of course, a competency-based teaching approach should be one something which is the ultimate aim of CL4STEM.

iii) Teacher Education in Sub-Saharan Africa (TESSA) - TESSA is a network of teachers and teacher educators stretching across Sub-Saharan Africa. A bank of open educational resources (OER) is at the heart of the network linked to the school curriculum and it is designed to support teachers and teacher educators in developing active approaches to learning. The network is coordinated by The Open University, UK.

The mission of TESSA is to make teaching more interactive, make school enjoyable for children, facilitate more learning, and encourage pre-service teachers to adopt and experience various approaches. TESSA materials (OERs) were produced in partnership with local African educational experts, some of whom were from the Open University of Tanzania. TESSA materials are free for everyone to use and adapt under a creative commons license. TESSA materials are used by communities located in individual schools and by institutions, though most teachers are not aware of the materials and even those who are aware may not be using them because of various reasons, particularly those connected with ICT usage. This project has contributed to the betterment of equity and inclusion issues in the country. CL4STEM project is expected to create awareness and the skills of using TESSA OERs materials are found in its portal (https://www.tessafrica.net).

No interventions are specifically aimed at supporting teachers from marginalized communities per se, but the ones indicated in the study serve the purpose, as they are part of CL4STEM in relation to the usage of other aspects, such as OERs.

2.5 Science And Maths Teaching And Learning In Secondary Schools

Factors affecting effective teaching and learning of science and maths in secondary schools

Various studies have been conducted on factors affecting effective teaching and learning of science and mathematics subjects in Tanzania. For example, the study of Itika et al. (2019) lists the following factors:

- **School-based factors -** Lack of library facilities, lack of ICT facilities, inadequate STEM teachers, lack of hostels, and lack of water and electricity
- **Home-based factors -** Household chores, long distance between school and home coupled with poor transport, limited moral and material support from families.
- **Social factors -** Girls' interest in science is influenced by the stereotyping of parents, relatives, and even teachers. Economic prospects also seem to influence the decision.

King'aru (2014) and Shimbi (2016) found that poor methodology in science education, negative attitude towards science subjects among students, and lack of resources, such as textbooks, teaching and learning materials, equipped laboratories, and students' attitude towards science subjects are the factors that affect teaching and learning of STEM subjects in Tanzanian secondary schools. The main reasons that contributed to the weak performance in the mathematics subject were the candidates' failure to apply correct formulae, rules, theorems, properties, and procedures, formulate expressions, inequalities, and equations from word problems, perform correct mathematical operations, draw diagrams and graphs, and interpret figures correctly (BEST, 2020).

Mazana, Montero and Casmir (2020) revealed that girls were underperforming in primary, lower secondary, and college examinations due to cultural factors. Ndume, Songoro and Kisanga (2020) asserted that the use of technology had no adverse impact on culture. Moreover, preliminary results on the mobile learning model showed that students' understanding of Mathematics considerably improved. Kisakali and Kuznetsov (2015) maintained that lack of interest in studying mathematics, triviality, lack of practice by students, lack of qualified mathematics teachers, and students' perception and attitude, made the subject difficult to learn. However, lack of interest and triviality were the most significant factors.

Factors influencing the performance of students in science and maths subjects and the reasons

Factors influencing the students' performance may be categorized into three major areas, namely, school factors, teacher factors, and students' home factors.

- Shortage of teachers - mostly noted in government-owned schools and the major reason is government budget
- Lack of technicians – The major reason is government and institutions budget
- Lack of students' interest in STEM subjects – reasons include poor teaching approach, stereotyping, e.g., girls, previous results, shortage of teachers, poor teaching approach etc.
- Shortage of STEM textbooks, teaching and learning resources – meagre government budget
- Shortage of good functioning laboratories with enough facilities and equipment- due to government budget
- Failure to take advantage of the use of technology in teaching and learning- Lack of awareness and training, negative attitude and lack of devices and facilities
- Absence and shortage of ICT devices and facilities- Lack of awareness and meagre budget
- Overcrowded classes – Shortage of teachers and insufficient classrooms

Challenges faced in science and maths teaching and the ways to overcome these challenges are listed

- Lack of students' interest in STEM subjects.
- Lack of resources for teaching and learning STEM subjects.
- Overcrowded classes
- In ability to complete the syllabus
- Quality lessons plan particularly where ICT is integrated
- Using ICT related resources to teach (implementation of the planned lesson)

- An alternative source of power is required in schools that do not have electricity.
- Deficiency in pedagogical and content knowledge and technical knowhow in competence-based teaching approaches

Competence-based teacher training programs and inclusive teaching and learning should be initiated and maintained to overcome these challenges. All obstacles that impede the use of technology should be solved to enable teachers and schools to take advantage of teaching and learning. STEM content needs to be updated and contextualized in the current environment. Relatively difficult concepts can have the corresponding ICT-enabled illustrations and simulations for students' understanding. Other suggestions include general enhancement in teaching-learning environments, classroom instructions, teaching skills, students' learning skills, an attitude of the community, and accountability of all involved parties.

Innovative pedagogical approaches used by teachers by using student-centered teaching and learning practices

Most teachers use traditional teaching methods of lecturing and employ the Socratic method of questions and answers with few cases of illustrations and experiments. Few teachers do use computer simulations as their technological pedagogical content approach, and some make use of field trips and real objects to teach. Generally, less work is done on innovative pedagogical approaches that could enhance and encourage students' engagements (pre-lesson, during lessons, and post-lesson).

Value and challenges of NQTs' participation in this intervention

All interviewed participants responded that this intervention would be valuable not only to NQTs but also to teachers, as these aspects of using competency-based inclusiveness and ICT in teaching are relatively new to teachers with more than five or ten years of experience.

2.5.1 Science and maths education practices

Language

English is the primary language of instruction for teaching in secondary schools. Swahili is the main language of Tanzanians, and it is informally used for teaching and learning in secondary schools.

Pedagogy

Many teachers use a teacher-centred approach, and few use a learner-centred approach. The data below show the types and extent to which various pedagogical approaches are used by teachers:

- Lecturing (mostly used)
- Question and answers (mostly used though not up to the required standard)
- Discussion (rarely - might be attributed to a large number of students in classes)
- Experimenting (rarely, only when final examinations are due shortly or when inspected)

Curriculum

The aims and objectives of secondary education in Tanzania are to (a) Consolidate and broaden the scope of baseline ideas, knowledge, skills, and attitudes acquired and developed at the primary educational level; (b) Enhance the development and appreciation of national unity, identity and ethics, personal integrity, respect for human rights, cultural and moral values, customs, traditions, civic responsibilities, and obligations; and (c) Promote the development of competency in linguistic ability and use communication skills in Kiswahili and at least one foreign language effectively. Other aims are to (d) Provide opportunities for the acquisition of knowledge, skills, attitudes, and understanding in prescribed or selected fields of study; (e) Prepare students for tertiary and higher education, vocational, technical, and professional training; (f) Inculcate a sense and ability for self-study, self-confidence, and self-advancement in new frontiers of science and technology, academic and occupational knowledge and skills; and (g) Prepare students to join the world of work.

Students joining secondary schools in Tanzania are supposed to take nine subjects, namely, Mathematics, English, Kiswahili, Biology, Civics, Physics, Chemistry, Geography, and History. Students in form III (Grade 11) are allowed to select one of the following optional bias subjects: Science, Business, Agricultural Science, Technical, and Home Economics. Thus, students opting for Science continue with Physics and Chemistry, while those not opting for Science could drop those subjects.

Ndalichako and Komba (2014) revealed that the choice of optional subjects is not a matter of students' decision in some cases, and it depends on the availability of such subjects in their schools. Due to the unavailability of teachers and insufficient teaching and learning facilities, some optional subjects are offered on a small scale within a limited number of schools and Information and Computer Studies (ICS) is one such optional subject. Table 2.18 shows the number of periods per week for STEM subjects at two levels.

Table 2.18. Subjects taught from the form I to IV and the corresponding number of periods per week

Level 1 - Form I (Grade 9) and Form II (Grade 10)			**Level II- Form III (Grade 11) and Form IV (Grade 12)**		
S/N	**Subject**	**Number of Periods Per Week (1 period =40 min)**	**S/N**	**Subject**	**Number of Periods Per Week (1 period =40 min)**
1	Mathematics	6	1	Mathematics	6
2	Biology	3	2	Biology	3
3	Physics	3	3	Physics	4
4	Chemistry	3	4	Chemistry	4

Source, TIE (2017)

According to TIE (2017), the general competencies by the end of the four-year course are:

i. **Mathematics -** The student should have the ability to:

- Think critically and logically in interpreting and solving problems.
- Use mathematical languages in explaining and clarifying mathematical ideas.

- Apply mathematical knowledge and techniques in other fields.

ii. **Biology -** The student should have the ability to:

- Make appropriate use of biological knowledge, concepts, skills, and principles in solving various problems in daily life.
- Record, analyse and interpret data from a scientific investigation using appropriate methods and technology to generate relevant information in biological science.
- Demonstrate knowledge and skills in combating health-related problems, such as HIV/AIDS, drug and drug abuse, sexual and reproductive health.
- Access relevant information on biological science and related fields for self-study and life-long learning.

iii. **Physics -** Students should have the ability to:

- Use Physics knowledge, principles, and concepts in daily life.
- Apply scientific methods in solving problems in daily life.
- Apply technological skills in interacting with the environment.
- Manage simple technological appliances.
- Use the language of Physics in communication.

iv. **Chemistry -** The student should have the ability to:

- Develop knowledge in Chemistry by doing various activities and experiments.
- Apply chemical symbols, formulae, and equations to communicate in Chemistry.
- Apply Chemistry knowledge skills and principles to solve daily life problems.
- Using science and technological skills in conserving and making sustainable use of the environment.

Resources

The main resources used by teachers are the books prepared by the Tanzania Institute of Education (TIE), which is mandated to publish books, and write, evaluate, and approve textbooks to be used in schools. All STEM subjects have books in place which are published by TIE as follows:

- **Physics -** Physics Forms 1 and 2 Students' Book; and Physics Forms 3 and 4 Students' Book.
- **Chemistry -** Chemistry for Forms 1 and 2 Students' Book; and Chemistry for Forms 3 and 4 Students.
- **Biology -** Biology Forms 1 & 2 Students' Book; and Biology Forms 3 & 4 Students' Book.
- **Mathematics -** Secondary Basic Mathematics Book 1, Book 2, Book 3 and Book 4.

Other resources to be used are recommended in the syllabus documents. Many teachers depend on the books published by TIE. However, some teachers, especially those working in private secondary schools, supplement TIE books with other material resources from other sources, like using Google and other search engines.

Writing and evaluating supplementary books are lawfully issued under the government authority pursuant to Sections 4 (d) and 21 (1) of the Tanzania Institute of Education Act (CAP 142 R. E. 2002).

2.5.2 Teacher proficiency in science and math education

Technical support provided to teachers and students on teaching and learning STEM

Teachers will be supported in a number of ways. For instance, budgets can be set for the procurement of facilities, equipment, and teaching and learning resources. Schools can provide opportunities to participate in science competitions and exhibitions by giving ample time to design and prepare projects and by providing funds to buy materials and lab apparatus and facilitate transport and subsistence allowances. In short, schools must try their level best to support because they must ensure all teachers and students are doing well academically.

Effective use of STEM labs for teachers trained in STEM pedagogy

Teachers well trained in STEM technological, pedagogic, and content knowledge are likely to use STEM labs effectively, since the training is expected to facilitate teachers with a competence-based teaching approach that emphasizes learning by doing. It is anticipated that participants would be able to change their mindset and would be positive with the use of STEM labs by the end of the training because one cannot teach STEM subjects effectively without using STEM labs. In addition, none of the teachers would waste their time and energy by using traditional methods of teaching because they would be trained to integrate ICT in teaching and because STEM teachers would be ICT literate and would be using electronic devices. For instance, the usage of digital devices to project video clips simplifies teaching and learning. If teachers use technology, their pedagogical content knowledge and skills would improve.

Teachers' professional development in STEM-related training for the past three years

According to the findings from the data collected from STEM teachers for the past three years, only 9 of the 76 sampled teachers (10.9%) have attended at least one STEM-related training program while 68 (89.1%) STEM teachers have not attended any training program (Table 2.19).

Table 2.19. STEM teachers' Professional Development Programs in 2018, 2019, & 2020

Year	Frequency and Percentage of those who have attended at least one program		Frequency and Percentage of those who have not attended any Program	
	Frequency	Percentage	Frequency	Percentage
2018	9	11.80%	67	88.20%
2019	8	10.50%	68	89.50%
2020	8	10.50%	68	89.50%
Average		10.90%		89%

Field Data (2021)

Professional development is required for STEM teachers in secondary schools and this need is further identified by interviewees as follows:

- Training on relatively difficult topics – for example, development of the corresponding ICT enabled illustrations, simulations, etc. – for internalization and understanding of the concepts

- Development of an approach that encourages student engagement (pre-lesson, during lesson, and post-lesson) rather than just teaching, which is also in line with the required competency-based teaching and learning.
- Competency-based teaching approach, training, and practical works.
- Capacity building to use ICT-related resources optimally.

Generally, digital literacy, competency-based and inclusive teaching and learning, and integration of ICT in teaching and learning are topical aspects in any of such interventions and these are certainly welcomed.

Challenging science and mathematics topics for secondary school teachers

In the course of this study, a number of STEM topics or subtopics that were challenging for secondary school teachers and consequently students were listed by the interviewed school quality assurers and teachers, as indicated in Table 2.20.

Table 2.20. Challenging Science and mathematics topics for secondary school teachers

Subject Name	Difficulty Topics/ Subtopics Identified by Quality Assurers	Difficulty Topics/ Subtopics Identified by STEM teachers	Common Difficulty Topics Identified by both STEM teachers & Quality Assurers
Biology	Classification	Coordination	Coordination
	Food test experiments	Transport	Transport of materials in living things
	Excretion	Excretion	Excretion
	How to preserve biological natural specimens for future teaching/learning	Protein synthesis	Genetics
	Genetics	Respiration	
	Transport of materials in living things	Photosynthesis	
	Coordination	Cell division	
	Growth in plants	Hormone regulation, oxygen transport and genetic manipulation	
Physics	Waves	Motion in two dimensions	Magnetism
	Electromagnetic spectrum	Gravity, Circular and rotational motion	Electricity
	Radio activity and nuclear atom	Statistical mechanics	
	Electronics	Electricity and magnetism	
	Electricity		
Chemistry	Qualitative analysis	Extraction of metals	Qualitative analysis
	Components of non-metals	Ionic theory and Electrolysis	Extraction of metals
	Organic chemistry	Scientific procedure	Electrolysis

Subject Name	Difficulty Topics/ Subtopics Identified by Quality Assurers	Difficulty Topics/ Subtopics Identified by STEM teachers	Common Difficulty Topics Identified by both STEM teachers & Quality Assurers
	Volumetric analysis	Energy and fuels	Chemical kinetics
	Chemical kinetics	Ionic theory	Electrochemistry
	Extraction of metals	Electrolysis:	Organic chemistry
	Electrolysis	Organic chemistry	
	Electrochemistry	Equilibrium	
		Chemical kinetics	
		Electrochemistry	
		Qualitative analysis	
Mathematics	Circle and sphere	Three dimensions	Three dimensions
	Probability	Circle and sphere	Circle and sphere
	Accounts	Congruent and similarities	Congruent and similarities
	Functions	Accounts	Accounts
	Linear programming	Geometry	Probability
	Matrix	Algebra	
	Congruency & similarities	Calculus	
	Three dimensions	Topology logic	
		Probability and number theory	

As can be seen in Table 2.20, some of the topics were identified by both school quality assurers and STEM teachers. Thus, the CL4STEM project should be given more priority when developing STEM modules in the envisaged intervention.

2.5.3 Science and maths education learning infrastructure and resources

Status of secondary schools in terms of STEM labs

The Science laboratory is an important resource input for teaching science. Access to science laboratories is essential for grounding science knowledge in practice, promoting critical and creative thinking, and providing access to higher educational opportunities. Learning chemistry, biology, and physics from textbooks limits their potential. Efforts have been made over the years on this aspect and Table 2.21 shows the total number of science laboratories required and available in all government schools in the academic year 2020-21. As shown in the table, a significant number of labs are available across the country, but a shortage of 1874, 1731, and 2075 laboratories could be identified for Biology, Chemistry, and Physics, respectively. In addition, data collected for this situation analysis report indicated that a majority of involved schools (94.1%) had some sort of Chemistry laboratory (definitive and improvised ones) and only a few schools (11.8%) had no Physics and Biology laboratories. Moreover, only four secondary schools (23.5%) had resource rooms for Mathematics. In terms of the status of these laboratories, 17 heads of schools from 6 districts were interviewed and those from community secondary schools pointed out that Biology and Physics laboratories lacked important apparatus and equipment, such as gas systems. In addition, most government schools did not have laboratory technicians. In contrast, all private secondary schools had laboratory technicians and excellent laboratories in terms of standard buildings, space, apparatus, and equipment.

Table 2.21. Number of science laboratories in all government schools as of 2020

Total Number of Secondary Schools	Biology Laboratory			Chemistry Laboratory			Physics Laboratory		
	Needed	Available	Shortage	Needed	Available	Shortage	Needed	Available	Shortage
3,863	3,930	2,056	1,874	3,927	2,196	1,731	3,927	2,075	2,075

Source: BEST, 2020

STEM resources included in the curriculum for efficient teaching and learning

Apart from teachers, teaching and learning resources are the most important resources required at the classroom level. Learning resources at the secondary school level are divided into two categories, namely textual and non-textual. Textual resources for STEM learning include textbooks, syllabi, modules and manuals, reference books, NECTA review question books, charts, and maps. On the other hand, non-textual resources include laboratory apparatus, prototypes, tools, chemicals, writing boards, illustrations, samples of actual materials, and ICT resources, such as computers, internet connectivity, photocopying machines, printers, and scanners (TIE, 2007). However, data collected for this situation analysis report indicated that resources available for STEM teaching and learning in public schools included science laboratories (Chemistry, Biology, and Physics), a few ICT devices, and some books for both science and mathematics subjects. On the other hand, private schools had most of the required resources, such as desktops, laptops, and tablets connected with the internet. In most public schools, the few available computers were mostly used for administrative purposes and not for teaching and learning. For example, 10 schools (58.8%) had a computer room equipped with either laptops or desktop computers. Thirteen out of 17 schools (76.5%) had projectors and 14 schools (82.4%) had printers and copiers. Twelve schools (70.6%) had no tablets and 14 schools (82.4%) lacked smart boards. Further analysis indicated that computer was the only ICT tool that was used to teach STEM subjects.

Source of STEM teaching resources to secondary school teachers

Tanzania Institute of Education (TIE) is a public institution under the Ministry of Education, Science and Technology. The Institute is responsible for interpreting government policies on education to befit curriculum programs and instructional materials and to provide quality education at pre-primary, primary, secondary, and teacher education levels. The main functions of TIE include the design and development of curricula for pre-primary, primary, secondary, and teacher education levels. TIE is expected to provide and oversee teaching methods, objectives, standards, and content of teaching and learning materials. Therefore, secondary school teachers get their STEM teaching resources from the academic offices in their respective schools, but TIE is responsible for designing resources (syllabi, curriculum, and textbooks) for schools. TIE also verifies and certifies the reference books to be used in secondary schools.

Teaching responsibility at secondary school

Teachers are assigned subjects at the secondary school level to teach according to the area of specialization and qualification. Normally, STEM teachers have two teaching subjects, but a teacher can teach only one subject (Physics or Chemistry or Biology or Mathematics) or two subjects (Physics and Mathematics, or Mathematics and Chemistry, or Physics and Chemistry, or Chemistry and

Biology), depending on the availability of teachers. For example, data collected for this situation analysis report indicated that a majority of teachers (23.7%) teach only one subject (Mathematics), while Chemistry and Biology (13.2%) were preferred the most for a combination of two subjects. On the other hand, a teacher can teach one class or more, depending on the number of teachers available. For example, the data collected for this situation analysis revealed that a majority of teachers (39.5%) teach more than one class.

In terms of teaching load, the optimum teaching load for an ordinary secondary school teacher is a maximum of 24 periods per week and 5 periods per day, which is equivalent to 16 hours per week and 3.2 hours a day, respectively (TIE, 2007). All teachers are engaged in professional/teaching duties between 8.00 am and 2.30 pm. Teachers prepare for teaching, mark assignments, and participate in supervising extracurricular activities that can be during or after classes. Teachers in boarding schools have additional responsibilities than teachers in the day school.

Teachers' flexibility in teaching

The ordinary level secondary education curriculum is organized into key learning areas from which the teaching subjects are generated. Teachers have to teach according to the topics outlined in the syllabus. Each topic is divided into several subtopics and each subtopic has one or more specific objectives. These specific objectives are the expected outcomes and reflect the process to attain competencies within the cognitive, affective, and psychomotor domains (TIE, 2007). Therefore, teachers do not have flexibility in choosing the topic, but they have to follow government-prescribed syllabus. However, a teacher may decide to re-arrange subtopics to attain a contextual and logical order starting from the simple to the most difficult ones.

Online modules feasible implementation schedule

In Tanzania, the CL4STEM project is implemented in ordinary level secondary schools. The Tanzanian school calendar for ordinary level secondary education begins in January and has two main terms (January to June and July to December) with a total of 194 days of teaching and learning (TIE, 2007) with a short midterm. Data collected for this situation analysis report from DEOs and heads of schools in the selected districts and councils indicated that NQTs were allowed to participate in this project and the possible schedule for implementing online modules was during the school calendar or after classes or on Saturdays. This was because heads of schools can monitor the effective participation of teachers and it was cost-effective to the project. However, the main challenge in the implementation of this project, especially on the ICT component, was the lack of ICT infrastructure in most of the secondary schools. In addition, teachers need to be facilitated with basic means, such as internet connectivity, so that they can access online modules.

2.5.4 Science and maths education initiatives

The Ministry of Education and Vocational Training took the initiative of developing and digitizing science and mathematics materials in difficult areas that were intended for use to improve teaching and learning in ordinary level secondary schools in 2015. This project was called retooling and was funded by the World Bank. Retooling projects generally aimed at building institutional mechanisms and capacities to apply ICT in teacher training through a pilot training program that upgraded the

content knowledge of Science and Mathematics teachers in difficult topics. Digital materials were designed and packaged in such a way that they were self-exploratory, and secondary school Science and Mathematics teachers were capacitated on how to use them and increase effectiveness. It was learnt that content development in difficult areas of Biology, Chemistry, Physics and Mathematics indicated a positive impact on retooled trainees. It was proposed that the output should be scaled up to the remaining secondary teachers in these subjects. Teachers were expected to raise the level of their understanding and eventually their students' pass rate and gain competencies. The CL4STEM intervention may gain from this project in terms of difficult areas, capacity building related to ICT integration, scalability, and sustainability after the end of the project.

2.6 Stakeholders

The success of a project depends on how comprehensively and efficiently the project key stakeholders are engaged. The following are the key stakeholders of this project in relation to Tanzania. Two ministries, namely, the Ministry of Education, Science and Technology (MoEST) and the Ministry of President Office, Regional Administration and Local Government (PO-RALG), function at the national level. At the regional administration and local government authorities, the stakeholders are from a sample of six zones, a district in each zone, and three schools in each district council.

Central and local government, regulators, professional bodies, and research councils

- Ministry of Education, Science and Technology (MoEST) – provides policy and ensures quality.
    - Division of basic education (teachers' training and schools' accreditation)
    - Division of schools (secondary) Quality Assurance - Six selected MoEST zones of secondary education quality assurance: Northern (Located in Arusha), Lake zone (Located in Mwanza), Southern highlands (Located in Iringa), Southern (Located in Mtwara), Eastern (Located in Dar es Salaam), and Central (Located in Dodoma).
- Ministry of President Office, Regional Administration and Local Government (PO-RALG) – manages basic education including the secondary schools
    - Secondary education section - part of education administration division
- Local government authority and secondary schools: This category of key stakeholders comprises DEOs of secondary schools for each district sampled and the head of three schools sampled in each district. These three sampled secondary schools in each district comprised government-managed public schools, community public schools, and private schools.
- Dodoma Municipal Council
- Msalato, Chinangali and Maria de Mattias Secondary schools
- Mtwara Municipal Council
- Naliendele, Mtwara Sisters and Shangani Secondary schools
- Nyamagana (Mwanza)
- Mwanza, Igelegele and Lake Secondary schools
- Kalenga (Iringa)
- Kalenga, Isimani and St. Dominic Secondary schools
- Arusha DC
- Iliboru, Enyoito and Enaboishu Secondary schools
- Ilala Municipal Council

- Michikichini and Pugu Secondary schools
- Tanzania Institute of Education (TIE)
- National Examination Council of Tanzania (NECTA)

Institutions offering teacher education programs for secondary school teachers

A number of teacher education providers are involved as representatives in the category of Universities and Teacher training colleges.

- Open University of Tanzania
- University of Dar es Salaam
- Tumaini University Dar Es Salaam College
- Kampala International University
- University of Dodoma
- Technical and Vocation Education Training (TVET)
- Tabora Teachers College
- Mpwapwa Teacher's College (https://www.mpwapwatc.ac.tz)
- Monduli Teachers College (http://mondulitc.ac.tz)

Development agencies and other non-governmental organizations

A number of organizations are involved in STEM teaching, ICT in education, and teacher professional development, which are as follows.

- United Nationals Development Projects (UNDP)
- United Nations Education, Science and Culture Organization (UNESCO)
- World Bank
- United States of America Aid (USAID)
- Japan International Cooperation Agency (JICA)
- Tanzania Education Authority (TEA)
- Tanzania Library Services Board (TLSB)
- Tanzania Education Network (TENMET)
- Human Development Innovation Fund (HDIF)

Other organizations with opinion leaders

The following are the organizations with leaders and mandates that might have an impact on the acceptability and scalability of this project output in future.

- Christian Social Services Commission (CSSC)- https://cssc.or.tz
- National Muslim Council of Tanzania (BAKWATA) - https://bakwata.or.tz
- Universal Communication Fund (UCSAF) - http://www.ucsaf.go.tz

3 About The Open University of Tanzania (OUT)

OUT - CL4STEM synergies

The Open University of Tanzania (OUT) is a fully-fledged, autonomous, and accredited public University in Tanzania. It is an Open and Distance Learning (ODL)-based University that has centres in all regions in the country and beyond. It has the vision to be a leading open online University in knowledge creation and application, and with a mission to provide relevant, quality, flexible, accessible, and affordable open online education, research, and services to the community for the social and economic development of Tanzania and the rest of the world.

The University provides affordable quality education for all, mainly through blended learning that allows both face-to-face and online learning, thereby providing flexibility to students to study from anywhere in the country and beyond. The syllabus is for certificate, diploma, and undergraduate to postgraduate degrees through its five faculties and two institutes. The faculties and institutes are Faculty of Arts and Social Sciences; Faculty of Business Management; Faculty of Education; Faculty of Law; Faculty of Science, Technology and Environmental Studies; Institute of Educational and Management Technologies; and Institute of Continuing Education. It also operates with a number of centres with internal, national, regional, and international perspectives including the African Council for Distance Education – Technical Collaboration Committee (ACDE TCC) and UNESCO chair on Teacher Education and Curriculum.

ICT and STEM teacher professional development

OUT is participating through UNESCO chair on Teacher Education and Curriculum in the CL4STEM project. The project members are mainly from Faculties of Science and Education, with expectations to enhance secondary school teachers' technological, pedagogical, and content knowledge. This enhancement will in turn contribute to quality teaching of Mathematics and Science in the country. This is a part of OUT's vision and mission that includes knowledge application and service provision to the community.

The overarching aim of the CL4STEM project is to strengthen STEM education in Tanzania and the participating countries as a whole by building capacities of secondary schools' NQTs in Science and Mathematics. This can be achieved by fostering higher-order learning in classrooms considering that no child is left behind in learning. The STEM faculty from science and education is coordinated by the UNESCO chair on Teacher Education and Curriculum and they are engaged in developing OER in STEM discipline that is aligned to achieve the aim of CL4STEM. The aim of CL4STEM is aligned with the OUT's vision to be a leading open online University in knowledge creation and application that leads to service provision to the community, in this case, schools' STEM teachers and associated supporting and learning communities.

OUT's academic staff attend various training related to ICT in education organized by OUT or other partners. Furthermore, there have been internally and donor-funded research and development projects that support ICT infrastructure development, such as the provision of computers and

improvement of network and connectivity, internally, nationally, and internationally, as well as ICT-related research on areas of interest to advance education and society as a whole.

Swedish International Development Agency (SIDA): SIDA supported purchasing ICT equipment, such as computers, printers, photocopiers, scanners, and construction of computer labs and LAN setup at 13 OUT regional centres. SIDA supported the training of all OUT staff on ICT literacy and ICT carrier development.

OER activities: OUT took the support of the South African Institute for Distance Education (SAIDE) and OER Africa and researched, developed, and launched OER-based policy and digital fluency courses for the academic staff. Other training on converting study materials into OERs were conducted. OUT customized and deployed Moodle in partnership with UNESCO and developed OER-based content for teacher colleges that are currently used.

UNESCO COL Chair Activities: Three different training were conducted under UNESCO COL Chair Activities, which were led by OUT. These training were:

i. Training of Directors of the Regional Centers (DRCs) of the Open University of Tanzania on online course development skills,
ii. ICT training to visually impaired persons,
iii. Training of OUT academic staff on knowledge and skills of integrating multimedia technologies, which include manipulating audio, video, and image/graphics into their respective online courses

EPICA project: OUT participated in the EPICA (Strategic Partnership for the Co-design of an Innovative and scalable ePortfolio ecosystem to improve the quality and visibility of skills) project. The project aim was to address the employability skills gap through a process of co-design, adaptation, implementation, and validation of an innovative and scalable competency-based ePortfolio. This was done with an international partnership that included industries, leading educational organizations, four universities (The Open University of Tanzania, Makerere University from Uganda, Maseno University from Kenya, and the African Virtual University) in three sub-Saharan countries and one EU University (Open University of Catalonia).

UNESCO Chair on teacher education and curriculum: Training of OUT academic staff on knowledge and skills of online teaching/facilitation, and using collaboration tools (e.g., Zoom) for handling effective teaching during the COVID-19 pandemic lockdown. The same tools are used after the lockdown to deliver lectures to both postgraduate and undergraduate students. This also applies to student orientations, and Masters and PhD proposal presentations. Furthermore, the arrangement is used to handle various meetings in the University, which allows many to participate from wherever they are and to handle many activities of this project (CL4STEM) across all participating countries and Universities.

Technology readiness to offer NQT online modules

OUT academic staff offer online courses using Moodle Learning Management System (LMS) and attend training on educational technologies, integration of ICT in education, instructional designing,

and online teaching/facilitation. Subsequently, OUT academicians have a competitive advantage to offer NQT online modules using Moodle LMS and cope with any prevailing online learning platform. Moreover, the presence of ICT and e-learning support teams and systems at OUT contribute to an ideal environment to offer online modules successfully. This is also testified with the award received by OUT recently (October 2021) on *"Best ICT Transformative Training Institution in the Country"* during ICT awards of various categories in the Tanzania ICT professionals' conference, 2021 (https://taic.ictc.go.tz).

Relationships with stakeholders

OUT offers a number of educational programs to both pre-service and in-service teachers. Graduates benefit from their services and these become the stakeholders. These programs are Certificate and Diploma in Early Childhood Education (CECE/DECE), Bachelor of Education (Special Education), Bachelor of Education (Teacher Education), Bachelor of Education (Adult and Distance Learning), Bachelor of Education (Policy and Management), Bachelor of Arts with Education (B.A. Ed), and Bachelor of Business Administration with Education (BBA ED). Other programs are Post Graduate Diploma in Education (PGDE), Master of Education (M.Ed.), Master of Education in Administration, Planning and Policy Studies (M.Ed. APPS), Master of Education in Open and Distance Learning (M.Ed. ODL), Master of Education in Quality Management (M. ED QM), and a number of specialized areas for Doctor of Philosophy (PhD). Yet other programs showing related key stakeholders are Post Graduate Diploma in Curriculum Design and Development (PGDCDD) that started as a collaborative program among OUT, UNESCO, and Tanzania Institute of Education (TIE) and was later upgraded to Master of Education in Curriculum Design and Development (MED CDD), which attracts students from different parts of the continent, mostly supported through UNESCO sponsorship (https://www.out.ac.tz/medcdd). OUT in partnership with Technical and Vocational Teacher Education (TVTE) offers Postgraduate Diploma in Technical and Vocational Teacher Educator (PGD TVTE), thereby strengthening pedagogical aspects in technical vocation training too (https://www.out.ac.tz/pgd-tvte).

Due to these educational programs offered by OUT or in collaboration with other stakeholders along with professional interactions with government and non-government organizations and other engagements, the education sector has created a number of relationships, such as:

- Tanzania Institute of Education (TIE) on partnership in running some programs together
- UNESCO on in running some programs together including sponsorship and creating further collaboration with its sister institutions
- VETA in running TVET for educators, thereby creating a mass of educators in this area, which is important for supporting the country's industrialization drive
- Ministry of education, science, and technology in producing more graduates for secondary school teachers, especially in STEM, and special education, which has a deficit.
- Several secondary teachers, heads of schools, district education officers, regional education officers, and secondary education quality assurers are currently serving in the education sector (public and private) in the country. These are either graduates of OUT or working students of OUT.
- Some of the faculty at OUT, among others, are involved in STEM-related school curriculum and learning material development, which is organized by TIE.

Profile of key teacher educators and ICT team members engaged in CL4STEM

A number of key teacher educators, advisors, and ICT technical team members are involved in this intervention. The list is shown in Table 3.1.

Table 3.1. Profile of teacher educators, advisors & ICT technical team engaged in CL4STEM

S No.	Name	Position title	Academic Qualification	Area of Specialization
Academics – Teacher's educators and advisors in a projector				
1	Prof Elifas Bisanda	Professor, Vice-Chancellor, UNESCO Chair and Advisor	B.Sc. (Eng) (UDSM); M.Sc. Materials (Cranfield, Bedford UK); PhD. Comp. Materials (Bath, UK)	Physics/ Research/ Dissemination
2	Prof Deus Ngaruko	Associate Professor, Deputy Vice-Chancellor Academics and Advisor	B.Sc. (Agric. Economics) Makerere University; M.Sc. (Agric. Economics) SUA; DIC (Economics) & Ph.D. (Econ) Imperial College London, UK.	Agric. Economics/ Research
3	Dr Edephonce Nfuka	Lecturer, UNESCO chair coordinator and OUT Overall project leader	B.Sc. Automatic control & Computer Eng. (Havana, Cuba); M.Sc. Software Eng., (Barcelona), Ph.D. (Stockholm)	ICT/ Education/ Research
4	Dr Paul Ikwaba	Senior Lecturer, Knowledge transfer leader, and Physics subject lead	B.Sc. Maths/Physics; MSc. Physics (UDSM); Ph.D. Physics (Ulster, UK)	Physics/ Research/ Education
5	Dr Felix Mulengeki	Senior Lecturer, UNESCO chair Coordinator & leader of Innovative diffusion research	Cert. in Edu. (Songea); Dip. Ad/Educ (IAE); B.Ed.; M.A.(Ed) (Dar); PhD (OUT)	Education/ Research
6	Dr Matobola Mihale	Senior Lecturer, Dean of Faculty of Science, and knowledge dissemination leader	B.Sc. (Ed) Hons; M.Sc. Chemistry (UDSM), Ph.D. Chem (VUB, Belgium)	Chemistry/ Research/ Education
7	Dr Seleman Ismail	Lecturer and Mathematics subject lead	Dipl. Education (Klerruu); B.Sc. Mathematics (Hons) (OUT); M.Sc. Mathematics & Computational Science (NM-AIST); PhD. Applied Mathematics & Computational Science (NM-AIST).	Mathematics/ Education
8	Dr James Mutasingwa	Senior Lecturer and Chemistry subject lead	B.Sc. (Ed) Chem/Physics: MSc. Physical Chemistry (UDSM), PhD Chemistry (UDSM)	Chemistry/ Education

S No.	Name	Position title	Academic Qualification	Area of Specialization
9	Dr Hassan Mateka	Lecturer	B.Sc. (Ed); M.Sc. Environmental Sc. (UDSM), PhD (UDSM)	Biology/ Education
10	Dr Josephat Saria	Senior Lecturer	B.Ed. (UDSM); M.Sc. Chemistry (UDSM); PhD. Chemistry (Univ. of New Mexico, USA)	Chemistry/ Education
11	Dr Harrieth Hellar Kihampa	Senior Lecturer	: BSC(Ed); MSc (UDSM); PhD (Antwerp – Belgium	Chemistry/ Education
12	Dr Rweyendera Ngonge	Lecturer and Impact study leader	BSc (HE &HN) (SUA), PGDE; M.A Ed. (Dar), PhD (OUT)	Chemistry/ Research/ Education
13	Dr Saidi Massomo	Senior Lecturer and Biology subject leader	B.Sc. Agric. (SUA); PG Dip. (Danish Government Institute); PhD. Plant Pathology (Royal Vet. & Agric University, Denmark)	Biology
14	Dr Yohana Lawi	Senior Lecturer	: B.Sc. (Ed.) (Hons); M.Sc. (Environ. Sc.); Ph.D. (UDSM)	Biology/ Education
15	Ms. Neema Magambo	Assistance Lecturer	B.Sc. (Ed) (UDSM); M.Sc. (Env. Studies) OUT; PhD (ongoing)	Biology/ Education
16	Dr. Agatha Mugogo	Lecturer	BSc (Ed), M.A Ed. (Dar), PhD (OUT)	Biology/ Education
17	Mr Fastine Nziku	Assistance Lecturer	B.Sc. (Molecular Bio and Biotechnology); M.Sc. (Botany) UDSM, PhD (Ongoing)	Mathematics
18	Mr Michael Peter	Assistance Lecturer	B.Sc. (Hons) Mathematics (OUT), MSc (Mathematics)	Mathematics
19	Mr. Mustapha Kiswanya	Assistant Lecturer	B.Sc. Ed (Univ. of Zanzibar), M.Sc. Mathematical Modelling, (UDSM)	Mathematics/ Education
20	Ms. Mary Swai	Assistance Lecturer	Dipl. Education (DTC); B.Sc. Mathematics and Economics (OUT); M.Sc. Mathematical Modelling (UDSM); PhD (ongoing)	Mathematics/ Education
21	Mr. Jalal R. Simkoko	Assistant Lecturer	B. Eng. in Electronics and Microelectronics. M. Eng. in Electronics and Microelectronics (Kazan State Power Engineering University, Russia)	Physics
22	Mr Salamba Kashinje	Assistant Lecturer	B.Sc. Ed (Hons) (DUCE), MSc (Ongoing)	Physics/Education
23	Mr Yusuf Muhangwa	Assistant Lecturer	B.Sc. Ed. (UCE, Zanzibar); M.Ed. (Science) Dar	Physics/Education

S No.	Name	Position title	Academic Qualification	Area of Specialization
ICT technical team				
1	Mr Shadrack Mbogela	Senior ICT expert	Adv. Dipl. in IT (IAA) Arusha, M.Sc. IT (finalizing it)	ICT, ICT in Education

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