CAUSES AND IMPACTS OF THE SCARCITY OF SCIENCE AND MATHEMATICS TEACHERS ON EDUCATION IN TANZANIAN SECONDARY SCHOOLS

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Approval of the Thesis

CAUSES AND IMPACTS OF THE SCARCITY OF SCIENCE AND MATHEMATICS TEACHERS ON EDUCATION IN TANZANIAN SECONDARY SCHOOLS

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Abstract

CAUSES AND IMPACTS OF THE SCARCITY OF SCIENCE AND MATHEMATICS TEACHERS ON EDUCATION IN TANZANIAN SECONDARY SCHOOLS

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This study examined the reasons and the impacts of the scarcity of mathematics and sciences trainers on education in Tanzanian secondary schools. The goals of the current research were to uncover the causes of the shortage of mathematics and science trainers in secondary schools and their effects on these schools.

The study used a mixed-methods research approach. To be able to collect quantitative data, questionnaires were employed, and to gather qualitative information from the common people at the grassroots, interview questions were used. The data were examined using percentage frequencies as well as thematic data analysis.

Moreover, students' performance and passion for learning science and mathematics are affected to some extent by the lack of scientific and mathematical teachers in secondary schools, which alters their decision to pursue studies in the arts rather than these courses. The research also showed that a scarcity of graduates in mathematics and scientific subjects, students' preference for scientific-related careers, students' avoidance of studying science and math, the unemployment rate in the nation, and insufficient educational facilities were all contributing causes of the shortage of science and math teachers.

The study found that the effects of a lack of scientific and mathematical teachers included poor performance, a dearth of graduates in those fields, students who showed little interest in those disciplines, and a high teacher-to-student ratio. Other factors were the beliefs of students that math and science were difficult to study, students asking for help from outside the classroom, as well as unfinished syllabi. The study also discovered a cyclical relationship between the causes and consequences of teacher shortages in science and mathematics on education in secondary school performance in Tanzania.

The study recommended that every stakeholder involved in education plays a part in addressing Tanzania's secondary schools' impact on the lack of science and math instructors. Also, the use of the blueprint may elevate the teaching profession and alleviate the insufficient number of teachers in math and science subjects.

Keywords: *Science, Mathematics, Scarcity, Impacts, and Tanzania*.

Declaration

I, Josephine Donald Mremi, declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

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Copyright

Dedication

I dedicate this Dissertation to my Parents the Late Donald Mremi and my mother Awaichi Anael Kimaro for considering taking me to school specifically my mother for encouragement and moral support.

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List of Abbreviations

ATTP	Alternative Teaching Training Program
AEU	Australian Education Union
COVID 19	Coronavirus Disease 2019
EFA	Education for All
EAM	Education for All Movement
ICT	Information and Communication Technology
IFM	Institute of Finance and Management
ILO	International Labor Organization
INSET	In-Service Education and Training of Teachers
JICA	Japan International Agency
MDGs	Millennium Development Goals
MOEST	Ministry of Education Science and Technology
MOEVT	Minister for Education and Vocational Training
NACTVET	National Council of Technical Vocation Education Training
NSFE	The National Standard Four Examinations
PDP	Professional Development Program
PEDP	Primary Education Development Plan
PSLE	National School Leaving Examination
RAS	Regional Administrative Secretary
SMP	School Mathematics Project
SSP	School Science Project
SACE	South Africa Council of Educators
SREB	Southern Reginal Education Board

STIP	Science Teacher Improvement Project
SESS	Science Education in Secondary School
SEDP	Secondary Education Development Plan
TAMASHA	Taasisi ya Maendeleo Shirikishi ya Vijana Arusha
TCU	Tanzania Commission for Universities
TDMS	Teacher Development and Management Strategy
TESSA	Teachers Education in Sub-Saharan Africa
TEAMS	Teacher Education in Mathematics and Science
TRS	Teacher Retirement System
UK	United Kingdom
UNICEF	United Nations International Children's Emergency Fund
UNESCO	United Nations Educational, Science and Cultural Organization
UREC	Unicaf Research Ethical Committee
URT	United Republic of Tanzania
USA	United States of America

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CHAPTER 1: INTRODUCTION AND BACKGROUND TO THE PROBLEM

Introduction

The research introduction is explained in Chapter 1 along with the problem statement, main study purpose, goals, and objectives of the study. The chapter also discusses the nature and significance of the study, which includes data collection techniques, data analysis, the importance of the study, and research study questions. The objectives of this study are the source of the research questions, and when these questions are resolved, those objectives are also established. In summary, Chapter 1 explains the research study's research proposal. The research section's major goal is to provide information to the reader about what is being provided here and pique their interest in continuing to read the entire dissertation.

Background of the Problem

Science and mathematics are important disciplines that are the key to progress and are useful in the daily human life development of any nation. These subjects are useful in many activities that humans perform in making life easier. Such activities include agricultural-related activities, medical-related practices, industrial activities, Information and Technology issues, useful in problem-solving, understating our environment, discovering new things of the past and future, helping in making proof of things we see or discover, and many more (Anaeto et al., 2016). In their studies, they recommend that among other things education should emphasize teaching science at all levels and equip the entire society with scientific and technological thinking to adapt the existing innovations and improve the people’s well-being in the societies they live in. The improvement in terms of technology in development should be stimulated and encouraged in both public and private sectors which together contribute to national development.

Based on another research by Nedev (2014), revealed that science and technology education is meant to be a priority in most Latin American countries' educational curricula. Most countries in Latin America are developing countries like Tanzania and are having similar educational problems. According to Nedev (2014), policies, curricula, teaching techniques, and materials connected to scientific disciplines, as well as the training of specialized instructors, have all been devoted to keeping the teachers up-to-date and enthusiastic in their professional purpose. Well-educated teachers will be naturally motivated to teach at the early school level. As a result of this social environment, pupils will gravitate toward scientific and technological areas. The scientific community has expressed grave worry in recent decades about the sharp decline in the number of male and female students enrolling in scientific and technological fields (Nedev, 2014).

Tanzania is among the developing countries that have realized that science and mathematics subjects are essential for economic stability and the improvement of the industrial sector (Hamilton et al., 2010). Therefore, for the country to achieve industrial growth and development, science and mathematics subjects are mostly needed to be taught in secondary schools. Moreover, based on the current discovery of natural gas and oil in Tanzania, and the intention to shift the economy to industrial production, the country needs to focus on training its people in those subjects. According to Moshi (2014), the extraction of natural gas which was discovered in Tanzania needs preparation including ensuring that human resources are made available to ensure the local community benefits from the resources. The Government has to reduce donor dependence and educate its people. However, for decades the country’s education sector has faced some challenges to achieving its goal to grow fully scientifically and technologically (Moshi, 2014).

Tanzania is one of several nations throughout the world that are struggling with the issue of a lack of scientific and math teachers, according to the United Nations Educational, Science, and Cultural

Organization (UNESCO, 2006). Additionally, UNESCO (2006) revealed in their study that there is a scarcity of scientific and math instructors in several nations in South and West Africa. According to Latifoglu (2016), the lack of scientific and math educators was getting worse in several other nations, and it was noted that remote schools were more likely to retain newly hired science instructors than metropolitan ones. The issue worsens in isolated rural areas where schools lack primary teaching and learning resources, standard social services, and other essential services. Latifoglu (2016) reported that it is also true that many new teachers do not plan to teach for the rest of their lives, which is a relic of a bygone era. Some new teachers are looking for quick promotions and fresh tasks. These are the main criteria in determining whether new instructors will continue with it or quit. It all depends on whether they receive appropriate support and supervision. These resources include a comprehensive induction program, rather than a one- or two-day orientation for new teachers to learn about their new school. Mentoring from qualified and dedicated peers is also essential.

Podolsky et al. (2016) reported that schools with adequate teaching and learning facilities and housing resources and hygienic resources; appropriate student and teacher standards; and adequate supporting staff have a constructive impact on teacher retention rates; and influence the ways of teaching and learning process. The downside is also true that schools that do not have adequate human resources and other teaching facilities are the cause of teachers' fluctuations (Podolsky et al., 2016). This means inadequate infrastructural facilities, as well as the ongoing failure and degeneration of current teaching facilities, are the key difficulties for schools' progress, and as a result, it is affecting students' achievement and academic performance.

In Tanzania, several challenges were reported by Osaki (2007) that are hindering the effective implementation of scientific and mathematics subject teaching in Tanzania and he explained that

this has increased as a result of the previous experience. Based on his argument Osaki (2007) reported that those experiences were the delay in deciding on the medium of instruction in teachers' education programs which lead to the employment of incompetent language teachers at pre-primary, primary, and secondary school levels, resulting in more of several incompetent teachers in mathematics, science, and language. This shortage of science and mathematics teachers has an impact on the effectiveness of teaching and learning those subjects (Ndalichako and Komba, 2014; Taasisi ya Maendeleo Shirikishi ya Vijana Arusha [TAMASHA], 2010). Furthermore, other studies revealed that in Tanzania the scarcity of scientific and mathematics teachers is increasing due to insufficient in-service programs and short courses for science and mathematics teachers, particularly in rural areas of the country (Hakielimu, 2011; Mamlok-Naaman, 2014; The Citizen, 2019).

Moreover, Hamilton et al. (2010), reported that due to current global educational needs, rapid changes, and advancements in science and technology, Tanzania has to take on educational improvements that will bring together the demands of the 21st century. Tanzania has to produce competent science and mathematics graduates to address the needs of progressively science and technology; the graduates who apply critical thinking, with working skills and knowledge in solving problems. This can be achieved through training our citizens and ensuring that they perform highly to become competent in the areas of science and mathematics disciplines. Similar recommendations have been made by researchers including Kalufya et al. (2015) and Moshi, (2014).

In their study, Kalufya et al. (2015), revealed that localization of the workforce in the natural gas and oil industry is necessary but there was a challenge during the implementation as there is a lack of local people who have the needed qualification. Furthermore, it was reported that there is no

local training institution that specializes in natural gas and oil and this made it difficult to localize the human resource. From that view, there is a need to educate our scientists who will specialize in natural gas and oil. The government has to prepare a system that fosters localization by establishing programs to train the local people in natural gas and oil which could create the candidate's employment in the industry. To be able to do so we need more competent science and mathematics teachers.

In the process of solving the scarcity of science and mathematics teachers, the Ministry of Education, Science, and Technology of Tanzania organized various reforms to develop and attain improved education in the country. Based on a report by Osaki (2007), the established educational reform programs comprised the School Mathematics Project (SMP) and School Science Project (SSP) established in the year 1968 at the University of Dar Es Salaam, which were financed by the United Nations Education Science and Culture Organization (UNESCO). The SSP program was an undergraduate package of three years of courses that were concluded with a Bachelor of Science with Education (BSc. (Education) degree award. The candidates involved in the course studied two science or mathematics subjects and education courses including Physics and Mathematics (PM), Chemistry and Mathematics (CM), Physics and Chemistry (PC), and Chemistry and Biology (CB). The student teachers who graduated from these subjects were employed to teach specialized subjects in various public secondary schools.

Furthermore, between 1985 and 1999, the Government of Tanzania in collaboration with the communities introduced community secondary schools in the country to encourage extra secondary school admissions. The intentions of introducing community secondary schools were to increase enrollment in secondary schools and to reduce pupils who were not capable of joining other kinds of schools (Projest, 2013; Wedgwood, 2007). These community schools rose to 380 in

numbers nationwide, causing more shortages of teachers which later affected the curriculum implementation (Projest, 2013). The increase in the community secondary schools and the enrollment of students caused more shortage of teachers and mostly in the science and mathematics subjects. To be able to cope with the increased enrollment, several untrained but licensed teachers were employed in public secondary schools. These teachers possessed diplomas or degrees but not education, meaning that they were not professional teachers.

Moreover, Sumra & Rajani (2006) and Mamlok-Naaman (2014), described in their research study that the community secondary schools were the most disadvantaged and challenged since they lacked most of the significant teaching and learning facilities including reading resources, teaching staff, laboratories, chemicals and the apparatus, libraries, textbooks, preparation rooms and teachers' facilities such as housing. As a consequence, teaching particularly science and mathematics subjects were affected mostly when compared to non-science subjects. Furthermore, Mamlok-Naaman (2014), discussed that the aforementioned challenges caused high school students to develop a low level of curiosity and concentration in science and mathematics subjects hence causing into further lack of scientists especially science and mathematics teachers in the country.

In another study, the parents' past perception, experience, and priority as reported from the research study by Fomichova & Misonou (2018) are important to ensure that their children study science and mathematics subjects for a better future. Children's attitudes regarding schooling are heavily influenced by their parents' perspectives, ideas, and experiences. According to Fomichova & Misonou (2018), in recent decades, educational interests have switched toward physics and chemistry. Furthermore, in comparison to the 'superior' subjects, biology and earth science were viewed as 'simple' and 'secondary' (physics and chemistry). This has been strengthened by the

calamitous condition for earth science, which is frequently denied to pupils in Japan's educational system. As a result, the parents desired a more balanced structure. Based on gender and academic performance, adolescents' opinions of science areas differed. Boys and best performers were connected with physics and chemistry, whereas biology and physical science were meant to be associated with girls and with low performance. This situation could have serious consequences for scientific and environmental education. Parents, on the other hand, want a more sustainable distribution system of education (Fomichova & Misonou, 2018).

However, Hamilton et al. (2010), discovered that there is extensive dissatisfaction between students and teachers, mostly those who study mathematics and scientific subjects. Hamilton et al. (2010) mentioned that in some secondary schools, the inadequate number of mathematics and science teachers is the cause of the student's decision to search for extra classes outside the schools to acquire sufficient training in these subjects. This shows that there is a commonness and continuous scarcity of science and mathematics teachers despite all the reforms done in the education system in the country. The current research study presumes that some unknown factors are maintaining and sustaining the scarcity of teachers in science and mathematics and this may have negative impacts on secondary schools as well as the country’s economic, scientific, technological advancement, and education sector in the future. Limited information exists in the literature on the factors that are causing the aforementioned problems and therefore, the current research study aims at investigating and revealing those factors. Also, the current research study aimed at assessing the impacts of the scarcity of mathematics and scientific teachers in Tanzanian secondary schools.

Statement of the Problem

The problem is the causes of the teacher shortages in scientific and mathematical areas and how it affects Tanzania's secondary schools. Currently, literature shows that this problem has been prolonged in Tanzania for years despite all the Government interventions that have been made through the Ministry of Education, Science, and Technology (Mamlok-Naaman, 2014; Ndalichako and Komba, 2014; Osaki, 2007; Sijaona and Kitula, 2022; Projest, 2013). Moreover, another study by Carver-Thomas and Darling-Hammond (2019), revealed that in the United States, the shortage of science and mathematics teachers is caused by the shortage of enough facilities for teaching; low earnings, and deprived conditions in workplaces. These cause most of the science and mathematics teachers to run off their professions more than others, especially those with alternative certifications, and in turn, it leads to more shortages of teachers in many schools. The current study accepts that there must be some unknown strong factors staining and maintaining this scarcity and this might emanate from the people in the grassroots.

Sijaona and Kitula, (2020) revealed that the early syllabi coverage is affected by the lack of both math and science teachers in secondary schools, as well as some topics not being offered at all. In many secondary schools, the lack of mathematics and scientific teachers has a similar impact on students' learning habits since students lose interest in studying science and math and opt to study the arts as a result of their negative attitudes about those disciplines. Moreover, Ndalichako and Komba (2014), in their study revealed the existence of a serious shortage of teachers for mathematics and scientific subjects in Tanzania’s secondary schools. This problem is a national calamity and has a severe impact on the efficiency of teaching mathematics and science subjects in secondary schools. Furthermore, Ndalichako and Komba (2014), in their study reported that sums of 14,060 teachers were employed in 2013 by the Government in secondary schools, and out

of these teachers only 2,014 (14%) were science and mathematics teachers. Nationwide there is a scarcity of 37,130 teachers in secondary schools and many of them about 26,948 (73%) are science and mathematics teachers.

The Tanzanian Government is still prioritizing employing science and mathematics teachers who are most needed, and deferment employment for art teachers in secondary schools. Kamagi (2017) reported the decline in the need for art teachers in both government and private schools. According to Kamagi (2017), public secondary schools have a sum of 88, 999 teachers, whereby arts subject teachers were 70,459 and science and mathematics teachers were 18,545 in total. Thus, there is a need for about 24,716 science and mathematics teachers as well as 355 laboratory technicians in the country as stated by the Deputy Minister for Education, Science, and Technology in the parliament (Kamagi, 2017). This indicates that there is still high a scarcity of teachers in science and mathematics and this is contributing to some impacts on secondary schools. The factors that are sustaining the problem of the scarcity of teachers in science and mathematics need to be addressed and it can be done by unveiling the factors that are causing the problem. The authorities in the education sector have to know the factors and deal with them to minimize or eradicate the problem.

Even though there have been ongoing initiatives and reforms to address the lack of scientific and math teachers throughout secondary schools across the nation, as evidenced by the different literary works, the issue continues. The goal of the current research study is to support efforts to address the dilemma of a lack of science and math instructors in secondary schools. As a result, the purpose of the present investigation is to identify the root causes of the ongoing shortage of mathematical and science trainers in Tanzania as well as their effects on secondary schools.

Purpose of the Study, Research Aims, and Objectives

Purpose of the Study

This mixed-methods study's major goal is to identify the causes of Tanzania's shortage of science and math teachers as well as how it affects secondary schools. By utilizing mixed research method tools for data collecting, analysis, and presenting of results, the present research study examined the reasons driving the shortage of science and mathematics instructors. In this mixed-methods study, questionnaires, interviews, and other instruments were utilized to gather data from the research subjects. The research study looked into what's behind secondary schools' present shortage of science and math instructors. The impact of the lack of scientific and math teachers in Tanzania's secondary schools, notably in the Kibaha and Bagamoyo areas, was also evaluated in the study.

Moreover, the study assessed the strategies that are been used by school management and other education stakeholders to minimize the scarcity of teachers in science and mathematics in secondary schools. Moreover, the research study determined the extent to which the strategies taken by the school management have been achieved and their intention to solve the problem of the scarcity of teachers in science and mathematics in secondary schools.

Aims of the Study

The main goals of the current study are to investigate the causes of the ongoing shortage of mathematical and scientific as well as to evaluate the effects on Tanzania's secondary schools.

Objectives of Study

The major goals of the current study are to identify the causes and impacts of the teacher shortage in science and mathematics in Tanzania's secondary schools. In summary, the study intended to specifically work and achieve the following objectives:

1. To determine the extent of the scarcity of teachers in science and mathematics in secondary schools in Tanzania.
2. To investigate the factors that are causing the scarcity of teachers in science and mathematics in secondary schools.
3. To assess the difference in the responses of the teachers and students on the factors causing the scarcity of science and mathematics teachers in secondary schools.
4. To determine the impacts of the scarcity of science and mathematics teachers on education in secondary schools in Tanzania.
5. To determine the difference in the responses of the teachers and students on the impacts of the scarcity of science and mathematics teachers in secondary schools in Tanzania.
6. To assess the strategies used to minimize the scarcity of science and mathematics teaching in secondary schools in Tanzania.
7. To evaluate how effectively the approaches used by the school management are to manage the scarcity of science and mathematics teaching in secondary schools in Tanzania.

Nature and Significance of the Study

Nature of Study

The deficiency of scientific and mathematics personnel in high secondary schools in Tanzania has persisted for several decades, which is a challenge and a concern for the Ministry of Education, Science and Technology (Kamagi, 2017; Ndalichako and Komba 2014; Osaki 2007; Projest 2018; Sijaona and Kitula, 2022; TAMASHA 2010; UNESCO, 2006). These studies have shown that there are scientific and math teacher shortages in numerous secondary schools throughout Tanzania, which may have a significant impact on the academic performance of Tanzanian secondary school learners. A report by Kamagi 2017, indicated the existence of a total of 88,999 teachers in public secondary schools whereby 70,459 were art teachers and 18,545 science and mathematics teachers. According to the research, secondary schools in Tanzania require more than 24,716 mathematical and scientific trainers.

From the literature reviewed, nothing is known about the effects of the lack of math and science subjects in Tanzania's secondary schools. As an example, Ndalichako and Komba (2014) documented the lack of science and math instructors but they left out any information regarding how much of an impact this lack had on these secondary education institutions and the nation as a whole.

While the literature has indicated many efforts and interventions that have been done to resolve the problem in different approaches including educational policy amendments and educational reforms, but still the problem subsists. With the global rapid change and growing science and technology, the country must work more to produce more scientific professionals who can work to meet the increasing changes in world technological time (Hamilton et al., 2010). This can be

achieved if the number of contributing factors that cause the persistence of the scarcity of mathematics and scientific teachers are thoroughly investigated and in place to help the educational stakeholders to work on them when resolving the problem. Thus, the present research study is working to reveal the causes and impacts of the continuous existence of the inadequate number of teachers in mathematics and scientific trainers in Tanzania's secondary schools.

Significance of Study

Teachers are an important part of education for a sustainable society, not only because they are a valuable resource in delivering education programs all over the world, but also because they are frequently key players in promoting and modeling socially sustainable behavior and attitudes. They are frequently the only tertiary educated, professional occupation present in many developing countries; in small towns and villages, their true job goes far beyond the classroom into many aspects of the community. The scarcity of teachers may be relieved to some extent through carefully focused recruitment initiatives, but they would need to be accompanied by a re-evaluation of teachers' working conditions and career paths. The completion of this research study will benefit education stakeholders in different sections of education including secondary school management teams, students, teachers, the government, and others like the parents. The following are the significance of this research study:

i. The research study findings could be useful to government education officers, policy-makers and decision-makers, school education managers, teachers, parents, students, and other stakeholders to understand the in-depth factors causing the scarcity of scientific and mathematical teachers in Tanzania's secondary schools.

ii. The research study findings could help government education officers, school education managers, and other stakeholders to comprehend thoroughly the impacts of factors that are been caused by the scarcity of teachers in mathematics and scientific subjects in Tanzanian secondary schools.

iii. The research findings may serve as a reference to the educational planners, policy-makers, and decision-makers to invest more in science and mathematics teachers' training, allocate enough of them in secondary schools to promote the provision of quality science and mathematics subjects and minimize the scarcity of these teachers in secondary schools in Tanzania.

iv. The research study findings might be of assistance be appropriate authorities such as the Ministry of Science and Technology, and the teachers' training colleges which are accountable for teacher training to find the best ways of training, retaining, and attracting scientific and mathematics teachers in the teaching profession to reduce the scarcity in secondary schools.

v. The information obtained from this research study could be the base for further assessment of the issues related to the scarcity of scientific and mathematics teachers in Tanzanian secondary schools. There are many recommendations for further research presented in this research study which created some avenues for researchers to investigate more on this subject matter.

vi. The research study findings could help the school management to review the approaches they have been using to minimize the scarcity of teachers in scientific and mathematics subjects and the impacts on the secondary schools in Tanzania. Through this research study,

the school management could be able to set appropriate strategies to minimize the scarcity of teachers, especially science and mathematics teachers as well as find a way to improve the existing strategies to be able to be more productive.

vii. The research study findings may be useful to students whose interest is to join science careers in their future endeavours. These students would be able to understand the importance of becoming future mathematics and scientific subject teachers in the society where they belong. Through this research, the student would be able to know that they have a big contribution to resolving the scarcity of science and mathematics teachers in secondary schools.

The research findings may be useful to parents whose priority and perception for their children is to join science for their future careers. Through this research, the parents could be able to understand better the subject matter and therefore be able to appropriately advise their children regarding science and mathematics subjects and related careers.

Research Questions

The primary goal of this study was to examine the causes of the shortage of science and math trainers in Tanzania as well as how it has affected secondary schools. To be able to unveil those factors this research worked to answer some questions with the help of people who are working in the education sector and the schools, hereby referred to as participants. In this case, the participants were the education officers, the teachers who were teaching science and mathematics subjects, and the students who were studying the same.

Generally, these research questions were used as the initial steps of research and formed major guidelines and the bases of where the researcher was going. When these questions were answered in this research study, the problem of the study is as well answered. As a result, the following primary research topics were addressed in this particular research study:

1. What is the scarcity level of science and mathematics teachers in secondary schools in Tanzania?

2. What are the factors causing the scarcity of science and mathematics teachers in secondary schools in Tanzania?

3. What is the difference in the responses of the teachers and students on the factors causing the scarcity of science and mathematics teachers in secondary schools?

4. What are the impacts of the scarcity of science and mathematics teachers on secondary schools in Tanzania?

5. What are the differences in the responses of teachers and students on the impacts of the scarcity of sciences and mathematics in secondary schools in Tanzania?

6. What strategies could be used to minimize the scarcity of science and mathematics teaching in secondary schools in Tanzania?

7. How effectively are the approaches used by the school management to manage the scarcity of science and mathematics teaching in secondary schools in Tanzania?

Data Collection Methods

This research study used mixed research methods with multiple case studies, to gather the necessary primary data from the study area (Creswell, 2009). During data collection, a non-probability sampling technique was used to collect the information from the participants and the

region, and the districts were purposively selected while the schools were randomly selected. The individual research participants were purposively selected. In this particular research, different education stakeholders were involved including different education officers, secondary school teachers who were teaching science and mathematics, and secondary school students who were studying science and mathematics subjects.

Two Tanzania mainland districts which are Kibaha and Bagamoyo were selected purposively from Pwani Region to be involved in the study based on the three years of secondary school performance of the national examination results. The choice reflected the limits of the performance, including good and poor performance schools in general in those particular districts. Science subjects including Biology, Chemistry, and Physics, as well as mathematics subjects, were taught in those secondary schools up to an advanced level repeatedly, for at least three years.

According to Etikan et al. (2016), samples were collected from 8 secondary schools from the two districts which were chosen by using the criterion which was purposively selected. The choices were done based on the intensity of their examination performance over the past three years. The schools were randomly selected from a list of all secondary schools which were teaching science and mathematics subjects for at least more than three years consecutively. Moreover, data were collected from various other stakeholders of education other than the schools, including the quality assurance team of the districts and other district education officers.

A total of eight (8) education officers and education quality assurance officers from the two districts were interviewed. A total of 45 teachers from all eight (8) secondary schools from both districts were interviewed and this made a total of 53 teachers and other education officers. Moreover, a

sum of 98 students from 8 secondary schools was involved in the response to the questionnaire provided to the students through their teachers.

Interviews and questionnaires were the research tools that were mainly used to collect data from the study area. Semi-structured and structured interview guiding questions were used with different education officers and science and mathematics teachers during data collection. The main points of the interviews were to collect and discover the views, practices, and beliefs on the factors causing the scarcity of mathematics and science and the impacts on secondary schools in Tanzania (Gill et al., 2008).

Before the beginning of the interview, the researcher briefly explained the purpose of the interview and obtained consent from the participants, and continue with the interview. The participants were allowed to choose to continue with the interview or to withdraw at any time during and even after the interview. The participants who agreed to be interviewed were given the consent form to sign. The participant's personal information remained confidential and was not included in this report.

During the interview sessions, the researcher established a rapport with the participants, before the interview as this can give positive sound effects on the development of the interview session. The most important idea during the interview was to ensure that the questions were neutral, open-ended, and understandable. The interview length varied according to the participant's understanding, the topic to be discussed; the researcher's ability to interview, and was conducted within an average of 30 – 60 minutes (Gill et al., 2008). During the interviews, the conversations were noted for further use in the research dissertation write-up and immediately after each interview session, the researcher made field notes that were used at the time of data analysis.

Also, simple questions were asked at the beginning of the interview followed by the more difficult ones to build the interviewee's confidence. The researcher listened to the respondents without interruptions to allow freedom of expression; body language was used mostly like smiling, nodding, and looking interested. At the end of the interview session, the researcher thanked participants for their responses, and time and asked them to say anything they felt they want to know.

Furthermore, quantitative data were collected according to Gill et al. (2008), where the students were given the questionnaire with the help of their teachers. The students were briefly informed about the aim of the research and they were also given a choice to join the research if they would like to and that it was a must. A consent form was supplied for all those who accepted to participate. The students were able to respond to the questionnaire provided to them by their teachers. An average of 12 students from eight (8) secondary schools students responded to the questionnaire. The activity was supervised by their teachers who monitored, guided, and assisted the students as necessary. Because the research data were gathered while the world was experiencing a coronavirus pandemic, there was little interaction between the researcher and the students. Interviews were at some point conducted using Kobo Toolbox through mobile phones to ensure that the participants and the researcher kept their distance. The medium of communication was by using both Kiswahili (the National language) and English languages, especially when giving a brief background of the research to give more opportunity and freedom to the participants to fully participate and communicate their experiences and views.

Before conducting the major research study, pre-testing was done to test the reliability and validity of the research instruments and assess the extent to which these instruments measure what it is designed to measure. This helped the researcher to be able to adjust the tools/instruments to be

more precise and consistently measure the theory under study. During the pre-testing of the tools, the researcher was able to realize the existence of biases and adjust accordingly to avoid unfairness in the major research work that followed later (Kimberlin & Winterstein, 2008). This was done to ensure that the interview guide questions were precise and were able to draw all the information needed during the interviews the questionnaire was answered and therefore the research questions were as well responded to.

Summary

In general, Chapter 1 was based on the research proposal which comprises the following subtitles: the introduction, which contains the problem's context and a summary of the issue. Chapter 1 includes information about the study's goals, objectives, and purpose as well. The chapter also covers the purpose and relevance of the study, as well as the methods used to acquire the data, how the data were analyzed, and why the study was important. Thus, this chapter carries the general overview of the whole research on the factors causing the scarcity of scientific and mathematics teachers and the impacts on secondary schools specifically in the Kibaha and Bagamoyo Districts in the Pwani Region in Tanzania.

The introduction part of this section discussed the importance of science and mathematics subjects in everyday life. Also, gives an overview of the significance of science and mathematics in economics and scientific development. The section emphasizes the difficulties encountered when implementing the curriculum in the areas of science and mathematics. The section also provides the existence of the problem of scarcity of teachers in scientific and mathematics and the impacts on secondary schools in Tanzania. In short, the section summarizes the background of the research problem.

Chapter 1 discussed the efforts that have been done by different education stakeholders in trying to minimize the scarcity of mathematics and science teachers in Tanzania. The main stakeholders who were involved in resolving the problem of scarcity of scientific and mathematics teachers included the Tanzanian Ministry of Education, Science, and Technology, school management teams, policy-makers, decision-makers, different researchers and scholars, teachers, and students. Some of the efforts undertaken to resolve the scarcity of science and mathematics teachers include the introduction of in-service programs, different research, and reforms in the education system. Yet the problem seems to continue persisting in Tanzania despite all the efforts discussed in the chapter. Therefore, the researcher is thrilled to be part of the education stakeholder to resolve the problem of the scarcity of scientific and mathematics teachers and the impacts on secondary schools in Tanzania.

CHAPTER 2: LITERATURE REVIEW

Introduction

Chapter 2 presents the literature review which is comprised of the chapter introduction; definition of terms and conceptual framework. The researcher read the literature on three different topics: the global shortage of science and math teachers, the shortage of scientific and math teachers in Africa, and the shortage of science and math teachers in Tanzania. A study of the literature was conducted on the relationship between socioeconomic, political, and policy, as well as cultural issues and the shortage of scientific and mathematics trainers. In addition, the investigator has conducted and presented an analysis of the literature in Chapter 2 that focuses on the effects of the teacher shortage in science and mathematics, the stakeholders' accountability in addressing the impacts of the teacher shortage, and finally a summary of Chapter 2.

The chapter provides a review of the theory and literature relevant to this study which is about the factors causing the scarcity of teachers in science and mathematics and the impacts caused on secondary schools in Tanzania. The concepts of the scarcity of science and mathematics teachers and the impacts of the scarcity are also explored. The chapter also reviews some of the existing research on factors causing the scarcity of teachers in science and mathematics and the impacts on secondary schools globally, in Africa, and Tanzania.

Moreover, the literature reviewed globally covered different countries such as the USA, UK, Australia, and others. In Africa the literature review covered countries such as South Africa, Kenya, and Nigeria, just to mention a few. The literature review also covers world reports by UNICEF, ILO, World Bank, and UNESCO just to name a few. The presentation of this chapter is organized under the following sub-headings: definition of terms as used in this research; the

conceptual framework, the scarcity of scientific and mathematics teachers – the global overview; Africa overview; and Tanzania overview. Other subtitles in the chapter include socio-economic factors and the scarcity of science and mathematics teachers; political and policy factors; cultural factors as well as the impacts caused by the scarcity of scientific and mathematics teachers in secondary schools; stakeholder's responsibility in resolving the scarcity problem and the impacts caused on secondary schools in Tanzania.

In general, the current chapter reviews the available literature related to this study from a wide range (globally) to a narrow range (Africa) and lastly to the specific study area (Tanzania). In this Chapter 2, the main work of the researcher was to search from the existing literature on the current research the related theories, and the scholarly research published recently within not more than five years back. However, for the exploration of a historical overview and the trend of the issues on the study subject, the researchers reviewed scholarly research published more than five years back.

Also, the chapter establishes a conceptual framework based on presumed variables, which are the factors causing the scarcity of mathematics and scientific teachers as well as the impacts of the scarcity on secondary schools in Tanzania. It involves mostly a thorough library and internet searches of the related literature based on a variety of scholarly resources. Different search engines were used to search for the current information related to the topic under the research study. The conceptual framework displays the idea of this particular research as related to other scholars' ideas and works on the presumed factors causing the scarcity of scientific and mathematics teachers in secondary schools in Tanzania. The conceptual framework shows how these causative factors interrelate with each other in the fashion that in the end, the impacts become the causative factors and the problem becomes difficult to solve and therefore remains unresolved.

The term factor as used in this research means something or event that influences or contributes to the effects such decision-making or the situation of something. In this research study, it (factor) means something that causes the scarcity of scientific and mathematics teachers in secondary schools in Tanzania. The term scarcity in this research study means a situation where there are limited resources or a shortage of supply. The situation on the availability of teachers is considered a shortage when more than 90% of the students are been taught by teachers who are not qualified to teach a given subject (Dlamini, 2014). The term impact means the effects on something, which may be positive or negative influence or repercussions on the surrounding community, individuals, institution, project, program, or policy. Positive impacts refer to something beneficial and negative impacts mean the unfavorable or adverse conditions in or situation.

Also, Munna and Kalam (2021), explained that learning is the process of gaining knowledge and abilities through instruction, experience, or study. Moreover, the knowledge that is passed from experts to learners can be characterized as the teaching-learning process. The process through which a teacher identifies and creates the learning objectives produces teaching resources, and puts the teaching and learning strategy into action is described as the combination of the different aspects within the process (Munna & Kalam, 2021). According to Padhi (2021), learning is an innate nature of man that exists in his surroundings or is facilitated by favorable circumstances. The teaching process might result in learning. On the other hand, a teacher should take learning into account when preparing classes because it is a crucial component of education (Munna & Kalam, 2021). Teaching is the act of involving students in the process of learning new information and abilities (Padhi, 2021). To put it another way, learning is the process of giving the learner the ability to comprehend and apply concepts, skills, and knowledge as well as to actively participate in activities or processes that entail the establishment of an environment for learning, while helping

learners learn. However, man can learn even without being taught, and this is referred to as experience. Teaching is done to learn to meet a predetermined package (Padhi, 2021).

However, there is no meaning in teaching until the learner acquires knowledge or skills that can be used to construct action (Padhi, 2021). Although man can learn without being taught, teaching is required for the purposeful learning of new things. This is why teaching and learning are viewed as a single concept which is termed teaching-learning. In other words, there is a relationship between teaching and learning processes. When we consider teaching-learning as a whole, there are five components: the learner (student), the trainer (teacher), the materials to be taught (curriculum), the teaching methods, and the environment for teaching-learning (Padhi, 2021; Munna and Kalam, 2021). These five components must be properly maintained for the teaching-learning process to be effective. The factors related to the five components mentioned are the factors that determine teaching-learning processes. Teaching is a collection of events that occur outside of the learners and are intended to support internal knowledge acquisition (Padhi, 2021). Furthermore, teaching (instruction) takes place outside of the learner and learning is internal to learners' learning. Teaching is the act of instructions to students in a classroom setting to help them to learn and acquire the desired knowledge, skills, and ways of living in society (Padhi, 2021).

Moreover, Padhi (2021), said that Teaching-learning is a process in which an educator assesses learning needs, develops specific learning objectives, develops teaching and learning strategies, implements a work plan, and evaluates the outcomes of the instruction. Also, teaching is a process in which the learner, teacher, curriculum, and other variables are organized systematically and psychologically to achieve some predetermined goals. From my point of view, teachers must be

qualified personnel, with adequate qualifications for the levels they are teaching and competent with the subject matter that they are teaching in secondary schools.

Another term that needs to be defined is the word research which can be defined as a systematic process of investigating the problem to establish facts and solutions or coming up with new findings through observation, experiment, comparison, and field study (Kothari, 2004). There are several types of research but this specific research study defines mixed research as an active search technique that was used in the current research. Mixed research involves both qualitative and quantitative research techniques for a better understanding of a research problem. A mixed-methodologies research design is a process for gathering, analyzing, and mixing research methods from the quantitative and the qualitative in a single study. To facilitate translation, mixed methods let researchers conceptually and analytically combine qualitative research and quantitative data (such as semi-structured interviews, observations, and questionnaires) with conventional epidemiological and quantitative research methodologies.

The qualitative research technique involves non-numerical data and is conducted primarily through interviews. The confirmation of truth claims involves logic and methods that may not be entirely appropriate, but the values underlying such claims, as well as the motivation for researching specific questions, do stem from the framework. Conducting research requires time, care, morality, precision, and perseverance with data collection and analysis methods, interpretations, and language (Kapur, 2018). These are required to realize one's quest for meaning by contributing to and connecting with diverse communities of researchers, teachers, learners, and marginalized individuals. The search for meaning is like a lamp, illuminating passages, and turning points as the researchers navigate multifaceted and diverse settings, questions, knowledge, and methods (Kapur, 2018).

On the other hand, the quantitative data collecting method involves gathering quantifiable numerical data through the use of surveys, close-ended or multiple-choice questions, and other techniques. Quantitative information is based on statistics and may be calculated or tallied. Quantitative information tells us how much, how often, or how frequently something occurs. Quantitative methods emphasize precise measurements and the statistical, mathematical, or numerical analysis of data gathered through surveys questionnaires, and other types of research, as well as the manipulation of statistical data that has formerly been calculated using computing techniques.

The word data can be defined as the facts or information for the things that are known or unknown collected for reference or analysis. Data collection means the process of gathering the information or data of interest from different sources, be the library, field, or laboratory through data collection tools like interviews, observation, surveys, or questionnaires to answer the intended research question, test hypothesis, or evaluate outcomes (Kothari, 2004). On the other hand, data analysis is the process of summarizing data, and interpreting it to get the pattern or the logical meaning, relationships, or trend of the data collected (Kothari, 2004).

Conceptual Framework

A conceptual framework is a framework that outlines how variables considered relevant in a study interrelate with one another and communicate the researcher's opinions about the study's concepts (Kothari, 2004). According to Adom et al. (2018), the conceptual framework is created based on a relevant literature review of the relevant research and/or theories. The conceptual framework aids in identifying and clarifying what the researcher values as central components of a study and links these components to other diverse components of other studies. A theoretical framework in

research is based on the idea of theories, but a conceptual framework is something the researcher can create based on the theory after conducting literature research (Adom et al., 2018). The researcher conducted a literature review for the present study and built the conceptual framework based on the evaluation of concepts from the review.

The current research study aims to examine the causes and impacts of the scarcity of scientific and mathematics teachers in Tanzanian secondary schools. From the literature, the scarcity of scientific and mathematics teachers that exists in secondary schools has negative impacts on students who are interested in studying these particular subjects. The conceptual framework is developed from the literature reviews on the related research. The literature revealed that the scarcity of science and mathematics teachers has emanated from various factors including poor performance which causes the diminished number of scientific and mathematics graduates. If some of these graduates join others for science and mathematics-related careers, then the teaching profession remains unflavored.

Figure 1 summarizes the conceptual framework as presumed by the researcher concerning the causes and impacts of the scarcity of mathematics and scientific teachers in Tanzanian secondary schools. The current research planned to come up with proof of the presumed factors causing the scarcity of scientific and mathematics teachers and their impacts on secondary schools in Tanzania. Figure 1 also shows how these presumed factors interact with each other. Moreover, Figure 1 also shows how these factors and impacts interact among themselves and affect the achievement in the teaching-learning process of these subjects in secondary schools in Tanzania.

Presumed causes and impacts of the scarcity of scientific and mathematics teachers include funds and budget for funding the two subjects in secondary schools; socio-economic factors such as

stigma and perception of the society towards science and mathematics subjects; factors related to education policy; other factors influenced by the political aspects; and teaching and learning environment in secondary schools. Some examples of policy-related factors include Education for All (EFA) movement that has increased the enrolment in pre-primary, primary, and secondary schools. The implementation of this Education for All Movement increased the teacher student-ratio because the number of students increased abruptly, while the number of teachers remained the same or it may be lower due to some of them reaching their retirement time, others dying, or dropping their teaching career.

The literature also indicated that students are not interested in teaching careers. Individual interest is what matters when it comes the time to choose the subject combinations that one is interested to learn. Cheung (2018) revealed that there are five factors affecting students' interest in science subjects including science self-concept, gender, grade levels, science self-concepts, situational influence in science lessons as well as individual interest in science. Furthermore, it was explained that the strongest factors that cause individual interest in studying science were science self-concept, followed by the individual interest in science, and lastly the situational influence on science subjects.

Some learners lose interest in scientific and mathematics subjects and want to select to study other non-science subjects. The result of that scenario is fewer individuals who graduate in science and mathematics and very few of them decide to join a teaching career. The consequence of this causes the scarcity of teachers in science and mathematics and the impacts on Tanzanian secondary schools (Figure 1).

Thus, the impacts have some negative consequences on individual students' achievement, the education system as well as the country's scientific and technological development at large. Therefore, these factors that are presumed to cause the scarcity of teachers in science and mathematics in secondary schools in Tanzania are presented in Figure 1. The factors include socio-cultural factors such as stigma and the perception of society towards science and mathematics in secondary schools. Socio-economic factors include the availability of budget and funds to support science and mathematics teaching, and policy and political factors that can affect curriculum stability (Figure 1).

The current research study investigates to unveil the factors causing the persistence of the scarcity of science and mathematical teachers to be able to find a way to resolve the problem. According to Kapur (2018), the education system can be enhanced through appropriate teaching-learning methods, a proper curriculum, trained and qualified teachers, and a suitable school environment. This implies that without appropriate teaching methodology, the student's performance is negatively affected. Furthermore, without a proper curriculum, the trainees would lack relevant knowledge and skills to be able to apply them in their daily life. Also, if the teachers are not well trained and qualified to teach, then the students will also perform poorly. Apart from that, also teaching methodology, the school environment should be favorable for teaching and learning to achieve the best results in the end.

According to Kapur (2018), effective curriculum and instructional methodologies, well-trained and competent teaching staff, acceptable teaching-learning strategies, and adequate school environments can all contribute to improving the educational system. Furthermore, effective implementation of the school curriculum is dependent on a variety of factors, including the

availability of learning facilities, such as textbooks, laboratories, computers with the internet, and, most importantly, qualified teachers' availability. Furthermore, the availability of teachers is insufficient for students' growth and development; teachers must also possess the necessary knowledge, skills, and abilities to deliver the subject matter. Teachers are simply not being produced in sufficient numbers by teacher education institutions. If they are being produced, then fewer are being employed. To improve teaching-learning, there is a need to employ sufficient numbers of qualified teachers to meet the demand in secondary schools (Kapur, 2018).

According to conventional wisdom, there are two staffing issues at the school level, which include two converging macro demographic trends: increasing student enrolment and increasing teacher turnover as this causes the teaching workforce declines (Kapur, 2018). As a result, teachers are in short supply, especially those who teach science and mathematics subjects. This problem persists high in rural areas and urban locations forcing most school systems to lower standards to recruit well-trained teachers and fill vacancies, which predictably may result in high levels of qualified teachers and improvements in school performance. In contrast, students ' performance appears to indicate that teacher turnover has a detrimental impact on the standard of the school. Yet, other simulations imply that under a policy framework where underperforming teachers can be precisely discovered and substituted with more competent instructors, turnover may alternatively have significant beneficial benefits (Adnot et al., 2016).

The lack of scientific and math teachers in such secondary schools has some influence on how those subjects are taught and learned. In a study, Cheung (2018) found that if teachers wish to encourage students to pick science disciplines, they should focus on tying academic self-concept with interest in the subject. As indicated in Figure 1 socio-economic factors are one of the

presumed causative factors in the scarcity of mathematics and scientific teachers in secondary schools. Socio-economic factors include the availability of budget and funds that could be used to support students and facilities in schools; socio-cultural factors (include stigma and perception); political and policy factors (Education for All Movement – (EAM) that has caused more students enrolment in schools); and uncertainty on the motivation to science and mathematics teachers. All these have caused the scarcity of mathematics and scientific teachers in secondary schools.

In Figure 1 it is indicated that the availability of budget and funds for science and mathematics subjects has an impact on the secondary schools which most of them fail to furnish the school laboratories with chemicals, instruments, and other necessary facilities. Whenever the budget and funds are limited it causes inadequate laboratory facilities and triggers a lack of interest in self-practice and limited experience in science and mathematics among students as justified in Michael (2015). In line with this, limited laboratory facilities can cause uncertainty of motivation to teachers and students since the science curriculum is only partially being implemented. Furthermore, the availability of laboratory facilities could make studying science effective and enjoyable for both the students and the teachers. Using the laboratory in learning science subjects enhances students' self-practice and brings more understanding of the respective subject (Michael, 2015). The use of the laboratory motivates teachers and it becomes possible and easier to illustrate or demonstrate difficult concepts under study. Thus, science laboratories and associate facilities must be available in secondary schools in Tanzania.

Furthermore, sociocultural factors such as stigma and perception of society on science and mathematics careers in the community affect mostly girls who want to join science and mathematics classes. According to Uwineza et al. (2018), there is a perception that females feel unwanted in science and mathematics-related careers because they lack role models and there is

only male domination in those STEM fields. Also, historically there are societal stereotypes about female students regarding science and mathematics subjects which are negative. Thus, females grow up with the perception that science and mathematics are for males, and this indicates the existence of education inequalities in society. Also, there is a perception in society that science and mathematics are hard subjects to study.

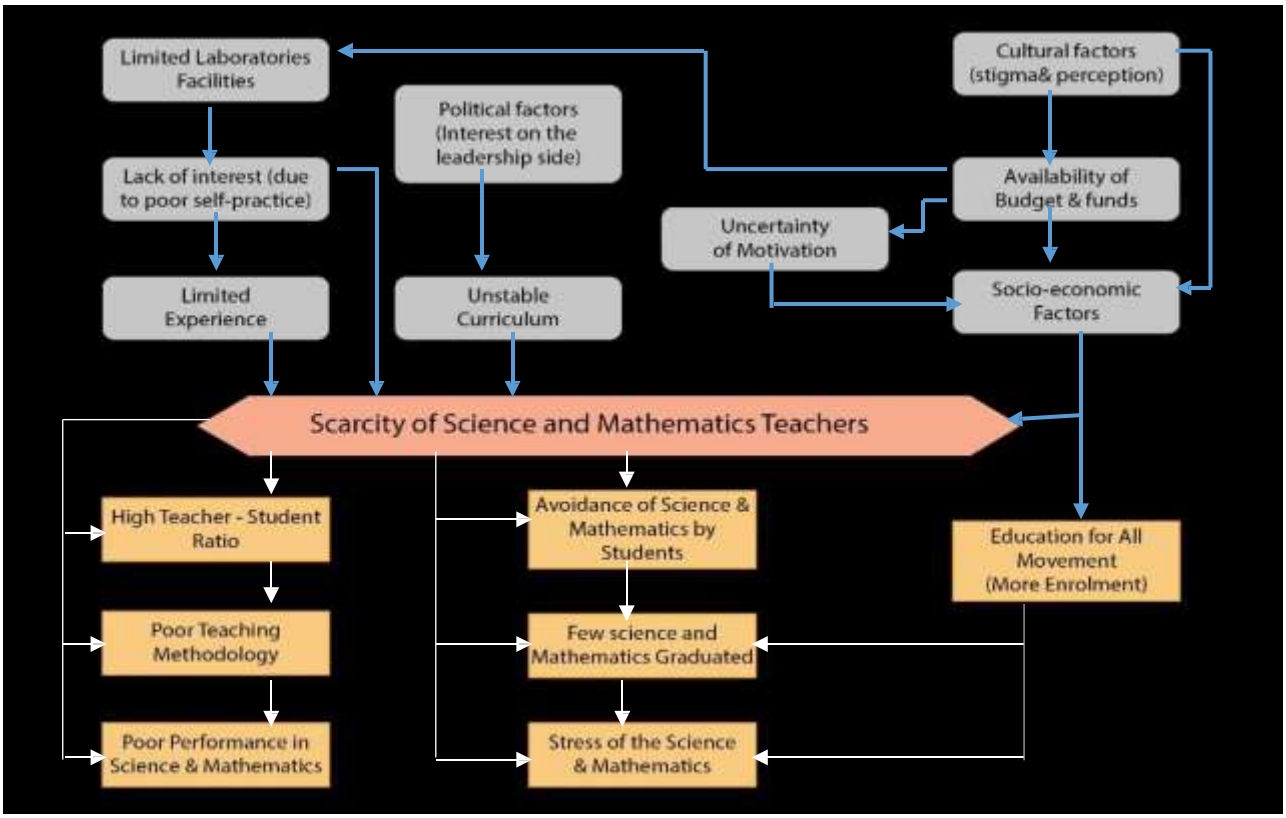
Moreover, during the implementation of the Education for All movement in Tanzania, the process has caused an increase in several schools in the country. These schools are community secondary schools which increased the number of enrolments in secondary schools and raise the problem of the scarcity of teachers specifically in mathematics and scientific subjects in secondary schools. The increase of community secondary schools in response to the "Education for All Movement" caused the scarcity of teachers since the number of teachers increased did not match the enrolments. This is justified by Projest (2013), in a study that revealed that the increase in community secondary schools has caused the scarcity of mathematics and science teachers in Tanzania.

Moreover, the implementation of the curriculum depends on the availability of teachers apart from teaching and learning facilities (Kapur, 2018). There have been frequent changes in the implementation of the curriculum whenever there is a change in the political leader in Tanzania. Some of the changes have caused the school curriculum to remain unstable. This unstable situation of the curriculum has been affecting the student's performance, especially in mathematics and scientific subjects. Politically, the interest on the leadership side might have some effects that can cause instability in the educational curriculum. A frequent change of political leadership in the country has an impact on the education curriculum (Figure 1). The newly nominated Minister of Education, Science, and Technology may come up with reforms in the education system that

sometimes affect the schools and this change has an impact when there is a need of changing the policy and may result in an unstable education curriculum (Figure1).

Figure 1

Conceptual Framework



The impacts of the scarcity of science and mathematics teachers include students' avoidance of science and mathematics (Figure 1). This is one of the reasons that there are few graduates in scientific and mathematics subjects in Tanzanian secondary schools which leads to stress in the concerned subjects, resulting in poor performance and later causing more scarcity of teachers in secondary schools (Michael, 2015). Moreover, it is reported that if there are few science and

mathematics graduate teachers, it may cause an increasing teacher-student ratio and result in poor teaching methods and poor performance which can further increase the scarcity of science and mathematics teachers (Figure 1; Michael, 2015). To be able to increase the teacher-student ratio the education sector in Tanzania decided to employ many untrained licensed teachers (Projest, 2013). Rural located secondary schools were affected most when compared to urban schools where the teacher-student ratio was 1:68 and 1:41 respectively (Projest, 2013). With this high teacher-student ratio (1:68), in rural located secondary schools, the teachers can't be able to teach effectively and the result is poor performance in science and mathematics subjects. According to Mazana et al. (2019), there are cross-factors relating to students, teachers, and schools with low mathematics performance. One of the elements or characteristics that is believed to have a considerable influence on whether students perform better or worse in mathematics is their attitude. Once a positive outlook is developed, it can aid students in learning more efficiently. Attitudes can change and grow with time. A negative attitude, on the other hand, prevents effective learning and therefore has an impact on performance (Mazana et al., 2019). Depending on the student, in many cases, attitude may have a favorable or negative impact on how well learners succeed in mathematics.

Furthermore, in 2014 the government of Tanzania introduced a free education policy that makes the pre-primary and primary schools fees-free which later in 2016 was extended to lower secondary education. This extension of free education was implemented using education circular no 5 of November 2015 which directed the education boards to ensure that secondary education is free. Through this policy, enrollment in secondary schools increased while the number of teachers remained almost the same. This means in a few years; a big number of these students were upgraded to upper secondary school. The schools demanded also a big number of teachers since

there was a high teacher-student ratio and a high teacher workload. In this policy registration and examination fees that parents used to pay in the past were waived. The implementation of the policy caused a significant financial barrier in schools. As a result of the implementation of this policy, the primary school population boomed by 31% in 2017 (UNICEF, 2018). This indicates that the issue of a lack of science and math teachers has gotten worse. The scarcity of teachers was a topic in the Tanzania parliamentary meeting as reported by Kamagi 2017 as cited in Chapter 1 of this research.

Additionally, Figure 1 illustrates the causes that contribute to Tanzania's shortage of science and math instructors as well as the effects of that shortage. Thus, the problem is maintained like that until something is done to interrupt the trend. If there is no action taken to address the implications of the lack of math and scientific teachers, the issue will not be resolved anytime soon but will instead continue to exist.

Table 1 provides an overview of the presumptive causes, consequences, as well as the impact of the lack of instructors in mathematics and science on learners and the educational system. The main factors include political and policy-related factors such as “The Education for All Movement” and the interest on the leadership side; socio-cultural factors (stigma and perception); and socio-economic factors (availability of budget and funds). These main factors have impacts on the students and the education system in general. Some of the effects as summarized in Table 1 are in turn causing the scarcity of mathematics and scientific teachers and therefore, they are also considered causative factors. They include budget and funds as well as a few mathematics and science graduate teachers.

The effects of the shortage of science and math teachers include a high teacher-to-student ratio, poor teaching techniques, subpar performance, a lack of self-practice and interest, the professions of science as well as math teachers shifting, and finally the shortage of science along with math teachers (Table 1). According to UNICEF (2018), the teacher-student ratio in primary schools stands at 1:145 in Tanzania's Mainland. With this ratio, the quality of learning is negatively impacted. This calls for an urgent need to increase the number of teachers in primary schools. At the same time, the schools are facing a challenge of infrastructure, where the classrooms become scarce and even the toilets are not enough. In this case, Tanzania has to hire tens of thousands of teachers to fill the existing gap. Hiring all those teachers is another challenge (UNICEF, 2018). Currently, UNICEF is supporting the government of Tanzania with adequate capacity building and training. There is also a volunteer program in which the UNICEF deployment among many unemployed college and university graduates clamoring for work as a stopgap measuring pending government recruitment procedures. The current gap in terms of teacher recruitment in Tanzania stands for thousands.

The scarcity and science and mathematics teachers and the impacts have effects on students who are studying those science subjects. These effects include limited experience and poor performance; avoidance of science subjects by students; few science and mathematics personnel hence more scarcity of those teachers; and lastly poor scientific and technological growth of the country (Table 1).

Table 1

Summary of the Factors Causing the Scarcity of Mathematics and Scientific Teachers and the Impact

Factors	**Impacts**	**Effects**
Political and Policy factors – (Education for All movement; Interest on the leadership side)	High teacher-student ratio Poor teaching methodology Unstable curriculum	• Poor performance in science and mathematics subjects
Socio-cultural factors	Stigma and perception of scientific and mathematics Stress in teaching science and Mathematics	• Student's avoidance of studying science and math
Socio-economic factors (Availability of budget and funds) Limited laboratory facilities	Lack of teaching facilities Low enumeration of science & mathematics teacher Lack of interest due to poor self-practice Science and mathematics graduates change their career	• There are limited laboratory facilities • Uncertainty of motivation for teachers • Limited experience and hence poor performance • Few science and mathematics graduate teachers
Few science and mathematics graduate teachers	Scarcity of scientific and mathematics teachers	• Tanzania's slow scientific and technical development

Shortage of Mathematicians and Scientists in Teaching – A Global Review

When there are not enough teachers in a certain subject area while the student population is expanding, this is referred to as a teacher shortage (Pister, 2007). The situation is faced at all levels of education and in many countries worldwide. The big problem is the retention of the teachers working in the educational sector which is caused by the fact that teachers are not enjoying the privilege of school curricula control delivery but rather they are acting as professionals where they value time above compensation (Pister, 2007). In a study conducted on the trends and issues related to science education specifically on the shortage of science teachers, it was found that many science teachers are leaving the teaching profession. Some science teachers are overwhelmed and feel unsupported in the classroom and their expectations are not clear (Mangrubang, 2005).

There are several factors mentioned in various studies about the scarcity of science teachers in different regions of the world including the USA, Europe, and Africa. A memo by McKenna (2018), in the USA from the Learning Policy Institute, said that some factors are causing the shortage of science teachers. The factors mentioned include challenging working conditions for the teachers, lack of administrative support, lack of adequate teaching preparation, teachers turnover, lack of science teachers' and low salaries relative to other science-related professions. For years, teacher shortages have been in the news and raising concern across the country and New York is no exception (New York Educational Conference Board, 2020). Indeed, state officials estimate that over the next ten years, schools will require an additional 180,000 teachers. Given the declining trends in teacher training programs, it appears unlikely that demand will be met. According to New York Educational Conference Board (2020), the number of students enrolled in the state's undergraduate and graduate teacher education programs fell by 53% between 2009 and 2017, from over 79,000 to over 37,000. The problem will be compounded by teacher

retirements. There were over 36,000 active Teacher Retirement System (TRS) members between the ages of 50 and 55 in November 2018, according to data from the New York State TRS (New York Educational Conference Board, 2020).

According to the New York Educational Conference Board (2020), the scarcity of replacements is caused by several variables. Individuals in teacher preparation programs (or recent graduates), for example, frequently substitute to get classroom experience; fewer enrollees equal fewer substitutes. In addition, the New York Educational Conference Board (2020), reported that when the economy is booming, many who might otherwise seek substitute teaching employment prefer to work full-time with benefits. Individuals without qualifications are not allowed to substitute for more than 40 days in a single school district each school year, which makes it difficult to recruit substitute teachers. Educators from various origins are likewise lacking in New York classrooms. In addition, school districts are dealing with a lack of diversity in the educator workforce. In other words, the workforce does not reflect the rich diversity of children in New York or across the country.

Teacher shortages, according to the Learning Policy Institute report, may force the school management to hire less experienced instructors, lower the number of courses provided, or increase class sizes, all of which hurt student learning (McKenna, 2018). Turnover has an influence on all kids in a school not just those with a new teacher, by undermining school stability, collegial connections, collaboration, and the accumulation of institutional knowledge. Taking it a step further, a study of 850,000 fourth- and fifth-graders in New York City over eight years found that grades with high teacher turnover had lower mathematics and English language arts achievement (McKenna, 2018). Students are also harmed by substitute teacher shortages. When replacements are not available, regular faculty members may forego preparation time to cover classes. Because

teachers do not have time to prepare for their classes or collaborate with colleagues, this is a lose-lose situation for all pupils concerned. Building leaders and paraprofessionals may be called in to cover courses, which means their usual responsibilities are jeopardized. When replacement teachers are unable to be placed in schools, kids are distributed to other classrooms, resulting in greater class sizes. Learning is interrupted once again since educators do not always teach at the same pace as their colleagues, and students may be assigned to classes that are ahead of or behind their own. New York's students are also harmed by a lack of diversity in the educational workforce (McKenna, 2018).

It is crucial to give instructors effective initial preparation for getting ready for teaching and continued assistance once they reach the classroom. According to Sterling (2020), a study suggested that teacher preparation has connections to both engagement and student accomplishment. Effective teacher preparation is not necessarily feasible as the need to hire instructors who are not qualified grows. Therefore, it is crucial to give instructors continual support throughout their first few years in the teaching profession when they are employed with little to no training as teachers. Sterling (2020) reported that within the first five years of classroom instruction, in the United States, the teacher retention statistic declines significantly, but it declines even more dramatically for those teachers who received inadequate initial preparation for their profession. Additionally, studies show that highly qualified teachers have the biggest influence on high student accomplishment.

Amongst the most important concerns confronting policymakers is how to recruit and hire teachers with stable teaching professions and be capable of meeting the complex needs of all students while also meeting the increasing demands of the health economy (McKenna, 2018). Recurrent teacher shortages are caused by both a decline in new teachers entering the profession and high rates of

teacher turnover, in particular, secondary school scientific and mathematics trainers. This turnover is costly and hurts student achievement and school improvement efforts. A good understanding of why teachers join and quit the job, as well as what, might entice them to remain or return, is critical to improving educational opportunities for all students, particularly those in the most disadvantaged schools (McKenna, 2018).

Furthermore, Dolenc et al. (2021), in a research study in Sylvania, provided evidence of a baseline for action to prevent the educational catastrophe that would result from the predicted shortage of STEM teachers in Slovenia's lower secondary schools by identifying factors and continuing to develop supporting experience-based opportunities which may encourage teachers to participate. It may be estimated that, without a modification in educational policy supporting students to choose to teach STEM courses as a vocation, the number of STEM instructors will fall below those acceptable thresholds, based on data received from relevant organizations.

According to Dolenc et al. (2021), there is certainly no need to discuss the value of persons who are highly educated in Science, Technology, Engineering, and Mathematics (collectively STEM) and who are adept in Information and Communication Technology (ICT) in any community. If societies require such profiles, they must recruit a sufficient number of students to enroll in study and qualification programs leading to the required professions. Furthermore, as has long been acknowledged, the fundamental obstacle is not in constructing physical structures or purchasing equipment; rather, the issue is in finding skilled workers to operate inside those structures and with the equipment that has been placed. To paraphrase what is being written, if nations require STEM-educated individuals, they must make every effort to develop sufficient numbers of well-educated instructors to give this training at all levels of education. Slovenia, a small country, faces three interconnected difficulties in STEM education (Dolenc et al., 2021). The only way to keep STEM

education of excellent quality is to raise the number of STEM-engaging students in pedagogical courses. The proposed solution will require strong government financial assistance as well as the integration of teacher education strategy into Slovenian national policy (Dolenc et al., 2021).

Furthermore, Laming (2021), reported that the current global teacher shortage has major ramifications for countries striving to adopt sustainable education. The inclusion of universal primary education as the second of the UN Millennium Goals recognized the importance of education in reducing poverty, promoting peace and security, and protecting the environment. Because of the anticipated teacher shortage, programs aiming at improving awareness of sustainable practices, such as the Australian Sustainable Schools Program, the British Sustainable Development Action Plan for Schools, or the Nepali Sustainable Community Development Program, may be jeopardized (Laming, 2021).

Laming (2021) in the study report, revealed that some of the world's most developed and least developed countries may face moderate to severe teacher shortages, especially in high-demand subjects like math and science. Unfortunately, rich countries such as the United Kingdom, the United States, and Australia see hiring foreign teachers as the simplest answer to the problem (Laming, 2021). Overseas recruitment is not a bad idea if done properly and with the understanding that it is only a temporary solution. Hiring teachers from developing countries, such as Africa and the Caribbean, to fill vacancies in wealthier countries is not a long-term solution (Laming, 2021). The loss of the capital invested in highly skilled employees has a significant negative impact.

Students' attitudes toward mathematics (motivation), student age, inadequate learning methodologies, poor background in mathematics, and previous test results are all factors that contribute to students' failure in mathematics (Mazana et al., 2020). According to Mazana et al.

(2020), education in primary and secondary schools, especially lower secondary schools, have greater failure rates. Gender disparities persist at all levels of education, with girls falling in elementary, secondary, and college exams as a result of cultural variables affecting female students' performance. Policy, environment, and culture all have a part in determining why students perform poorly in mathematics in Tanzania. According to Mazana et al. (2020), the research findings the majority of mathematics educators have mixed feelings about their students' abilities and the teaching-learning environment. Furthermore, enhancements in teaching-learning settings, classroom instructions, teaching skills, student learning skills, teacher training programs, community attitude, and accountability are offered as ways to improve the problem. The findings give educators and other stakeholders information regarding mathematics achievement patterns and associated factors, allowing them to assess the implications of mathematics curriculum and instructional techniques at all levels of education (Mazana et al., 2020).

The world experienced and reached enormous scientific and technological development in recent years but not all countries have been affected equally by progression (The United Nations Educational, Science and Cultural Organization – [UNESCO], 2006). Some countries are growing faster than others. Also, the ability to cope with and apply sciences and technology depends on the country’s modernization and economic development. According to UNESCO (2006), many countries are facing a shortage of teachers in science and mathematics and therefore it is a big challenge worldwide including countries in Africa and South Sahara. Teachers allow their students to learn about many parts of the world that they would otherwise be unaware of, and the effects of their loss extend far beyond the classroom. Teachers are generally highly esteemed community members who serve in a variety of leadership capacities, especially in rural communities where other professionals are scarce. Since a lack of education is intimately related to sickness,

impoverishment, and uncontrolled population growth, the skills and knowledge they possess are at risk of being lost, which poses an imminent danger to national and regional stability (UNESCO, 2006).

According to UNESCO (2006), concerns about current or impending teacher shortages have been raised in both industrialized and developing countries for decades. However, the nature of these gaps can vary significantly. Some countries have well-established education institutions that include nearly all children in primary school and are rapidly doing that at the secondary level. Their teaching staffs have minimum qualifications or exceed them, and they do pretty well in terms of efficiency, quality, and equity. Because of the constant fall in the number of school-aged children, education spending has increased. As a result, the problem isn't necessarily one of meeting rising educational demand. Moreover, UNESCO (2006), reported that teacher shortages are most commonly caused by a lack of specialized teachers, either in terms of subject matter or the capacity to work with special needs students. Concerns have also been raised concerning the ability of certain schools, notably those serving the most disadvantaged students and communities, to attract instructors. Other countries' school-age populations are continually increasing, and universal primary or basic education has yet to be achieved. Furthermore, the teaching force has a poor degree of qualification. In this case, teacher shortages are due to a lack of supply or placement of teachers to satisfy demand.

Another study by Nedev (2014), in Mexico, reported that engineers should be trained not only in how to utilize operations manuals more effectively but also in how to use them more effectively. Indeed, the goal is to determine, within the constraints, which aspects are the most relevant in influencing the educational problem. Mexico's engineering level is considered to be lower than that of developed nations. There are also several engineering schools, but they all suffer from a

shortage of development resources, such as laboratory equipment and highly educated people, to varying degrees. This is attributable, in part, to an individual country's technological dependency.

Moreover, another report by the International Labor Organization - ILO (2008), highlighted that a widespread issue in many countries is the lack of trained scientific and mathematics teachers. The International Labour Organization (ILO) estimated that 18 million more teachers would be needed globally by 2015 to meet the demands of the Education for All movement and the Millennium Development Goals (MDGs). To achieve this, many nations have increased their efforts to enroll a sizable proportion of students in scientific and mathematics courses. Enrollment attempts have rarely produced the expected effects in the majority of these countries since there are insufficiently competent and passionate instructors in mathematics and science (ILO, 2008).

Whenever there is increasing in student enrolment and the increase results in a scarcity of teachers, especially in science and mathematics subjects (Kapur, 2018). The shortage of science and mathematics teachers is the result of many reasons including the number of teachers in demand and the number available for supply; the issue of existing working conditions and existing policies (Garcia & Weiss, 2019). Shortage of teachers and turnover have become crucial issues affecting education in schools as they affect the quality of teaching which causes poor performance in science subjects. Moreover, this poor performance has impacted the students' future careers and their perception of science-related study (McKenna, 2018).

Furthermore, the memo by McKenna (2018), revealed that in some schools the classrooms were staffed by under-qualified science teachers as a result of the shortage of teachers. Also, this study revealed that there is poor retention of some new teachers within five years of the teaching career and that if these teachers are receiving good collaboration, extra resources, and a strong network,

teacher turnover could be minimized. According to McKenna (2018), teachers' turnover in science and mathematics varies with states from 19% to 70% where the smaller percentage is in schools that offer high salaries and the higher percentage is in schools that pay low salaries.

Sterling (2020) reported that there is a rising issue in the United States of America with the shortage of scientific and math teachers. Whenever the teacher shortage intensifies, underqualified instructors are hired to fill the gap, or teachers without credentials in science or mathematics are assigned to teach those subjects. Since these underqualified educators are not staying in the field, the teacher shortage issue is not being resolved, and the level of turnover for educators is increasing. Additionally, more experienced teachers are quitting the field due to low pay and job discontent. According to Sterling (2020), teachers' initial training and support whenever they enter the field are essential for their survival and retention in the early years. Additionally. The greatest influence on successful classroom management and excellent student accomplishment is exerted by well-prepared teachers.

Furthermore, it is revealed that teachers' turnover may be caused by some factors which include salaries, and inadequate provision of mentorship programs, especially in the early years of teaching (Kapur, 2018). However, Ingersoll (2003), reported that the shortage of teachers in secondary schools is caused by some different factors including the retirement of the aged teachers, personal or family problems, job dissatisfaction, poor professional advancement, student discipline problems, too large classes, inadequate knowledge and skills, inadequate time to prepare and change to pursue other careers. Moreover, it was reported that the shortage of teachers is associated with two demographic converging trends which include increasing teacher turnover and increasing student enrolment (Ingersoll 2006; Kapur 2018). These trends are forcing school systems to employ unqualified teachers so as solve the problem and later lead to poor school performance.

Teacher turnover impacts students' achievements at all levels of education by disrupting the school's steadiness and the buildup of knowledge (Ingersoll, 2003).

According to Dee and Goldhaber (2017), teacher-hiring difficulties have greatly expanded, but there is no evidence that these challenges are a prevalent issue in the United States of America (USA) public schools. However, in their research, they did find compelling evidence of teacher hiring and retention challenges in sufficiently high levels and difficult-to-staff schools. These targeted teacher shortage challenges are related to long-standing issues with how we recruit, train, and compensate teachers. The shortage of Science Technology Engineering and Mathematics (STEM) teachers varies from one state to another in the USA according to the location of the school and the economic status of the school. As a result, the solutions to staffing issues should be targeted as well. These issues are indeed strongly evident by considering the implications of using monetary incentives to address staffing shortages. The most straightforward policy lever that can be used to make a teaching job more desirable is to increase its pay. Investigation showed that the shortage of teachers in the United States of America (USA) is a challenge that exists for a long time due to the way they train, recruit, and compensate (Dee & Goldhaber, 2017). Moreover, White (2019), revealed that in the United States of America (USA) Department of Education report, the shortage of teachers between 2018 -2019 was high in some districts including Georgia, Florida, and California where the shortages were in the high and middle schools and special education, science, and mathematics teachers.

Dee and Goldhaber, (2017) reported some other initiatives to address teacher shortages that hold a lot of promise. For example, by establishing a regional or even national employment market for educators through genuine licensing requirements reciprocity, the attempt to teach the employment market would become more flexible and capable of addressing local shortages. Dee and

Goldhaber, (2017) reported that somewhere at the local level, districts can engage in strategic planning to address their recruitment challenges. To encourage teachers, for example, some municipalities are going to experiment with assertive, high-touch, digitally native recruitment methods. This technique has the advantage of being immediately implementable and strictly restricted to a specific region's esteem needs. These issues may indeed be best illustrated by considering the implications of using monetary incentives to resolve staff shortages. Increased pay is the most simple and direct policy mechanism that can be used to start making a teaching job unite desirable (Dee & Goldhaber, 2017). In the research methodology Dee and Goldhaber (2017), demonstrate the importance of directing resources to areas of greatest need; purposeful impacts on staffing necessitate requires relatively large financial investments. Allocating funds for salaries and increasing teaching facilities to resolve issues that are receiving attention in specific subjects and schools dilute the success of those limited resources.

In the USA Dee and Goldhaber (2017), the scarcity of scientific and mathematics instructors is a growing problem and as the situation worsens in the schools, teachers without science and mathematics backgrounds are assigned to teach while in other schools unqualified teachers are hired to fill the shortage. These un(der)qualified teachers include those who have Bachelor's degrees in science and mathematics but they have not studied education courses. Some un(der)qualified teachers are not permanent in the teaching profession, thus when they leave, they create a high teacher turnover rate in schools. The high teacher turnover has a large impact on effective classroom teaching and learning and students' achievement or academic performance.

According to Dee and Goldhaber (2017), the necessity of allocating resources to areas of high need is demonstrated by research on this technique; considerable impacts on staffing need very large financial outlays. Allocating funds to pay raises across the board to address problems that are

predominantly cantered in specific courses and schools spreads those scarce resources so thinly that their impact is severely diminished. Other techniques to deal with teacher shortages are also promising. For example, full licensure equivalence would make the teaching labor market more flexible and better able to solve local shortages by creating a regional or even nationwide labor market for instructors. There are other entrepreneurial approaches that districts might use to handle their hiring difficulties at the local level.

Dee and Goldhaber, (2017), explained that this strategy has the advantage of being quick to deploy and tightly focused on specific areas of need. Early recruiting initiatives that widen the pool of eligible candidates, as well as the forward-looking utilization of student-teaching placements in anticipation of near-term hiring needs, can help districts alleviate teacher shortages. There must be careful emphasis that, while these solutions, and persuasive logic and empirical backing, the underlying evidence base is damaged. Given the scarcity of evidence, Dee and Goldhaber, (2017), advise states and districts considering these recommendations to adopt an inquiry mindset, in which the design, execution, and evaluation of such efforts are iterative, accelerating the efficacy of reforms at scale.

According to Ingersoll & Perda (2009), in their report mathematics and science teachers have roughly the same annual turnover rates as other teachers. However, unlike in the case of English teachers, the educational system does not have a large surplus of new mathematics and science teachers in comparison to total turnover. In the field of English, the supply of new teachers from the pipeline and the reserve pool is more than enough to cover all losses due to retirement or other reasons. In mathematics and science, the balance between new teacher supply and total turnover, which includes both retirement and other reasons, is much tighter. The pipeline and reserve pool supply of new teachers is insufficient, with only slightly more than one new mathematics or science

teacher for each science and mathematics class who leaves the teaching profession (Ingersoll & Perda 2009). Furthermore, Ingersoll and Perda (2009) reported in their research findings that, teacher turnover is not distributed evenly. There are large variations in turnover within states, as well as large differences in turnover between schools. Also, these disparities are related to the attractiveness of working conditions in schools. While retirement accounted for less than a quarter of all mathematics and science teachers who superannuated at the finish of the 1999-2000 academic year, job dissatisfaction accounted for roughly half of their attrition (Ingersoll & Perda, 2009).

Also, there have been education and curriculum reforms that have missed the necessary resources for implementation. During these reforms, it sometimes takes time for the teachers and the students to be able to cope, adapt and change their routine of teaching and learning methods respectively (Osaki, 2007). Many of the above problems have persisted due to insufficient planning by the education administrators and the involved secondary schools.

However, with the changing world of science education, it is important to strengthen the students, especially at the secondary school lower level. The emphasis could be on the need for early childhood science education to prepare scientists and technologists for advancements in research and innovation as a basis for economic prosperity and the welfare of a rising economy (Hamilton et al., 2010). These groups of students are the base who feed the middle and tertiary levels. From the economic perspective, uncertainty, and rapid technological changes, it is proper to train and improve the quality and flexibility of the workforce through training. Science education has suffered economically which led to a decrease in funding in many countries. Darling-Hammond and Carver-Thomas (2016), revealed in their study that high-poverty schools are likely to suffer a lack of highly qualified teachers as these teachers tend to join schools that proved them with better

pay, working conditions, and other support. This means that it is very difficult to retain highly qualified teachers in high-poverty schools since those schools offer low-income to the teachers. Garcia and Weiss (2019), in their study, reported that to retain teachers in schools, we must tackle the working conditions and some other factors contributing to the long-lasting scarcity of teachers in high-poverty secondary schools.

Moreover, Sutcher et al. (2016), reported a shortage of qualified teachers in mathematics, science, special education, as well as bilingual education in the United States of America in 2015. To address the problem, several states have opted to employ untrained teachers. According to Sutcher et al. (2016), report the shortage of teachers has been caused by the decline in the enrolment of teachers and the increase in the teacher-pupil ratios which are caused by increasing student enrolment and high teacher turnover.

From the above literature, there is a shortage of teachers, especially in scientific and mathematics subjects. Reasons for the lack of teachers vary from one place to another worldwide. All in all, the scarcity of teachers in scientific and mathematics subjects has impacts on individual students, the nation as a whole, as well as the educational system. Scarcity plays some negative consequences on the learners' achievement in the academic area. The increase in enrolment with few teaching staff causes stress to the teaching process, especially when the turnover is caused by the teachers departing from their jobs (Ingersoll, 2003). The students have been affected negatively items performance and their future careers. The current study intends to examine the main factors that are causing the scarcity of teachers in scientific and mathematics subjects in secondary schools and the impacts on Tanzanian secondary schools.

Scarcity of Scientists and Mathematicians Teachers: Africa Review

Tanzania and other African nations, like those in the rest of Africa, also have a teacher shortage in mathematical and scientific subjects. Many academics and researchers in Africa are attempting to determine some of the causes of the dearth of secondary-level mathematical and scientific instructors. Some of them were studying the shortage of one among the science subjects, either Physics, Biology, or Chemistry while others were studying all science subjects.

One of the most pressing public policy concerns facing many countries is finding enough trained teachers to staff classrooms. Teacher shortages have long been a concern in Ghana, caused by educational expansion as well as bad socioeconomic and political conditions, and exacerbated by a high attrition rate (Cobbold, 2015). The search for a solution is still ongoing. Moreover, Cobbold (2015), reported that in exchange for a pay raise, teachers' workloads are increased by raising class sizes and/or the average number of classes given to each instructor, as well as lengthening their working hours. The "double-shift" arrangement, in which schools provide lessons for one group of students in the mornings and another in the afternoons, is a variation of this policy (Cobbold, 2015). This means less money spent on equipment and fewer teachers, with the added benefit of being able to deal with a shortage of infrastructure and teaching-learning resources. Such overloading strategies are common in developing nations; they can ultimately drive skilled instructors into other professions, particularly as overall working conditions and real compensation rates continue to deteriorate (Cobbold, 2015).

According to Cobbold (2015), research findings showed that the second policy strategy is to increase the number of teachers by using monetary and nonmonetary incentives to make teaching more appealing and flexible to enter. One strategy is to lower teacher qualification standards by

hiring persons who are not fully licensed or requesting certified instructors to teach areas in which they are not prepared, a practice known as out-of-license and out-of-field teaching in the literature. Some countries hire retired and international educators. Another possibility is to reform teacher education and certification systems to produce more teachers in a shorter time and at a lower cost. Another supply-side approach that has been considered in the literature is reducing the average class size to improve working conditions and recruit more teachers. Thus, it is suggested and recommended that having a small class size could eventually result in high-quality learning. Cobbold (2015) research findings revealed that class size decreases had a small positive influence on student learning, while class size increases have a detrimental impact. The problem is that class size is both a demand and supply component, so any strategy that aims to use the classroom must account for both.

According to the Government of the Republic of Tanzania (2020), a primary school teacher must teach 28 to 30 periods per week, while a secondary school teacher must teach 12 to 24 periods per week, according to the Ministry of Education, Science, and Technology. Only twelve periods are meant to be allotted to school administrators. Manyengo (2021) in a study discovered that some primary school teachers had more than 70 periods per week. These teachers are typically found in public primary schools teaching grade one. High enrolment rates and teacher shortages are two factors contributing to the heavy workload (Manyengo, 2021). It was discovered that some science teachers at public secondary schools had up to 50 periods each week. In addition to teaching, teachers had to oversee extracurricular activities as directed by the school's head. Private primary school teachers often teach 25 to 30 lessons per week, while private secondary school teachers typically teach 22 to 30 lessons per week. The workload at secondary technical schools is

comparable to that in private schools. This information shows that there is a shortage of teachers from primary to secondary schools.

Dlamini (2014) did an overview study on the factors associated with the shortage of Physics teachers in secondary schools in Swaziland. The research study findings by Dlamini (2014), revealed that there are some factors associated with the shortage of Physics teachers including policy-related factors and institutional and professional-related levels. Dlamini (2014) revealed that the government of Swaziland is aware of the shortage of science teachers that exist in the education system and the Ministry of Education and Training in the country has been working to find strategies on how to increase the intake of scientific and mathematical teachers to supply and fill the noted scarcity gap in the education system.

According to Barrett et al. (2019), there has been a lack of qualified teachers specifically for scientific and mathematical subjects in secondary schools from Sub-Saharan Africa. This problem worsened with the introduction of the 'Education for All' movement at secondary school levels where more students were enrolled while there is no recruitment and retention of teachers (Kapur, 2018). To improve teachers' status and attract more of them to the teaching profession, many efforts and strategies have been made in the region to ensure that there is the retention of scientific and mathematical teachers in secondary schools. The increments of the teachers' salaries, clearly defined career pathways, accreditation of achievements, and opportunities for promotion should be considered (Barrett et al., 2019; Kapur, 2018). The academic success of secondary school students may be hampered by a lack of qualified teachers and their unequal distribution, particularly in impoverished communities. However, Abdi and Kharbirymbai (2019), argued that following self-rule, Kenya steadily grew the pool of qualified teachers available for employment, with the number of qualified teachers without jobs soon expected to exceed that of government

employees. Yet, there are not enough teachers in public schools, and there are differences in the initial training and deployment of teachers, including some localities having yet to generate a single certified teacher.

In Sub-Saharan Africa, including Tanzania, there are few science and math instructors despite the tactics and attempts made to reduce the shortages. This is due to the dearth of science graduates individuals who chose teaching as a profession. It is obvious that these people do choose other careers or leave the teaching career after joining and as a result retaining them becomes more problematic (Barrett et al., 2019; Kapur, 2018). The impacts of this shortage affect mostly the learners who have various learning abilities and skills that with the shortage they may not be able to achieve (Kapur, 2018). This is a negative impact on the learners. There must be continuous intervention to ensure that the impacts are at minimal levels. The lack of qualified teachers and their unequal distribution, particularly in underserved areas, typically aggravate the equity gap in education (Abdi & Kharbirymbai 2019). Teachers should receive professional training, be suitably hired and paid, be motivated, and be supported within well-resourced, functional, and controlled systems because they are an essential requirement for ensuring the highest possible standard of learning.

Many scholars have studied and indicated that there are shortages of scientific and mathematics teachers in secondary schools, but many of them have not ascertained the causes of the shortage and the impacts of the scarcity on students, teachers, or the education sector at large (Kapur, 2018; Projest, 2013; Ndalichako and Komba, 2014). According to Kapur (2018), the issue of a shortage of scientific as well as mathematics teachers in secondary schools must be addressed throughout all levels of education from primary through to the tertiary level as these levels feed one another.

This means that learners at all education levels must be equipped with science and mathematics knowledge and skills to be able to enroll in those subjects at the tertiary level.

To improve the recruitment of Science and Mathematics teachers, many Sub-Saharan African countries decided to offer scholarships and bursaries. In South Africa for example there are two programs which are Funza Lushaka Bursary Program (FLBP) and the South African Mathematics and Teacher Intern Program (SAMTIP). These two programs have improved the enrolment of B Ed and PGEC courses in science and mathematics disciplines (Barrett et al., (2019). Apart from all those efforts of minimizing the scarcity of teachers, it is still an issue that needs to be addressed in many countries in Africa. Magano (2014) reported that there is a need to strengthen the Funza-Lushaka Bursary through proper planning to ensure that the training of the teachers is done effectively based on identified needs. If the scarcity of teachers is identified in the rural area the Funza-Lushaka bursary should specifically address the shortage.

The South Africa Council of Educators (SACE, 2011) revealed that teachers' supply is influenced by the number of private and public institutions that are licensed to train teachers. The number of new teachers will rise as more colleges train them. However, this expanded number of institutions must never come at the cost of the quality of the studies they offer. If no learner's engine for programs and those who do not drop out, having institutions is insufficient. Moreover, SACE (2011) revealed that by permitting alternative pathways into teaching, the combination of full and part-time interaction in obtaining the B.Ed. assures a prospective rise in supply. If potential teachers take advantage of distance education, it will boost the supply of student instructors. Simultaneously, the proposed regulation allows teachers who wish to alter the phase or study area in which they are qualified to teach to do so by completing additional training. It allows teachers

to move around the institution without losing their jobs. The issue, as with the other strategies for increasing supply, is the quality of the permitted suppliers and their supervision.

The role of legislation, natural attrition, unplanned attrition, economic considerations, and the expense of education was investigated by the South African Council of Educators. Teacher-demand research must shift away from aggregate studies, which miss out on hidden demand. Teachers teaching outside of their area of specialization or teachers migrating to other schools, but are not lost to the education system, are examples of hidden demand (SACE, 2011).

According to SACE (2011), teacher demand, from an economic standpoint, is a function of pricing for purchasing teacher services and represents the number of instructors a monopoly (government) is willing to buy at a given price. This economic definition also implies that future instructors may opt out of the teaching market if the current monopoly prices are lower than teachers' reservation prices, rising demand. There is always a trade-off between demand and price from the government's standpoint, which results in an increased or decreased need for instructors. Demand can also be viewed from a policy perspective, in which demand is determined by set policy imperatives such as the learner-to-educator ratio. Regardless of the available budget, these decide how many teachers are required. Learning areas and instructors with the necessary skills for inclusive education will urge that this be stretched. The amount of teacher demand is the result of two processes occurring at the same time.

SACE (2011) reported the legislation and policy that governs the educational system, and the second one is the effects of using technology in the classroom on demand. The first is the educational legislation and policy that controls the system. Second, demand is affected by the usage of technology in the classroom. South Africa is also a signatory to the Dakar Framework,

which lays out six objectives for achieving universal basic education by 2015. Two of the six goals have direct implications for the provision of excellent educators since they commit governments to increase the basic education that is both free and required for all children. The government must also ensure that all young people and adult learning needs are satisfied. This could potentially boost enrolment numbers in areas where school coverage isn't perfect. It also indicates that students will stay in school longer, meaning a higher demand for an excellent education.

According to the SACE (2011), the challenge of distinguishing between rural and urban areas complicates demand. What is evident, however, is that some geographic areas and institutions provide significant recruitment and retention issues. The difficulty of working and living conditions for teachers is a defining feature of certain geographic areas and schools. It's worth noting that in other nations, regional demand is more closely linked to the characteristics of students in particular schools than to a shortage of resources including teachers (SACE, 2011). The impact of pedagogical change on demand is the focus here. The implementation of new pedagogy implies that there is a demand for teachers who have been trained in the new pedagogy. Even if teachers are actively teaching, there is a lack of teachers until they are trained, whether through inset or preset, which is another sort of hidden demand. It is crucial to highlight, however, that in most circumstances, the shortfall is generally masked because classrooms have teachers who are instructing. Learner performance is affected by incorrect teaching or misinterpretation of the new methodology (SACE, 2011).

A push to lower learner-to-educator ratios would increase demand, which must be balanced against the budget and learning impact. If the policy is to be completely implemented, it will increase demand. The rate of educator attrition has an impact on teacher demand. Deaths, resignations, retirement, dismissals, and temporary exits from the profession all affect the attrition rate (SACE,

2011). Teachers' age distributions can be used to forecast demand due to retirements. Similarly, by modeling death rates in the profession, mortality rates, and the needed results can be predicted and prepared for. The rate of resignations from the profession or inside the organization is the most difficult to plan for. That means policymakers will continue to plan based on assumptions rather than actual educational needs. The rate of educator attrition has an impact on teacher demand. The rate of resignations from the profession or inside the organization is the most difficult to plan for (SACE, 2011).

That means policymakers will continue to plan based on assumptions rather than actual educational needs. To begin with, the South African Council of Educators (SACE) had to work with other stakeholders to identify critical teacher quality metrics. These should include factors such as general qualification, specialization, and other indicators of teacher quality. Currently, supply and demand research does not take into account the impact of quality and its distribution. What the quality indicators suggest about the quantity-quality tradeoff, the quality-price relationship, and estimates on teacher supply quality and quantity are all needed. Second, because SACE is the licensing agency, the impact of the teacher certifications it certifies must be assessed (SACE, 2011).

Moreover, Barrett et al. (2019), revealed that South Africa introduced two more programs which are Alternative Teaching Training Program (ATTP) and Professional Development Program (PDP). The two programs were aimed at training and supplying suitably qualified teachers and addressing the issue of unqualified teachers' practice by improving their knowledge and teaching skills respectively. Moreover, there has been a widening of using mobile technology to play a role in developing teachers' knowledge and skills through programs such as The Teachers Education

in Sub-Saharan Africa (TESSA) and the Secondary Science Project (SSP) in Zambia. These programs provide educators with materials to improve pedagogical skills and subject knowledge.

The use of laboratories in teaching science gives students more practical and improves scientific skills and understanding. This is because active involvement, participation in activities, and quality teaching are all dependent on students' interests. Therefore, teachers must incorporate such activities into their teaching approaches while presenting difficult subjects such as science and mathematics topics. In Zimbabwe for example the distribution of enough scientific laboratory kits enabled teachers to perform demonstrations that also improved their teaching methods and the understanding of their students in science subjects (Barrett et al., 2019).

The studies by Dlamini (2014) and Kapur (2018), revealed that the main solution to the scarcity of teachers in this field of science and mathematics, the policymakers and the educationist to consider improving science and mathematics working conditions, the teachers' remuneration, and their status. Improving science teachers' working conditions by empowering them with classroom management skills and providing them with content knowledge in science and mathematics could probably retain most of them in the teaching profession much longer. Dlamini (2014) reported that policy is an essential improvement and substance of human resources in the education system and lack of the policies affects the processes of teaching at the institutional levels. Policies must state how to empower pre-service teachers at the tertiary level to handle the science subject concepts.

Lack of educational policies has much more effects on the quality of science teachers that may result in the employment of non-specialist science and mathematics teachers. Employing non-specialist science and mathematics teachers affects the learners as they will not acquire enough basic knowledge to pursue the subjects. It may also cause and affect the teacher-student ratio and

employing non-specialist teachers can result in poor performance of students (Dlamini, 2014). The result of this poor performance is to keep the problem of the scarcity of scientific and mathematics teachers in secondary schools since more students will shy off from choosing to study science discipline. If this will happen, it means fewer scientists are produced, especially science and mathematics teachers.

Furthermore, Kapur (2018), argued that the less pay for many teachers also results in individual teachers looking for other high pay jobs. Also, it was revealed that more reasons for the shortage of teachers including the ones who reach retirement age, and others due to family or personal problems that remains temporary or permanent and result in a shortage of teachers in secondary schools. The World Bank (2006) report shows that the teacher-student ratio in Swaziland is 1:32 and 1:13 in primary and secondary schools respectively, indicating the adequate number of teachers in that country. However, due to low enrolment in teacher training institutions, there was a shortage of science and mathematics teachers (Dlamini, 2014).

In another study by Bourdon et al. (2007), in Francophone Africa, primary school enrolment is quite low. In recent years, many countries have launched large teacher recruitment programs, in which teachers are no longer employed as civil servants, but instead based on (fixed-term) contracts, which typically imply significantly lower salaries and a significantly shorter period of professional training. While this program has increased primary enrolment, there is concern that school quality may suffer. Bourdon et al. (2007) examined the influence on educational quality in this study by estimating non-parametrically the quantile treatment effects for Niger, Togo, and Mali, using highly informative data that is comparable across these countries.

According to research findings, contractual teachers operate better for low-ability students from lower classes compared to high-ability students in the upper grades (Bourdon et al., 2007). Positive treatment effects appeared to be more prominent at the low to moderate ability quantiles, while negative treatment effects tended to be more pronounced at the high ability quantiles. As a result, it appears that contractual teachers are better at teaching pupils with learning disabilities than they are that advanced youngsters. This means that contract instructors are more likely to eliminate student outcomes inequalities. Simultaneously, Bourdon et al. (2007), noticed that there are significant variances between the countries. Overall, findings showed that there are positive benefits in Mali, mixed effects in Togo (with good impacts in 2nd grade and negative effects in 5th grade), and negative effects in Niger. Bourdon et al. (2007) reported that this ranking is in line with theoretical predictions based on a closer look at the three countries' distinct approaches to implementing the contract teacher program. The contract teacher system functions largely through local communities in Mali and, to a lesser extent in Togo. This may have resulted in more effective monitoring and recruiting of contract instructors.

Moreover, Mamlok-Naaman (2006), in a research study revealed that the community schools are the most underprivileged and challenged with a high enrolment of students and low in employing scientific and mathematics teachers. Moreover, community schools lack most of the significant teaching and learning facilities including libraries, reading resources, teaching staff, preparation rooms, laboratories and apparatus, and teachers' necessary facilities such as housing. As a result, the process of teaching-learning particularly scientific and mathematics subjects is affected the most in comparison with non-science subjects.

Scarcity of Scientists and Mathematicians Teachers: Tanzania Review

The scarcity of scientific and mathematics teachers in Tanzanian secondary schools is existing in both urban and rural areas. This is most likely causing some impacts on either students or schools and the nation at large. Several scholars reported the issue related to the factors causing the scarcity of scientific as well as mathematics teachers in secondary schools (Kamagi, 2017; King'aru, 2014; Mamlok-Naaman, 2014; Saga, 2014; Ndalichako and Komba, 2014; Projest, 2013; Semali and Mehta, 2012; and The Citizen, 2022). The lack of scientific and mathematics teachers in secondary schools is a difficult problem in Tanzania, as it is in other nations throughout the world. Mamlok-Naaman (2014); Saga (2014), in different studies revealed that the scarcity of science teachers and mathematics in Tanzania is increasing due to the inadequate in-service programs for science and mathematics teachers mainly in rural areas. Projest (2013) reported the shortage of teachers problem and provided the measures taken against this challenge including the employment of untrained and with less instructional skills teachers to teach science subjects.

According to the Government of the United Republic of Tanzania (2020), 97.8% of primary school teachers in both public and private schools were qualified in 2019. Comparable to primary schools, 93.2 percent of teachers in secondary schools, including public and private, were qualified, while the other teachers either did not teach or had qualifications below a college diploma. A total of 80,000 teachers in both primary and secondary schools are needed in Tanzanian, whereas teachers in public schools require 66,000 in primary schools, and 14,000 in secondary schools (Malanga 2019; The Citizen, 2019). Particularly science and mathematics subjects are more impacted. In the 2019–20 fiscal year, the government is taking steps to hire 13,526 teachers in public primary and secondary schools (Manyengo, 2021). Thus, the information given here is proof of the existence of scarcity of teachers in both mathematics as well as scientific subjects in Tanzanian secondary

schools. Also, this implies that we still have a lot to do to minimize the scarcity of teachers not only in secondary schools but also in primary schools.

The impacts of the scarcity of scientific as well as mathematics teachers in secondary schools have been reported regarding the national examination results for Tanzanian secondary schools for the year 2018. Physics and mathematics were the most poorly performed subjects with 20 percent passing in that year (The Citizen, 2019). The lack of mathematical and scientific teachers was cited as the cause of these findings. Other explanations included a high teacher-to-student ratio, pupils' negative perceptions of mathematics as a challenging subject, and a dearth of textbooks in secondary schools. According to The Citizen (2019), about 10 students once at a time used one book in a lesson indicating the inadequacy of this important teaching facility. Additionally, The Citizen (2019) found that mathematics is very easy to forget, needs extensive practice, and requires logic and reasoning and the capacity to think in words from the standpoint of the students. This an evidence of the scarcity of teachers in scientific as well as mathematical subjects in secondary schools in Tanzania. The present study looked into the factors causing the scarcity of the teachers and effects of Tanzania's secondary schools' lack of science and math teachers.

The study by Semali and Mehta (2012), revealed that many schools enroll more than their capacity and as a result, they share available resources with a large group of students. Such resources include science textbooks and laboratory facilities such that some students end up watching others experimenting as there are not enough chemicals or equipment. Some schools lack laboratories and therefore teaching and learning took place in a theoretical way than on a practical basis. In their study, Semali & Mehta (2012), reported that many of the science textbooks used between 2007 and 2009 are authored outside of Tanzania, and therefore may have missed the local content that can address the students’ familiarity.

Resources for teaching and learning, such as adequate instructional supplies and equipment, clean equipment, rational student-to-teacher ratios, laboratories, library, and appropriate support staff, can personal characteristics of employee retention and the type of classroom instructions be necessary to ensure high student performance. Limited resources and a high number of students in a classroom demoralize the teachers during the instructional process and cause poor performance.

Semali and Mehta (2012) in their study also reported that there is a perception that science and mathematics subjects are hard, and this perception discourages girls from studying science subjects. While mathematics can be considered an important subject at this age in secondary schools, students do not like to study mathematics subject. According to Ukobizaba et al. (2021), the reasons why students hate mathematics relate to how mathematics is taught. Mostly, the teachers fail to demonstrate the use of mathematics and the relationship between mathematics and students' everyday life. The teachers provide a few worked examples that the students consider not enough for them to like mathematics. Students receive poor grades or marks at the close of the school term. Semali and Mehta (2012) in their study further come up with the finding that there is low motivation for teachers who teach science regardless of their efforts to prepare laboratory experiments and lessons. Science and mathematics subjects need more practical work than theory to help the students to understand them.

According to King'aru (2014), a study conducted in Tanzania showed that there is still a lot to be done in secondary schools to raise the performance of science subjects to standard. There is a need to increase the reading resources both textbooks and supplementary books, improve teachers' science knowledge, and skills, and equip all laboratories with the important and necessary equipment and chemicals. Secondary schools lacked important teaching and learning facilities, according to the research literature including libraries, labs, textbooks, classrooms, and furniture.

Syllabus coverage received a low rating as well. King'aru (2014) reported that unfavorable evaluations of teaching and learning tools raise major questions about their efficacy in teaching as well as the learning process. A lack of suitable teaching and learning resources has been linked to poor syllabus coverage. A scarcity of textbooks, for example, limits the number and quality of tasks that instructors can assign to students, slowing down the teaching-learning activities and reducing syllabus coverage. And insufficient coverage of the syllabus is likely to result in poor achievement academically.

The above challenges lead to the further problem of producing scientists who cannot practice but only have the knowledge to respond correctly to the examination questions. It is a very serious challenge as these students become unqualified graduates to teach in the class. Apart from all those challenges yet student teachers opt to study science and mathematics subjects. According to Semali and Mehta (2012), the main reason revealed from their study on why the students choose to study science and mathematics includes the personal interest of the student teachers in those subjects which are Biology, Physics, Chemistry, and Mathematics. However, it was also revealed in their study that some students who are studying science and mathematics abandon those subjects when they join the tertiary level due to poor knowledge that has been caused by the lack of teaching resources, laboratories, and other learning facilities in secondary schools.

King'aru (2014) revealed that science subject performance among students in secondary schools seems to be very poor. The reasons given for this poor performance include negative attitude toward science subjects among students, poor teaching methodology, lack of teaching as well as learning material or resources such as textbooks, and lack of well-furnished laboratories. Also, there is an unfit environment for teaching scientific and mathematical subjects in some secondary schools. In some schools' science practices are carried out in the classrooms where the theory part

is also taking place. Moreover, teachers were also facing difficulty and were discouraged to teach science subjects due to students' negative, perceptions of science subjects and as a result poorer performance (King'aru, 2014). Many students have the perception that science and mathematics are hard subjects to learn.

Semali and Mehta (2012) realized in their study that effective education is the outcome of the collaboration of multiple performers including teachers and students, community and administrators, and teachers must be sufficiently competent with the content of science subjects, and teaching methods while appreciating also local knowledge systems. In their study, Semali and Mehta (2012), suggested that the challenges to reforming the Tanzanian educational formation to meet the 21st - century demands will require extensive, further research. Therefore, the current study is designed to investigate the causes and impacts of the scarcity of teachers in sciences and mathematics on Tanzanian education in secondary schools.

From the literature reviewed, there is also limited information on the factors that are causing this scarcity and maintaining the problem for many years. The current study is working to find out the factors contributing to the scarcity of secondary school scientific and mathematical teachers and make an assessment of the impacts caused by this scarcity problem on the secondary schools in the country. The study intends to examine the participants' interest in science and mathematics teaching; evaluate the efficiency of the approaches used by the school management to reduce the impacts of science and mathematics teachers scarcity, and determine the ways to minimize the scarcity and the impacts of the scarcity of these important scientific and mathematical teachers.

Socio-economic Factors and Scarcity of Science and Mathematics Teachers

From the current research conceptual framework, it was presumed that there are socio-economic factors that were causing the scarcity of scientific and mathematical teachers. Shortages of trained teachers in secondary schools have caused the schools to employ unqualified personnel, especially in the rural areas where teachers are scarcer. The employment of unqualified teachers may be the result of the budget and funding limitations, and also the challenging working conditions. The choice of unqualified teachers is because the cost of paying them is low compared to the most qualified teachers. The result of this low pay as perceived by society is that the status of the teacher declines because unqualified people are also been called teachers (Hellsten & Prytula, 2018). Low pay affects the teachers' motivation and morale to teach which in the long run affects the students' performance. This implies that the teacher should be motivated, encourage and get better payment so that they perform their daily teaching activities effectively.

According to Handal et al. (2018), reported that the opportunity to secure a permanent position; the attraction to a rural environment; the perception of a stronger sense of collegiality in rural locations; and the attraction to gaining rural educational experience/exposure are the first four emerging possibility factors influencing the decision to accept a rural teaching position. Personal incentives appear to be behind some of these factors. Teachers also showed a readiness to assist those who were less fortunate. As a result, they are potent possibility factors. If efforts aiding low socio-economic groups are included or combined with recruitment techniques, attitudes can be very useful.

Moreover, Handal et al. (2018), revealed that when acting as a restrictive predictor of teaching in rural and isolated places, family considerations might become an essential constraint factor.

Females and those who grew up in rural regions were more affected by family issues than males. While promoting the idea of having rural teaching experience/exposure can be exploited in a recruitment campaign or a teacher national curriculum, this is not achievable due to family considerations (Handal et al., 2018).

Also, Handal et al. (2018), reported that the majority of teachers at rural and distant schools are relatively inexperienced, according to the research study. It was also discovered that the vast majority of teachers only stayed for a short period. The system appears to spend resources encouraging if not outright tempting, instructors to relocate to rural and isolated schools. To keep them there, additional resources are used. However, the majority of teachers leave, and the resources spent have not resulted in the expected result. Overall, Overall, there are benefits to both in-service as well as pre-service teacher education. from the findings of this study by focusing more on potential factors and establishing supportive experience opportunities that may encourage teachers to explore rural and remote teaching assignments (Handal et al., 2018).

The provision of motivation is an opportunity strategy that can be used to increase professional progression and if it has not been provided, the teachers tend to leave their careers (Hellsten & Prytula, 2018). Motivation to teachers can be provided through salary increments, short course programs, promotions, in-service courses, and access to teaching resources. Motivation varies from intrinsic to extrinsic among teachers and also differs with marital status, gender, program of study, and age group (Hellsten & Prytula, 2018). Moreover, this teacher most teachers could raise their performance in such a way that even the students are also motivated to join the teaching career.

Several researchers have done some studies and revealed that in Tanzania like other countries there is an existence of scarcity of teachers specifically in science (Chemistry, Physics, and Biology) as well as Mathematics teachers in secondary schools in Tanzania (Kamagi, 2017; Ndalichako and Komba, 2014; Nghambi, 2017; Osaki, 2007; Projest, 2014; Saga, 2014). The scarcity of scientific and mathematical teachers is the result of many factors including the change in the numbers required at a particular period and the number of teachers available for supply at that same time (Garcia & Weiss, 2019).

In recent years, researchers have shown that there has been increased enrolment of students in secondary schools which mismatch with the available resources such as teachers, teaching materials (including radio, printed material like charts, maps, textbooks, and non-printed materials such as real objects, machines, computers), laboratories and funding (Saga, 2014; Nghambi, 2017). There was a greater demand for trainers as a result of the increase in secondary school enrollment. Ndalichako and Komba (2014) revealed in their study that in 2013 there was a shortage of about 37,130 teachers in secondary schools in Tanzania, whereby about a total of 26,948 teachers were science and mathematics teachers. Three years later Kamagi (2017), reported a shortage of about 24,716 scientific and mathematical teachers in Tanzanian secondary schools. This is relatively a big number of required teachers in this particular education area that if not addressed the impacts on the education sector might be challenging to reverse.

According to the literature, numerous initiatives and changes have been implemented to at least lessen the issue of a shortage of science and math instructors. There must be significant effects on students as well as the education sector from the continued shortage of instructors in mathematics and science in Tanzanian secondary schools. There is a constant need for these teachers due to the dearth of scientific and mathematics trainers in secondary schools, which results in fewer students

enrolling in science courses in teacher preparation programs (Saga, 2014). The studies by Nghambi (2017) and Saga (2014) recommended that the Tanzania Ministry of Science and Technology should train and employ an adequate number of scientific and mathematical teachers to fill the gap of scarcity in secondary schools.

According to the literature, Tanzania's Vision 2025 development plan correctly correlates Tanzania's weak economic base with low science and technology usage, which has resulted in low productivity and growth. According to the Tanzania Vision 2025 plan, education should be considered as a strategic agent of mentality transformation and for the creation of a well-educated nation that is very well furnished with the knowledge needed to fully resolve the country's development challenges (UNESCO, 2013). Unfortunately, despite considerable advances in the science and technology industries, this shift has yet to take place.

Tanzania's National Vision for 2025 expresses a strong intention to transform the country from one of the "poorest of the poor" to a middle-income country by 2025 and make significant progress toward meeting the millennium development objectives (UNESCO, 2013). This goal will be impossible to fulfill without considerable improvements in educational quality at all levels. Quality education is one where the educational intentions are realistic and current, and the system of education, from the formulation of policies to the design and construction of curriculum and syllabuses, as well as teaching, learning, and assessment, is functioning well. In most circumstances, if these components are in place, learners should attain high levels of success. Achievement may be low despite high requirements, or it may be high despite low standards due to test circumstances or flawed and unreliable assessments. When considering a relevant education, factors such as strong education policies, good curriculum, good textbooks, and other teaching materials, good teaching as well as learning procedures, effective methods of assessment,

evaluation, and remedial education programs may all be taken into account. (Projest, 2013).

However, there existed a Bachelor of Education (B. Ed) degree that produced a small number of graduates who went on to work in adult education institutions or teacher training programs to train future teachers. To further their awareness of issues related to professional education, these graduates studied educational administration, educational psychology, curriculum, or adult education alongside or in addition to one major subject (Biology, Mathematics, Chemistry, Physics, Geography, English language, etc.). While BA (Ed) and BSc (Ed) individuals took additional courses in their chosen fields of study to prepare for employment as educators of such subjects at suitable levels, B. Ed students selected more elective subjects in their fourth year (Osaki, 2007).

According to Osaki (2007), initiatives have been put in place to enhance and expand the teaching of mathematical and scientific subjects in Tanzania's secondary schools. One of the initiatives was The Science Teacher Improvement Project (STIP) in secondary schools, which used a 'starter experiment' approach and saw positive results in its initial testing. This initiative, however, never progressed beyond the trial stage. The University of Dar es Salaam's Teacher Education in Mathematics and Science (TEMS) effort fostered pre-service education program review and reform between 1996 and 2004. As a result, new pedagogy courses were established inside the four-year BSc (Ed) and B.Ed. (Science) programs. The unfortunate part is that the pre-service portion of TEAMS has been severely harmed by the decrease of the four-year undergraduate program to a three-year bachelor’s program, which has resulted in the elimination of courses that took eight years to conceive, create, and test (Osaki, 2007). Without a competent professional review and assessment, political order was used to accomplish this (Osaki, 2007). The most important lesson is that we must avoid the behavior of refusing to learn from the past and

abandoning a project once it has been completed without attempting to maintain the positive aspects through local finance (Osaki, 2007).

The lack of links between the technology and education sectors is having a significant impact on national growth in two ways. One approach is through the educational system's inability to generate qualified science and technology graduates - those with the knowledge, skills, and competencies to fulfill present and future demands. These expectations are not confined to the commercial sector; they also include public-sector development requirements. Tanzanian institutions tasked with solving challenges in public health, food security, and other sectors frequently struggle to fill positions in research, policy, and support roles due to a lack of trained scientific and technical personnel (Kihwele, 2014).

Another way that these weak ties are impacting national development is by limiting the technology sector's ability to meet the country's development needs. Both commercial and public sector organizations can't contribute as much to national progress as they could if they had skilled employees and the kind of creative collaboration and invention that comes from a thriving educational system. As a result, the country's growth plan is hampered by an insufficient educational system that is incapable of fulfilling its intended purpose of teaching youngsters to satisfy the country's current and future demands (Kihwele, 2014). Although more research is needed to understand the technology sector's unique potential for driving national economic growth and development, it is evident that considerably more investment in science and technology education is required. However, such investment must begin with a more defined set of policies that link the expansion and development of the technology industry to Tanzania's social and economic development goals.

Recently, education sectors encountered a problem that interfered with the teaching-learning process in all countries worldwide. The problem was the COVID-19 pandemic that has wreaked havoc around the globe. It originated in China and is now spreading throughout the world. The COVID-19 epidemic has caused major disturbances in people's lives and many countries are pursuing a variety of steps to stop the spread including lockdowns to foster social separation (Olanrewaju & Mremi, 2021). To control the spread of the novel coronavirus, state governments started to close schools and colleges in many countries across the world. Coronavirus was first announced in the mid-month of March 2020 and to avoid crowding the schools were closed temporarily as a measure to avoid the spread. Initially, for a month closure of schools was announced by many governments but gradually the time of closure was extended and it is uncertain when they will reopen. All schools, colleges, and other institutions have been declared closed because of the pandemic. This is causing havoc with the educational system as a whole. Policymakers are confronted with a slew of issues when it comes to developing educational policies. The traditional method of teaching using offline settings has been replaced by online teaching (Allo, 2020; Olanrewaju & Mremi, 2021; Saavedra, 2020). It was the first time for both students and teachers to experience this new online teaching-learning method in the education sector. Students, teachers, and parents are all experiencing difficulties as a result of this shift in teaching techniques.

The closure of schools, colleges, and universities has affected not just the instruction of students but also the assessment of students all over the world. Because of the closure of educational institutions, several tests and assessments have been canceled or postponed (Olanrewaju & Mremi, 2021). The closure of educational institutions such as secondary schools, colleges, and universities as well as both internal and external evaluations for qualifications are interfering with students'

ability to learn. The labor market placement of new graduates is also being impacted by the lockdown. Moreover, the availability of several mathematics and science instructors in secondary schools is impacted by this matter. To avoid new graduates experiencing extended periods of unemployment, new policies supporting their entry into the labor market should be developed. This had the greatest impact on science and mathematics topics, which require more practical work than any other subject. It is impossible to do laboratory tasks online.

Moreover, students lacked appropriate skills and knowledge in the use of e-learning programs. They also did not have access to equipment or an internet connection for e-learning. Before the pandemic, the pupils were not well equipped to use e-learning. As a result, it was difficult for teachers to prepare their students for learning in an online environment in the event of an emergency. Generally, secondary school science and mathematics instructors found it difficult to use e-learning as a medium of instruction during the COVID-19 pandemic's school closures. Students' lack of understanding and skill in using e-learning, as well as their lack of access to gadgets and internet connections, were the most important impediments (Olanrewaju & Mremi, 2021). Thus, due to the coronavirus pandemic, the student’s performance is negatively affected especially in science and mathematics subjects.

From the above literature, the issue of the scarcity and mathematics teachers is complex and also there has been little known on the factors causing and maintaining, and sustaining the scarcity of mathematics and scientific teachers, despite all efforts. Therefore, the current study strives for working on any more contributing factors to this problem and also to find out the specific impacts that may have been caused on the student and the education system in Tanzania.

Political and Policy Issues and Lack of Science and Math Teachers

Based on the conceptual framework of the research study, political and policy-related factors were presumed to cause the scarcity of mathematical and scientific teachers. According to Hamilton et al. (2010), in a report to the United Nations International Children's Emergency Fund (UNICEF) revealed that science students' performance as well as mathematics, and technology is not only affected by the inadequacy policy but also other factors such as inadequate both in pre-service as well as in-service training, the questions of teachers' competency, lack of relevancy of education programs as well as policy implementation. Furthermore, it was suggested in that report that, in contrast to other issues like enrollment in elementary and secondary schools, the strategy does not address the issue of the shortage of scientific and mathematics teachers. The enrolment of students and the number of available or recruited science and mathematics teachers do not match and thus create the problem of a high teacher-student ratio.

The most effective policies for attracting and retaining strong science and mathematics teachers include increasing their compensation or salaries, improving their training, providing continuous professional development programs, and improve their working conditions, encouraging seminars and workshops, and improving school management practices that otherwise create barriers to recruitment and retention (Podolsky et al., 2016). Moreover, in a report, Podolsky et al. (2016), reported that both the quantity and the quality of individuals who are training to become teachers, as well as the availability of qualified teachers and how they are distributed across the nation, are all impacted by teacher salaries. Also, salaries appear to influence teachers who are likely to quit when they work in rural areas.

Podolsky et al. (2016) in a report identify five primary elements, as well as related policies, that influence teachers' decisions to enter, stay in, or quit the teaching profession based on a study of a large body of literature on teacher recruitment and retention which include salary and other forms of remuneration; entrance requirements and costs; human resource management and hiring; new teacher orientation and assistance; and working environments, such as school management leadership, collaboration among professionals and participatory decision-making, accountability procedures, and teaching and learning resources. One of the most critical drivers of a well-functioning education system is that it must equip the students with complex knowledge that will enable them to cope with the changing world of science and technology. However, a recent spike in teacher demand, along with a dwindling supply and a consistent rate of teachers quitting the field, poses a threat to student's academic and economic performance. Premature retirement of teachers hurts student learning and costs taxpayers money (Podolsky et al., 2016).

The performance of students in scientific as well as mathematical in secondary schools is also been affected by the lack of books, lack of professional and experienced teachers, instructional time, committed teachers, the language of instruction, curriculum reform, shortage of qualified mathematics and science and class size (Michael, 2015; Nghambi, 2017). There have been curriculum reforms in Tanzania that have been frequently changing with the change of political leadership. Taking curriculum as an example, Hamilton et al. (2010), in their study revealed that sometimes curriculum reforms happen and the teachers are supposed to implement them while they have not received any training on how to use such curricula. This has been observed during the change of secondary school syllabi from content-based to competent-based (URT-MOEVT, 2010). The main objective of the change was to involve the student in problem-solving activities that will finally lead to effective learning. If the teachers are not trained to perform the new method,

the importance of this method will not have an effective impact on the learners (Michael, 2015). Therefore, in such cases, the policy reform used to enhance the standard of instruction and learning in such institutions seem to be undermined (Hamilton et al., 2010). Moreover, Hamilton et al. (2010), reported that due to the current global educational needs, advancements in science, and rapid changes in technology, Tanzania has to make educational improvements that will concentrate on the demands of the 21st century. Tanzania has to address the needs of progressively scientific and technological development by producing competent science graduates who will think critically, with proper working skills and knowledge in solving problems.

The Tanzania National Vision 2025 is to take the country into a middle-income state (URT, 2000). This vision is to be achieved through the improvement of the quality of education at all levels among other things. Some reforms have been done to improve the education sector and rectify the problem of the scarcity of teachers in science and mathematics in secondary schools without success. Some of these efforts on educational reforms are reported by researchers including Osaki (2007); Projest (2014), in which the move in preparation of teachers in science, as well as mathematics, started long in 1968, and also there was an in-service program designed for the existing teachers. The reforms, among other things, include the introduction of educational programs where two science subjects were taught at the medium college and university levels to create more science teachers. Such subjects which were taught included Chemistry and Mathematics, Physics and Mathematics Chemistry and Biology, Chemistry, and Physics, (Osaki, 2007). Apart from those efforts, the issue of scarcity of teachers in science along with mathematics in secondary schools is still experienced in Tanzania.

According to Osaki (2007), some of those reforms took off, and later they were discontinued more changes came in 1973 when Tanzania started its institution – the Tanzania Institute of Education

(TIE) which works in preparing some science and mathematics teaching and learning materials, examined by National Examination Council of Tanzania (NECTA). At this time Tanzania stopped using the Cambridge Overseas Examination system. So many efforts have taken place to improve science and mathematics including the introduction of some projects like the Secondary Development Program (SEDP), Science Teacher Improvement Project (STIP), and Science Education in Secondary School (SESS) just to mention a few (Osaki, 2007).

Tanzanians have learned many lessons from recent interventions and reforms in science as well as in mathematics education, and teacher training, but Osaki's study focuses on five of the most important lessons including:

- Science curricula that do not stimulate inquiry learning, problem-solving, and independent thinking among students will fail to produce effective future scientists.
- Science curriculum designers and developers must acknowledge that a considerable majority of students will not become research scientists, and as a result, they require a softer science that addresses their role as scientifically educated and responsible citizens now and in the future. This means that science education should promote investigative methods, as well as local and social issues, and connect them to their current and future lives.
- Creating a good curriculum is not alone sufficient. Through MEd programs and other upgrading programs, there is a need to prototype and test new teaching and learning materials, in-service teacher training programs, relevant textbooks, and professional growth processes. Some attempted materials and courses may be rejected or modified after pre-testing.

- To reach all of the children, the type and level of language used in textbooks and the classroom are critical. At the very least, it is necessary to enable each child to understand and relate to what we are discussing in the classroom, as well as to recognize its significance in their lives. We recently realized that information and communication technology (ICT) can play a significant role in this area by making easily written content more accessible to students and teachers rather than relying solely on old textbooks.
- To train instructors who are proficient in both content and pedagogy, because no system of education, no matter how enormous the library, how large the classroom, or how much better the material facilities are, can overcome the competence of its teachers. Teachers must have access to high-quality professional development programs regularly. According to a new MOEVT initiative financed by Japan International Agency (JICA), there are intentions to modernize the classroom.
- Plans to develop laboratories and educate laboratory technicians in most secondary schools. The move to decentralize INSET (In-Service Education and Training of Teachers) to districts is a game-changer. Professional development may become less expensive and easier to administer at the district, ward, and village levels as a result. If this program is to be successful at the grassroots level, qualified INSET trainers are required, and the time to develop, test, and implement it is now. Strong, professional teachers and subject organizations go hand in hand with competent trainers. For instance, Science Teachers Associations, for example, or subject associations for teachers of physics, chemistry, biology, mathematics, geography, and other subjects, should include teachers at all levels.

- Schools, particularly non-government schools, invest much in gaining a high social status to recruit good pupils and well-off parents. As a result, some institutions have expelled weak students, leaving only those who have demonstrated the ability to pass the Ordinary - 'O' and Advanced level - 'A' level examinations on their own. For the most part, this approach contradicts the entire notion of high-quality secondary education. It's particularly terrible when this is done by religious school leaders, who are, on the whole, expected to devote themselves to serving and assisting the weaker members of society.

While those reforms were practiced there was also the expansion of secondary schools which meant also an increase in enrolment which in turn increased the demand for more teachers. Projest (2013) revealed that there was an increase in the number of community secondary schools to 383 in number.

However, on the 1st of July 2020, Tanzania announced to the World Bank that its position is raised from poor to lower-middle income, five years earlier than planned (World Bank, 2020). This recent achievement of the National Vision 2025 which came five years before the planned year means that Tanzania has advanced its development to a high extent and faster than expected. Moreover, the (World Bank 2020), reported that there has been steady economic growth which has been observed or noted in transportation infrastructures and energy sectors. Apart from the mentioned advancement economically the scarcity of science and mathematics teachers is still an issue that needs to be resolved. Therefore, this particular research study is working to find out the unknown factors that are causing the persistence of the scarcity of teachers in science as well as mathematics in Tanzania’s secondary schools.

Cultural Considerations and the Shortage of Science and Math Teachers

In the conceptual framework, the researcher assumed that cultural factors contributed to the dearth of scientific and math instructors in Tanzania's secondary schools. In the literature, some scholarly researchers reported the cultural issues which are causing the scarcity of teachers, especially science along with mathematics teachers. According to Michael (2015), in his study conducted in Kibaha Tanzania, the cultural background of a student plays a major role in educational achievements. In the study by Michael (2015), it was reported that the family background of a student can affect his/her academic performance. This means that two different individual students with different cultural backgrounds are affected differently in their mathematics performance since their families do differ in experience and care, perception and interest in mathematics, cultural view of learners, and attitude towards mathematics. Also, parents' economic status tends to determine the student's performance. Michael, (2015) reported that those students who have parents with high income perform better than those with parents with low income. Moreover, students with two parents tend to perform better than those with single parents, likewise, the students who speak English perform better than those who do not.

In summary, Michael (2015), revealed that there is a cultural influence on students' performance, also other factors that influence performance include the teacher-student relationship, the nature of the school environment, the school management system, and the process of learning mathematics. In his study, Michael (2015), found that individual students' poor mathematics background, inadequate self-practice, and poor teaching as well as learning environment are the main challenges that affect students in learning mathematics. Based on those challenges there is a need to investigate whether they have caused the scarcity of teachers in scientific and mathematics in Tanzania's secondary schools. On the other hand, they may also be the impacts of this scarcity.

Therefore, this specific research is thrilled to find out the factors causing the scarcity of teachers and the impacts on secondary schools in Tanzania.

Effects of Teacher Shortages in Scientific and Mathematics in Secondary Schools

In the conceptual framework, the researcher presumed that the scarcity of teachers in scientific subjects as well as in mathematics has negative impacts on students' achievement and the national education system at large. The students' perception of mathematics and scientific subjects reflects what is existing in society even without assessing the situations in their community. There is a belief in society that science and mathematics are hard subjects to study in society (Kihwele, 2014; The Citizen, 2019). Society's perception of studying science and mathematics subjects may have effects on students in secondary schools. The effects of scarcity of teachers in science as well as in mathematics affect the student who studies those subjects in secondary schools. Students who were studying science and mathematics subjects performed very poorly in science and few of them continue to study science (The Citizen, 2019).

Also, Ieren and Innocent (2017), in a study conducted in Nigeria, revealed that there is a phobia of mathematics among students and that lack of interest contributes to the performance of students in mathematics. This lack of interest is caused by other factors including a lack of qualified mathematics teachers, poor teaching methods, poor orientation about the usefulness of mathematics, and the teaching resources that teachers utilize to teach mathematics.

Ieren and Innocent (2017) explained that on the side of mathematics teachers, lack motivation, suffer poor or low enumeration, and face negative perceptions of the students towards mathematics and lack of support from their parents. Poor or lack of motivation for both teachers and students reduce the interest and achievement in mathematics and scientific subjects. In other words, the

lack of qualified teachers has affected negatively the performance and interest of the students in mathematics (Ieren & Innocent, 2017). Thus, when the methods of teaching are poor, the effects appear in the performance and cause hatred of mathematics subjects which increases the lack of interest in such subjects in both students and teachers. There are many factors mentioned to hinder the interest of both teachers and students to be fond of mathematics as well as scientific subjects and affect the number of scientists joining the teaching profession.

According to some researchers, Tanzania has had a long-standing shortage of scientific and math teachers. (Kihwele, 2014; The Citizen, 2019). Based on the previous experience reported in the literature, some challenges are hindering the effective implementation of scientific along with mathematics education in Tanzania. A study by Osaki (2007), claimed that those past experiences include the delay in deciding on the medium of instruction in teachers' training education programs. As a result, many incompetent language teachers were employed at pre-primary, primary, and secondary school levels. The employment of incompetent teachers and the shortage of teachers in mathematics and scientific subjects have impacts on the effective teaching of the mentioned subjects (Ndalichako & Komba, 2014; TAMASHA, 2010; The Citizen, 2019).

Moreover, HAKIELIMU (2011) and Mamlok-Naaman (2014), reported that the insufficient in-service training programs for mathematics teachers along with scientific subjects in Tanzania have worsened the scarcity of science and mathematics teachers in secondary schools. This scarcity of scientific and mathematics subjects is increasing due to the insufficient in-service training programs for the teachers in scientific and mathematics subjects predominantly in non-urban areas. Many teachers prefer to work in urban settings where advanced social services are present compared to rural environments.

To improve the number of science as well as mathematics teachers, Tanzania through the Ministry of Education Science and Technology has introduced an education policy and implemented some reforms to help to minimize the problem of the scarcity of science and mathematics. According to Osaki (2007), in 1968 there were established educational reform projects including the School Mathematics Project (SMP) as well as the School Science Project (SSP), both of which were developed and funded by UNESCO at the University of Dar Es Salaam. Moreover, the SSP program comprises of Bachelor of Science with Education degree undergraduate package of three years of course. Two science subjects and education were studied including Chemistry and Mathematics, Mathematics and Physics, Chemistry and Physics, Biology and Chemistry. The main reason for the teachers trained in only two subject measures to train to study was to increase the number of scientific and mathematics teachers in Tanzania's secondary schools. These two subjects were studied as a major subject together with education courses.

Apart from the above efforts, it is reported in recent years that there is still a need to employ more mathematics and scientific teachers in Tanzania (Mamlok-Naaman, 2014; Ndalichako and Komba, 2014; Osaki, 2007; Projest, 2013). The scarcity of teachers in science and mathematics in Tanzania is like in other countries worldwide as confirmed in the report by Ndalichako and Komba (2014). In the report, Ndalichako and Komba (2014), revealed that in 2013 about 14,060 teachers were employed by the Government, and out of them only 2,014 (14%) were science teachers. According to Ndalichako and Komba (2014), there is a need for 37,130 teachers in secondary schools, and out of them, a total of 26,948 (73%) by science teachers. The deficit of several science and mathematics teachers indicates that this is a national problem and therefore the teaching process in the two subjects might not be effectively done in secondary schools in Tanzania. Based on the data from the parliament, Kamagi (2017), revealed that about 88, 999 teachers were employed in

Tanzania's public secondary schools, where only 70,459 were art teachers. This shows that there are enough art teachers and that the government has to employ more science and mathematics teachers to improve the teaching of the subjects. According to Kamagi (2017), the country needs a total of 24,716 science and mathematics teachers and 355 laboratory technicians.

Based on the literature review it shows that there is a trend of the persistence of the scarcity of teachers in mathematics and science subjects which is growing and being reported by researchers for decades. In other words, the increase in students in primary schools which also feed secondary schools has raised the teacher-student ratio from 1/45 to 1/50 in 2017 and 1/62 in 2021 and it is still going up (The Citizen, 2019). This trend has impacts on student's performance especially in mathematics as well as in science subjects. Since the number of students is growing, it creates more teacher scarcity in secondary schools and maintains the impacts of this scarcity on respective schools.

Moreover, the lack of mathematical and science teachers in secondary education in Tanzania is a challenge that is currently being gradually addressed, according to observations and evidence from the literature, but there are still insufficient research studies that have looked at the main causes of the problem and its effects. Furthermore, the research has demonstrated the effects of the lack of scientific and math teachers on the execution of the curriculum in Tanzanian secondary schools, but it is sparse and lacks clear explanations for why this issue is not being resolved. The results of the scholarly search showed that secondary schools are affected by the lack of enough qualified scientific along with mathematics teachers and have not been comprehensively examined. This is verified in the report by Ndalichako and Komba (2014), which is silent on the impacts of the shortage on these secondary schools and the country at large. Meanwhile, the current research study is premeditated to assess the impacts of the scarcity of scientific teachers along with

mathematics in Tanzania's secondary schools and recommend ways to minimize the impacts on both the schools and the country's education system.

Resolving the Causes and Impacts of the Teachers' Shortages - Stakeholders' Responsibility

According to the literature reviewed and the current research findings all education stakeholders are responsible for resolving the problem of a short supply of qualified mathematics as well as science teachers in secondary education. The stakeholders include students, teachers, parents school management, and the government. According to Flannery (2020), schools across the USA country has been struggling for years to fill vacant thousands of teaching jobs and the situation has only gotten worse during the coronavirus pandemic, as many educators refuse to return to classrooms, they fear are unsafe. It is an educational crisis that obstructs learning and has a profound impact on students, particularly in high-poverty areas where there are more likely to be shortages of highly qualified teachers. Moreover, the scarcity of teachers in scientific and mathematics subjects is a crisis for all the teaching profession levels and it is a major issue for the entire education systems worldwide (Flannery, 2020). It is detrimental to students, teachers, and the public education system. However, it is not an intractable issue; in fact, a recent report from the nonpartisan Economic Policy Institute (EPI) outlines approaches for a long-term solution.

Moreover, Flannery (2020), revealed that there is a shortage of teachers in the USA which is growing and also causing dangerous impacts on students. In the report, Flannery argued that the shortage is not an impossible situation and that it can be resolved when the education stakeholders work together. The education stakeholders include the government and the school management who have all the powers to make changes that will attract and retain the school teachers. By increasing the teachers' pay, improving in-service training or professional development, and

improving learning communities, the teachers could be attracted and retained in secondary schools. Teachers must be involved in solving the problem especially when it comes to the issues of teaching, preparation of the teaching materials, professional development program preparation, and reviewing of the school curriculum that they use to teach (Flannery, 2020).

Moreover, Flannery (2020), suggested that increasing teachers' payments could attract and retain new teachers and experienced ones respectively. Also nurturing schools with needed facilities and making available teachers' needs would minimize the barriers that make the teachers work harder and improve the teaching process. The problem of the scarcity of teachers especially in scientific as well as mathematics subjects is complex since it is being caused by multiple factors and the solutions must be strong and comprehensive (Flannery, 2020). To be able to solve the problem require funding that can be used to increase the teachers' pay as well as buy facilities that are missing in the schools.

The scarcity of science and mathematics teachers must be minimized if not eradicated from the education systems in any county if we need to go hand in hand with changing world of science and technology. Michael (2015) revealed that to resolve the problem of the scarcity of teachers in scientific and mathematics subjects, the school management team has to effectively deal with the problem. The school management has to deal with the shortage of teachers and should be aware that there is a need to mitigate the problem through the provision of science facilities such as laboratories, and libraries, undertaking science practices, and motivating both teachers and students. Moreover, the school management has to ensure they do everything possible to improve the performance of the students in mathematics and science through the provision of a suitable environment as well as adequate teaching and learning facilities.

Flannery (2020) suggested that policymakers must take action to address the underlying causes of our current predicament: Among the specific issues to be addressed are increasing teacher compensation to attract new teachers and retain those who are already there; increasing teacher impact, and a sense of belonging by elevating teacher's voice and building stronger learning communities; removing obstacles that make it more difficult for teachers to complete their tasks; and providing professional development opportunities for teachers to improve their sense of purpose, career development, and efficacy. Because the problem is multifaceted and driven by various variables, the researcher warns that solutions must also be comprehensive. They will also necessitate increased investment or financing aimed specifically at teachers' salaries and working conditions.

From the literature reviewed, many scholarly reports have shown the existence of the scarcity of teachers especially in scientific and mathematics subjects as well as revealing some factors that are causing this problem and its impacts on secondary schools. Some of the researcher's works have reported some efforts that have been done by school management, governments, teachers as well as students but still, the problem persists in secondary schools. This persistence of the problem of the scarcity of teachers and specifically in science and mathematics might have unknown factors that are causing and retaining it which have not been revealed by the researchers. It is believed that there might be something unknown that maintains the scarcity of scientific and mathematics teachers that needs to be unveiled. Therefore, the current research study is investigating the causes and impacts of the scarcity of teachers in science as well as mathematics subjects in Tanzania's secondary schools.

Summary

This chapter started with an introduction, followed by some definitions of the terms that are used frequently in this research study. The terms that were defined include factor, impact, teaching, learning, teaching-learning, research, and qualitative research. The chapter has provided the conceptual framework and reviewed the literature on the scarcity of teachers in scientific and mathematics teachers at the global level, in Africa and Tanzania. The literature review has shown that the scarcity of teachers is a very complex issue that is caused by many factors that are similar or vary depending on the country or region worldwide. The literature review also covered sub-titles related to socio-economic, cultural, political, and policy-related factors that are causing the scarcity of teachers in science subjects as well as mathematics and its effects on Tanzania's secondary schools. The reviewed portion of the research literature was conducted under the presumption that there are socioeconomic, political, cultural, and policy-related reasons contributing to Tanzania's secondary schools' shortage of mathematical and scientific teachers.

This chapter has presented the issues raised in the conceptual framework through the analysis of the reviewed literature studies that are related to the study. In the conceptual framework, the researcher provided the assumptions on factors that have influenced the scarcity of scientific and mathematical teachers in Tanzania. These assumptions have been progressive as it has shown proof with theoretical works and observed literature reviewed. It was noted that a variety of policy-related, socio-culturally based, socio-economic, and school management-related factors, including imparting knowledge as well as teaching and learning methods, teacher-student relationships, school learning environments, student performance, and the school management system, all play a role in the shortage of scientific and mathematical teachers. It also seems that the factors that are causing the scarcity of teachers in science and mathematics in turn have effects that later maintain

and perpetuate the scarcity of scientific as well as mathematics teachers. Although there are different efforts from the Ministry of Education, Science, and Technology to try to resolve this problem, the scarcity of teachers in secondary schools is still existing. The literature revealed that the drop in enrollment at teacher-training institutes and the rise in secondary school enrollment are both contributing factors to the shortage of mathematical and scientific teachers in many nations.

Almost without exception, it is widely assumed that the countries are facing a teacher shortage crisis, particularly in mathematics and science subjects, caused primarily by an insufficient supply of new teachers or increased students' enrolment in secondary schools. It is also widely held that a shortage of mathematics/science teachers is a major contributor to poor educational performance and, as a result, the economy and even the nation's security. Based on the literature assessment, many schools struggle to find appropriate individuals to fill their classrooms, indicating that there are pervasive staffing challenges in education. Furthermore, the literature data show that the severity of these issues varies across schools and fields in different countries. In the USA between 1999-2000, approximately 7,200 secondary schools, or 31%, reported having serious difficulty finding qualified teachers to fill either their mathematics or science gaps. (Ingersoll & Perda, 2009).

Lastly, in this study, the research gaps were developed from the literature reviewed indicating the existence of limited information on the factors that are causing the scarcity of scientific and mathematical teachers and the impacts on secondary schools in Tanzania. The goal of the current research study was to help adjacent these gaps by contributing to achieving its intended objectives, which included identifying the causes of the shortage of secondary school mathematical and science teachers, evaluating the effects of this shortage, and assessing the participants' interest in the scientific and mathematical education in Tanzania's secondary schools. Also, this research

study intends to evaluate the efficiency of the approaches used by the school management to reduce the scarcity of teachers in science and mathematics fields and its impacts on Tanzania's secondary schools.

CHAPTER 3: RESEARCH METHODS

Introduction

Chapter 3 presents thoroughly, the mixed research design methods and data collection methods, and the research tools used in this research study. In this chapter, the research approach and design are presented and data collection methods are discussed. Also, the study area is discussed, the population and sample of the research study; study procedures and ethical assurance; data analysis, methods, and lastly the summary of Chapter 3 are discussed. In this research, mixed research methods were used and interview and questionnaire tools for data collection were used are discussed. The study area is discussed and the population and sample size are presented in this chapter. All ethical procedures were adhered to, to ensure that the research will not create any harm to the research participants. The thematic data analysis method was used to analyze the data collected step by step (Braun & Clarke, 2006; Clarke & Braun, 2013).

This chapter presents the research methodology, research design, and approaches used in the collection of the information, data analysis, and interpretation of the factors causing the scarcity of teachers in science and mathematics and the impacts on secondary schools in Tanzania. The chapter is working on the mixed research methods used for data collection, data analysis, and interpretation. Research methodology, according to Kothari (2004), is the systematic and theoretical evaluation of the methods used in a field study. It involves the methods of explaining, describing, and predicting phenomena to solve the problem through conducting research. The chapter discussed data collection methods which is a mixed research technique, the study area, the research population and study sample size, instrumentation of the research tools including interview and questionnaire, the study procedure including sampling procedure ethical assurance, and the data analysis method.

This educational research aimed at contributing knowledge to educational processes to improve their effectiveness. Educational research is concerned with the purification of educational processes and attempts to answer an educational question and it is the systematic application of scientific methods to solve educational problems. It is the activity of developing behavioral science in educational institutions to enable educators to work effectively toward the achievement of goals and objectives. Its goal is to practice scientific and philosophical methods to solve educational problems. Educational research is primarily conducted to provide systematic and methodical explanations for problems that arise in the education arena (Kapur, 2018).

According to Kapur (2018), to a large extent, educational research is conducted to serve a purpose and a goal which could be to gain an understanding of a specific area, region, or state about some matter or issue related to education. As a result, data is gathered and appropriate methods are used to conduct an analysis. When doing educational research, the analysis of the data is a stage that is necessary to produce the results. It attempts to organize data quantitatively and qualitatively to make a statistical conclusion that focuses on the present and future. Two types of research can be used in educational research: quantitative and qualitative. Quantitative analysis methods employ numerical data, whereas qualitative analysis employs non-numerical data. The researcher must make appropriate selections of these methods based on the areas of research and the regions in which it is being conducted.

This research used a mixed-methods technique during data collection and analysis. Qualitative research methods are used to collect, analyze and interpret non-numerical data collected from the participants to understand their opinions, experiences, and suggestions. Qualitative data are frequently subjective, rich, and contain in-depth information that is typically conveyed in the form of words. Qualitative data analysis involves reading a significant number of transcripts to look for

similarities and differences, subsequently identifying patterns, and creating categories. The majority of qualitative data comes from unstructured text. Interview transcripts, observation notes, journal entries, and records are examples of textual data (Wong, 2008). The aspect of qualitative research that best distinguishes itself from quantitative research approaches is data analysis. Apart from being a technical exercise such as quantitative techniques, the qualitative method comprises more of a dynamic, intuitive, and imaginative process of inductive analysis, conceiving, and theorizing (Wong, 2008).

The main tools used in this particular research include interviews and questionnaires for students. During the data analysis, qualitative methods such as thematic analysis was used to analyze the collected data from the research participants, and after the analysis, the results were presented in thematic maps to show the analysis of the information collected from the field through interviews. Quantitative data analysis of the data from questionnaires from students was done using frequencies of occurrences and percentages.

Thematic analysis method for analyzing qualitative data was used step-by-step, to analyze the qualitative data that were obtained from the participants through interviews (Attride-Stirling, 2001; Clarke and Braun, 2013; Maguire and Delahunt, 2017; Thomas and Harden, 2008;). The causes contributing to the shortage of science and math instructors were discovered during the thematic data analysis by grouping the key concepts into fundamental themes. The important elements in the information gathered from the participants were then summarized into organized themes and afterward blended to generate global themes. The data about the impact of the shortage of scientific as well as mathematical teachers in secondary schools was analyzed using the same procedures. Frequency count and percentage were used in the analysis of quantitative data.

Like other nations throughout the world, Tanzania too struggles with a lack of scientific and math instructors. This issue is thought to be perpetuated or prolonged by a few of the unidentified causes of the teacher shortage in scientific and mathematical subjects and its effects in Tanzania's secondary schools. There is a significant issue with the school system as a whole because of the lack of science and math teachers. Currently, the literature reviewed shows that this problem has been prolonged in Tanzania for years despite all the Government interventions that have been made through the Ministry of Education (Mamlok-Naaman (2014); Ndalichako and Komba (2014); Osaki (2007); Projest (2013).

The current research study accepts that some factors are maintaining or sustaining this problem of scarcity of teachers in scientific and mathematics subjects. Carver-Thomas & Darling-Hammond (2019), in their research study, stated that in the United States of America (USA) the same problem is caused by the shortage of enough facilities for teaching; low earnings, and deprived conditions in workplaces. These cause most of the scientific and mathematical teachers to run off their profession more than others especially those with alternative qualifications, resulting in more shortage of science and mathematics teachers in many secondary schools.

Kamagi 2017 reported that there is a declining need for the requirement for art teachers in government and private schools in Tanzania. In public secondary schools, there were a total of 88, 999 teachers, whereby arts subject teachers were 70,459 and science and mathematics teachers were 18,545 in total. Thus, there is a need for about 24,716 science and mathematics teachers as well as 355 laboratory technicians in the country as stated by the Deputy Minister for Education (Kamagi, 2017).

In their study, Ndalichako and Komba (2014) found that there is a severe lack of teachers of science and mathematics in secondary schools, which has a negative impact on how effectively those disciplines are taught. Furthermore, Ndalichako and Komba (2014), stated that sums of 14,060 teachers were employed in 2013 by the Government in secondary schools, and out of these teachers only 2,014 (14%) were science and mathematics teachers. Nationwide there is a scarcity of 37,130 teachers in secondary schools and many of them about 26,948 (73%) are science teachers.

Although there have been ongoing initiatives and measures to address the country's lack of scientific and math teachers, as seen by the various literary works, the issue continues. By identifying the causes of the lack of scientific and mathematics instructors in secondary schools, the current research study hopes to support these efforts. This would be achieved by investigating the responses from teachers, students, and other education stakeholders on the factors causing the scarcity of teachers in scientific subjects as well as mathematics in Tanzania's secondary schools.

As a result, the major goal of this research study is to identify the causes of the teacher shortage in science and mathematics as well as how it affects secondary school students in Tanzania. The shortage of scientific and math instructors in Tanzania, like in other nations, is an issue. According to the literature, there have been ongoing initiatives to address the shortage of scientific and math instructors, but the issue persists. Additionally, the lack of scientific and math teachers in secondary schools has effects, according to the literature. Furthermore, the literature showed that various efforts were used by the government, the school management, teachers, and other education stakeholders to resolve or eradicate the problem, but still, the problem continues to affect many secondary schools in Tanzania. The goal of the current study is to aid in attempts to address the dilemma of shortages of teachers throughout secondary schools for both mathematics as well as science. The research study looked at the effects of the lack of science and math teachers

currently working in secondary schools. Moreover, this research study assessed the strategies that are been used in schools to minimize the scarcity in secondary schools. The research study also evaluated the effectiveness of the approaches used by the school management in reducing the scarcity of teachers.

Research Approach and Design

This research study used a mixed research approach and design to investigate the factors causing the scarcity of teachers in scientific and mathematics subjects and the impacts on Tanzanian secondary schools (Table 2). A mixed research approach mainly qualitative and quantitative was used in data collection and describes the outcomes acquired through interviews and questionnaires (Table 2). Quantitative data is concerned with subjective assessment of attitudes, feelings, behaviors, and perceptions (Kothari, 2009). A questionnaire was used to collect quantitative data which was analyzed using percentages and frequencies.

Table 2

Summary of Research Methodology and Design

Research design	Mixed research method (qualitative and quantitative)
Data collection tools	Interviews and questionnaires were used
Data analysis (Interviews)	Thematic data analysis (Braun & Clarke, 2006)
Data analysis (Questionnaires)	Frequency count and percentage

The current, mixed research approach is used to collect, analyze and interpret the information on what people say about the scarcity of teachers in scientific and mathematics subjects in secondary schools. The mixed research approach requires the researcher to use observation, interviews, questionnaires, and focus group discussion during data collection (Kothari, 2009). In this particular research, the researcher used interviews and questionnaires that intend to answer the research questions which, when answered then the research problem is also answered. The research questions were derived from the research objectives which are presented in Chapter 1.

Choosing a sample size is a crucial stage in the research technique (Kaur, 2021). Choosing how many observations or replicates to incorporate into a representative sample seems to be the act in question. Sometimes the improvement in accuracy brought on by larger numbers of samples is insignificant or nonexistent. Determining the sample size for descriptive research is different from the same as for experimental investigations. Choosing an appropriate sample size aids in improving the standard of evidence-based research (Kaur, 2021).

This study was conducted in the Kibaha and Bagamoyo districts of Tanzania's Pwani region. Based on the National Examination Council of Tanzania (NECTA) performance records, the region was purposively chosen. The region maintained its performance for more than five years, positioning itself among the top ten secondary schools in the nation (Said, 2018). The two districts were randomly chosen among six from the region. This is a 33% representative sample size which is above a good representative (10 -12.5 percent) sample of a population (Babbie, 1983). Eight (40 percent) out of 25 secondary schools in total were chosen. The schools were chosen randomly from a list of those that offered Advanced-level subjects in science and mathematics. It was assumed that a standard class has 40 students, so 12 students were chosen randomly which is a

representative sample. On the other hand, teachers were purposively selected provided they were teaching STEM subjects. An average of 6 teachers were selected from each secondary school.

Both interviews and questionnaires were used to gather the data. The questionnaires were completed by 98 students in total. Confidentiality, obtaining consent, obtaining research authorization, approving the research tools, and avoiding plagiarism are only a few examples of ethical considerations that were taken into account.

The research employed mixed research methods (both qualitative and quantitative) to collect data from the participants (Table 3). Collecting data through qualitative techniques through interviews allows data collection from multiple sources that help to understand the problem through the participants or respondents (Akinyode & Khan, 2018). Questionnaires were used to collect quantitative data from the students to ensure the triangulation of data collection methods to ensure the reliability of the information collected. The mixed research method which is the triangulation of data collection methods must start with the research design process; it cannot just be a name applied after the fact to imply multi-method rigor (Aguilar-Solana, 2020).

Table 3

Summary of the Nature of the Study

Origin of Data	Mixed research methods (Qualitative and Quantitative methods)
Tools used	Interviews and Questionnaires
Participants involved	Teachers and students involved in Science and Mathematics
Study Area	Tanzania, Pwani Region at Kibaha and Bagamoyo districts, and Secondary schools
Information collected from participants	• Reasons for students' choice to study scientific and mathematics subjects • The existence of scarcity of scientific and mathematics teachers • Causes of the scarcity of scientific teachers as well as mathematics • Impacts of shortage of teachers in scientific and mathematical fields • Strategies for minimizing the issue of shortages of teachers and their effectiveness

Despite inconsistencies in how triangulation is interpreted in translation and interpreting research, it is obvious that multi-method approaches can provide fuller insight into the social complexity of interpreting environments. Multiple data collection methods in interpretation research can contribute to a thorough knowledge of how interpretation scenarios are socially produced, what processes are at play among different actors of the three-component event, and how these impact the interpreter's function (Aguilar-Solana, 2020). Moreover, triangulation provides the option of datasets to illustrate various elements of an interesting phenomenon, which might enhance research

(Noble & Heale, 2019). It also aids in proving cases where data invalidates an assumption made using information from another. When one set of findings supports another set, it might help confirm a concept. Lastly, triangulation can assist in explaining a study's findings.

To exploit completely restricted datasets and conduct fine-grained analysis using a well-designed research strategy that employs triangulation of data collection method, with the ultimate goal of improving the trustworthiness of the findings by examining the same social phenomena from various perspectives (Aguilar-Solana, (2020). Through the triangulation of data collection methodologies, it is possible to improve the credibility of case study research in interpreting studies. The relevance of triangulation for qualitative case study research has long been debated in the social sciences; interpreting scholars should contribute more effectively to these discussions and the creation of creative research approaches (Aguilar-Solana, 2020). Triangulation is explained as a process of using a different point of view to support, refute, or broaden previous discoveries (Turner & Turner 2009). Methodological triangulation promotes the use of a range of data collection methods, such as questionnaires, observations, and interviews.

Triangulation (mixed research method) can be an effective strategy for increasing the reliability of research interpretation if methodologies are carefully designed to be complementary and contributively to one another, and attention is being paid to the research design in terms of both techniques used and the conceptual frameworks that guide data interpretation. In terms of data interpretation, the employment of qualitative methodologies was widely regarded as worrisome by positivist social scientists. Concerns concerning subjectivity and prejudice put qualitative researchers' interpretation of social activities into question. Due to concerns regarding bias and subjectivity, qualitative researchers' interpretations of behavior patterns as approximations of

actuality were called into question (Silverman, 2017). Based on that the current research opts to use a mixed research method to increase the reliability of the research interpretation.

However, data collected through qualitative methods give room for the researcher to build rapport with the interviewee and help the researcher to give further explanation of the question whenever she or he feels that the interviewee misunderstands the question asked. Open-ended questions can be used in qualitative data collection techniques which can allow the research participants to provide more information that does not restrict their opinions (Akinyode & Khan, 2018).

The current research study employed mixed research data collection methods including observation, interviews, and questionnaires (for students) to collect data regarding the causes of the scarcity of scientific and mathematics teachers and its impacts in Tanzania's secondary schools. Primary data were collected from the study area using interviews and questionnaire (for students) tools. During data collection, a non-probability sampling technique was used to gather the information from the area of study. The samples from the population in the study area were purposively selected and specifically, maximum variation sampling also known as heterogeneous sampling was used to capture a wide range of data. This sampling technique was preferred because the researchers believed that the information sought could be provided by experienced science and mathematics teachers and the students who were teaching and studying the subjects respectively. The participants were selected based on the teaching subjects, being either Mathematics, Physics, Biology, Chemistry, or two of them.

The selection of region under study among others in the regions was purposively selected by considering the best performance in secondary schools' national examinations results for three years. Two districts Kibaha and Bagamoyo are selected randomly among others in the region

following the said criterion above. A list of secondary schools teaching from lower to advanced levels was prepared from where eight secondary schools are randomly selected for the data collection. Biology, Chemistry, and Physics subjects, as well as Mathematics subjects, must be taught in those secondary schools up to the level of advanced level (which is from ordinary to advanced secondary school levels) repeatedly, for at least three years.

Before starting the interview sessions, the researcher explained briefly to the participants about the main purpose of the research. Also, the participants were informed to decide to join the research or to withdraw at any time they wished to do so. During the interview sessions, the researcher established a rapport with the participants, before the interview as this can give positive sound effects on the development of the interview session. The interview guide questions were neutral, open-ended, and understandable. To build the interviewee's confidence, simple questions were asked first followed by the more difficult ones. The interview length varied according to the participant's understanding, the topic to be discussed; the researcher's ability to interview which were conducted within an average of 30 – 60 minutes. The researcher most of the time listened to the respondents without interruptions to allow freedom of expression; body language was also used mostly smiling, nodding, and looking interested to encourage the respondent to provide even more information.

During the interviews, the conversations were recorded for further use in the research dissertation write-up, and immediately after each interview session, the researcher made field notes that were then been used at the time of data analysis and the research write-up. At the end of the interview session, the researcher thanked the participants for their responses, and time and ask them to say anything they feel they want to.

To obtain quantitative data, the questionnaires were distributed to the students with the help of their teachers. The students involved in this research were randomly selected from the group of students who were studying science and mathematics subjects in their respective schools. The students responded to the questionnaires and the analysis was done by counting the number of occurrences of an issue. The findings were presented as frequencies which were converted into percentages and presented in pie charts for easy understanding.

The study was conducted in Tanzania which is one of the Eastern African countries. Tanzania is located just south of the equator at 06.370S, 34.890E. Tanzania is one of the East African countries which is also one among the countries around the great lake which are Lake Victoria, Lake Tanganyika, and Lake Nyasa (also called Lake Malawi). The country is bordered by eight countries in Africa including Kenya, Uganda, Burundi, Rwanda, the Democratic Republic of Congo, Zambia, Malawi, and Mozambique. In the east, the country borders a coastline at the Indian Ocean which is also shared with Comoros and Seychelles.

According to Netherlands University Foundation for International Cooperation (Nuffic, 2015), Mazana et al. (2020) the education system of Tanzania is based on a 2-7-4-2-3+ structure. In other words, the education system of Tanzania has five levels of education which are pre-primary school (two years), primary school (seven years), ordinary secondary school (four years), advanced secondary education school (two years), university (three years) as well as vocational colleges. Primary school level is required for youngsters aged 7 to 14. There are two levels of secondary education: ordinary secondary school and advanced secondary school. The ordinary secondary school level is for students aged 14 to 17, while the advanced secondary school level is for students aged 18 to 20. Primary school is 7 years long and culminates in the Primary School Leaving

Examination. This examination, however, does not result in a certificate. Students are admitted to secondary schools or vocational training centers based on their grades (Nuffic, 2015).

Enrollment and retention in pre-primary and primary education are mandatory, and the government has implemented pre-primary schools in all public schools for children aged 4-6 years (Mazana et al., 2020). In public schools, Kiswahili is the primary language of instruction; nevertheless, there has been a significant surge in the number of private schools that teach using English as a medium of communication. National examinations are taken at the end of the 4th and 7th years of primary school (Mazana et al., 2020). The National Standard Four Examinations (NSFE), as well as the National School Leaving Examination (PSLE), are the two primary school examinations. Students who pass standard four exams advance to standard five, whereas those who fail must repeat the class until they pass. The selection of pupils for four-year secondary education or vocational training is based on standard seven examination results (Mazana et al., 2020). Kiswahili is a medium of instruction in primary schools in public schools while private schools use English as a medium of instruction and also English is used as a medium of instruction in secondary schools. This shows that there is a transition period as students upgrade to secondary schools and they find learning a difficult task due to the language barrier in the classroom teaching and learning. This may be one of the reasons why student performance becomes low in secondary schools in Tanzania.

Moreover, Nuffic (2015), and Mazana et al. (2020), explained that Secondary education is divided into two levels: basic and advanced. Forms 1 through 4 are on the ordinary level, whereas forms 5 and 6 are on the advanced level. Pupils take examinations for the Certificate of Secondary Education and Advanced Certificate of Secondary Education after these levels respectively. Pupils

who have completed the Certificate of Secondary Education and received a good grade may be upgraded to pursue an Advanced Certificate of Secondary Education.

There are various subjects are taught at secondary schools including agriculture, business, home economics, and technology are among the subjects. Other subjects taught at secondary schools are civics, English, Kiswahili, history, geography, physics, chemistry, biology, and mathematics which are studied by students in forms 1 - 4 (ordinary level). Advanced-level students concentrate on commerce, arts, social sciences, or natural sciences. They also undertake General Studies as a subject. The Advanced Certificate of Secondary Education qualifies students for entrance to a higher education institution. The Certificate of Secondary Education and Advanced Certificate of Secondary Education exams are given all across the country. Students must take exams in at least seven subjects to receive the Certificate of Secondary Education. Exam results are written in letters, with the letters A through D denoting a passing mark.

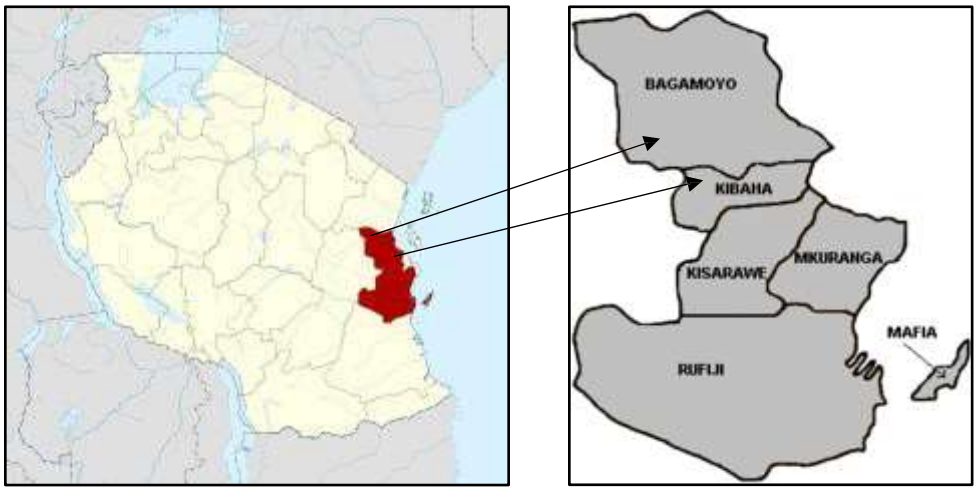
Students in ordinary secondary school have the option of advancing to advanced secondary education or continuing their studies in vocational training education which is available in Tanzania at several vocational training centers. These institutions provide study programs in a variety of technical and vocational subjects, such as those for students interested in becoming architects, electricians, or construction workers. These programs usually end after two or three years, with traditional exams leading to various certificates or diplomas (Nuffic, 2015).

According to Nuffic (2015), various government bodies have responsibility for all the education activities in Tanzania, including the Ministry of Education, Science, and Technology which is responsible for research, monitoring and evaluation, and quality assurance for primary and secondary education. Also, the Office of the Prime Minister, the local Government, and the

Regional Administrative Secretary are responsible for governance as well as monitoring education services in secondary schools. Moreover, the Ministry of Education, Science, and Technology is responsible for high education at the university level. The public universities are semi-autonomous and they are independent in preparation of their education curricula and they can award degrees.

The Tanzania Commission for Universities (TCU) is responsible for the supervision of all universities in the country including all private and public ones. On the other hand, all vocational and technical colleges which offer non-university courses are under the responsibility of the National Council of Technical, Vocation, Education Training (NACTVET).

The current research study was conducted in secondary schools that were pursuing advanced secondary school certificates. Two districts Kibaha and Bagamoyo are selected purposively from the Pwani Region and are involved in the study based on the three years of secondary school performance of the national examination's results. The reasons for choosing these districts were the fact that many samples are spread across the two Districts so it would be easy to get the required information. Pwani Region is located in the Coast Zone of Tanzania where also others like Dar es Salaam, Lindi, Mtwara, and Morogoro are located. The Coast Zone is located between latitude 8°37′37.20″ South, and longitude 37°52′37.20″ East of which the study area is within (Figure 1).



a). Map of Tanzania b). Map of Coast region

Figure 1. Map showing the study area – Tanzania and Coast Region.

Source: https://sw.wikipedia.org/wiki/Mkoa_wa_Pwani

Population and Sample of the Research Study

Samples of the data from the two districts were collected from 8 secondary schools which were selected randomly from the list of all secondary schools from the two districts under study. On the other hand, the districts were nominated by using purposively criteria selected based on the intensity of their examination performance for the past three years (Etikan et al., 2016). Moreover, there was data collection from various other education stakeholders, for instance, education officers, the quality assurance team of the districts; teachers; and students. The main purpose of collecting data from different stakeholders was to triangulate the data and capture a wide range of information to ensure the validity and reliability of the data. Four (4) education officers and four (4) education quality assurance officers from the two districts were interviewed. At least six (6) teachers from the eight (8) secondary schools from both districts were also interviewed and this

made a total of 53 teachers and education officers. Moreover, a sum of 98 students from 8 secondary schools was involved in responding to the questionnaires from both districts. At least an average of 12 students were chosen from each of the 8 secondary schools visited during the research study.

Table 4

Summary of Study Population and Sample

Region Selection	Purposively Selected based on the National Examination results for three consecutive years
Districts Selection	Two were randomly selected above the representative sample (Babbie, 1983).
Schools Selection	Eight schools out of 45 were randomly selected as the representative sample
Students selection	An average of 12 students was randomly selected from science and mathematics classes from each school visited. A total of 98 students were involved in responding to questionnaires
Teachers selection	Purposively Selected (only Science and Mathematics teachers) A total of 53 Teachers were interviewed

Instrumentation of the Research Tools

This research study used mixed research approaches to collect data using interview and questionnaire tools and a thematic data analysis method (Table 4). The respondent's data were gathered using a combination of quantitative and qualitative approaches. Qualitative approaches are useful for providing rich descriptions of complex interactions, reporting exceptional or unforeseen incidents, enlightening the expertise and assessment of the situation by stakeholders with widely varying stakes and responsibilities, giving a platform to those who have been rarely mentioned, undertaking preliminary investigations to partially explain and produce as well as make predictions, and progressing toward interpretations (Creswell & Miller, 2000). Qualitative and quantitative methodologies can be employed in conjunction or together in one research. The greatest qualitative research is methodical and thorough, to reduce biases and mistakes while also identifying proof to support initial or spontaneous beliefs (Creswell & Miller, 2000). On the other hand, quantitative research involves data, reasoning, and an unbiased viewpoint. In contrast to divergent understanding, detailed, consistent reasoning is the emphasis of quantitative studies.

In the qualitative research paradigm, reliability and validity are defined as trustworthiness, rigor, and quality (Aguilar-Solana, 2020; Creswell & Miller, 2000). It is also through such relationships that perhaps the qualitative researchers' opinions on how to accomplish validity and reliability of research are influenced, which are to remain objective and strengthen the researcher's trustworthiness of a thesis about some sociological trend through triangulation of data collection. Therefore, triangulation is defined as a validation technique in which researchers look for similarities across many and disparate sources of data to establish themes or groups in a study (Creswell & Miller, 2000). Triangulation can be a valuable strategy for improving the reliability of research interpretation if methodologies are carefully designed to be complementary and

contributively to one another, and attention is paid to the research design in terms of both the combination of methods and the theoretical constructs that guide data interpretation (Aguilar-Solana, 2020). As a result, if reliability, validity, and triangulation are to be important research concepts, particularly from a qualitative standpoint, they must be reformulated as we have seen to represent the numerous ways of maintaining accuracy through a variety, truthfulness, and triangulation (Creswell & Miller, 2000).

The current research study used qualitative research methods during the data collection where interviews, observation, and questionnaires are used. It was the task of the researcher to ensure that the interview questions were precise and understandable and this could be achieved only when there is a good rapport between the participants and the researcher. Neutral semi-structured and structured questions were prepared for the interview and some guiding questions were administered to different education officers, teachers, and students. The research was conducted and involved different education stakeholders to be able to triangulate the data and cover a wide range of information.

Interviews and questionnaires are the research tools that were mostly used to collect data from the study area and in very minor cases observation was employed. Guiding questions for semi-structured and structured interviews were used with different education officers, teachers, and students during data collection. For the education officers including District education officers, school quality assurance officers, and teachers who are the key informants, interviews were conducted at the district levels.

The main points of the interviews are to collect and discover the views, practices, and beliefs on the extent of the scarcity and the factors causing the scarcity of scientific and mathematical

teachers, as well as the impacts on Tanzania's secondary schools. During interviews, the researcher was able to establish a rapport with the participants before the interview as this can give positive effects on the development of the interview session. Also, the interview questions were neutral, open-ended, precise, and understandable. The interview length was varying according to the participant's understanding, the topic discussed; the researcher's ability to interview, and was conducted within an average of 30 – 60 minutes (Gill et al., 2008). During the interviews, the conversations were recorded and noted down for further use in the research dissertation write-up. Also, the researcher made field notes immediately after the interview that was also used at the time of data analysis and the dissertation write-up.

During the interview session, simple questions were asked at the beginning followed by the more difficult ones to build the interviewee's confidence. The researcher was listening to the respondents without interruptions to allow freedom of expression; body language was also used mostly like nodding, smiling, and looking interested. At the end of the interview session, the researcher thanked participants for their responses, and time and ask them to say anything they feel they want to.

According to Gill et al. (2008), the interviews were conducted with teachers and students in separate sessions and were involved in responding to questionnaires to collect the needed information. At least a total of twelve students were selected from each of the secondary schools to be involved in this research. The students were monitored, guided, and assisted by the researcher or their teacher to be able to respond to the given questionnaires. Interviews and the questionnaire were instructed by using both Kiswahili and English languages to give more opportunity and freedom to the participants for participating and communicating their experiences and views.

Before conducting the major research study, pre-testing was done to test the reliability and validity of the research instruments and assess the extent to which these instruments measure what it is designed to measure (Kimberlin & Winterstein, 2008). This was used to help the researcher to be able to check and balance the accuracy of what is been measured thus in case of any drawback in the use of the research tools, the researcher adjusted the tools/instruments to be more precise and consistent to measure the theory under study. During the pre-testing of the tools, the researcher was also able to realize the existence of any biases and adjust accordingly to avoid unfairness in the major research work (Kimberlin & Winterstein, 2008). Thus, the guide questions should be precisely able to draw all the information needed during the interviews and questionnaires to be able to come up with well-answered research questions.

Study Procedures and Ethical Assurance

While conducting research, researchers must observe suitable values at all phases. It is possible that if this is not observed, scientific misconduct will occur. And it is within this context that we explore ethical issues in research, with a focus on those relating to the research itself, research subjects, and the research method (Akaranga & Makau, 2016). Moreover, some norms help researchers achieve their goals, which include information diffusion, reporting or telling the truth, and eventually, error correction. The development and approval of a research proposal is the first stage in the process, which leads to the actual research investigation. A researcher must choose the appropriate methodology to use, and relevant methods of data collection, present the research findings, and interpret them appropriately, resulting in a logical presentation of information (Akaranga & Makau, 2016). The information is then examined and presented in a well-written article, project report, thesis, or book. In this particular research, the researcher followed all the

stages in the process from proposal writing, all approvals by the university were obtained and a permit was given and allowed to conduct research investigation.

According to Akaranga and Makau (2016), a researcher has to be vigilant about disclosing his or her research results if they may jeopardize his or her sponsor's good working relationship. This is obvious if the information concentrates on the organization's policies and could reveal sensitive information about the people or the organization. This needs successful collaboration with other academics while also respecting the intellectual property rights of other researchers. If this is not followed, it may result in rebellion or even protests. In academic institutes of higher learning, plagiarism is a contentious issue. This is the technique of a writer or researcher making sure that any research they produce is unique and free of writings, findings, or even phrases that have been obtained, modified, or even used without acknowledging the sources of information, such as suggestions, procedures, findings, or even the writer's or publication's phrases (Akaranga & Makau, 2016). The current research followed all the procedures of dissertation write-up and all the information from other sources was paraphrased and acknowledged to avoid plagiarism. The intention is to come up with a unique piece of work in the end.

Furthermore, Akaranga and Makau (2016), explained that when the same written material appears in two or more publications, this is known as duplication or plagiarism. This could happen due to laziness, ignorance, or cultural difference, compromising the researcher's honesty. Plagiarism is most commonly found in the initial paragraphs, such as the background and literature review. It is the writer who must properly quote or cite the source material. According to Akaranga and Makau (2016), self-plagiarism and multiple duplications, sometimes also known as salamis, are two

different types of plagiarism. The other type of plagiarism is redundant publication, which occurs when a researcher reuses his previous work in a new study without properly referencing it, or when previously published data is republished with new information (Akaranga & Makau, 2016). Perhaps the researcher's objective is to exaggerate previously published findings. However, this is obstructing research and is illegal.

The current research study abided by ethical procedures and principles which are necessary. The ethical principles based on issues such as being informed, avoiding harm and doing good, confidentiality, reflecting fairness, the right for dignity, and the need to be respected are the foundations of research ethics in the social sciences. Moreover, these research principles are essential since they are concerned with a range of research areas including scientific and academic research (American Psychological Association, 2002; The British Psychological Society 2010). These research ethical approaches apply to all research that involves humans as participants or subjects including this particular research. The main ethical principles that are important in this qualitative research include that the researcher must minimize the risks or burden (socially, physically, and psychologically) and maximize the benefits to participants, that the researcher must have respect for persons in terms of autonomy, decision-making, and dignity of the participants – at some point a researcher should seek the consent of the participants before involving them in the research (American Psychological Association, (2002; Benatar, 2002; British Psychological Society 2010; Haggerty, 2004; William, 2006).

In this research, before starting an interview, sessions, or distributing the questionnaires to the participants the researcher briefly explained to the participants the purpose of the research. All the time the researcher informed the participants in this research that they were allowed to withdraw from the research at any time as they wish. They were as well allowed to withdraw their

information at any stage of the research. This research complied with these basic research ethical principles to avoid the rejection of the research by the institution's ethical committee, or supervisor.

Data Collection and Analysis

According to Akinyode and Khan (2018), qualitative data analysis is defined as step by step process of both performed to summarize the collected data and organize these in such a method that they answer the research questions. Creswell (2007) described qualitative research methods as a process where the problem of the research is studied in its natural setting than in a laboratory study. Data analysis is the process involving working with data, organizing, and breaking it into manageable units to compare, scale, and measure the information from the research respondents. According to Wong (2008), in qualitative research, data analysis refers to the process of carefully searching and organizing interview transcripts, observation notes, and other non-textual materials gathered by the researcher to better understand the phenomenon. The majority of qualitative data analysis involves coding or categorizing the data. Making sense of huge volumes of data includes reducing the volume of raw data, identifying noteworthy patterns, and finally extracting the meaning of the information and establishing a rational sequence of evidence. It is more of a dynamic, intuitive, and system process of inductive logic, thinking, and theorizing than a technical exercise like quantitative approaches (Wong 2008). The majority of qualitative data analysis involves coding or categorizing the data. In simple words, codes are labels or tags used to assign discovered themes or subjects from the study's data. Traditionally, coding was done by hand, with colored pens used to categorize data and then cutting and sorting the data. Electronic data coding approaches are becoming more popular among qualitative researchers as software technology advances.

The open-ended nature of data, as opposed to statistics alone, is one of the challenges of qualitative research. Interview transcripts, newspaper articles, questionnaire replies, diaries, movies, photographs, and field observations are all examples of qualitative data. It's often more difficult to reduce and find patterns in the text as data than it is in numbers as data. Because of the complexity of qualitative research's unstructured data, the diversity of the data, and the way discoveries and ideas develop from the data, the use of software applications in qualitative data analysis is limited. The computer software, however, does not perform the analysis for the researchers. Users must still define categories, code, determine what to collect, detect patterns, and interpret the data. Finally, the researcher must synthesize the data and interpret the obtained meanings. As a result, the use of computers in qualitative analysis just improved the efficiency and manageability of data organization, reduction, and storage (Wong, 2008). This methodology evaluation focuses on thematic analysis (TA), a data analysis procedure that is commonly utilized across all qualitative designs. TA is frequently employed in research projects and then classified as qualitative research without providing the relevant details about how the analysis reduced the data into manageable themes and the conclusions that emerged.

The research used mixed research data collection tools which were interviews and questionnaires as well as thematic data analysis. The technique involved both qualitative and quantitative techniques where interviews and questionnaires were used respectively. More importantly, in this mixed research, three activities were conducted including research design, fieldwork for data collection, and data analysis. (Attride-Stirling, 2001; Braun & Clarke, 2006). The thematic data analysis method was used to analyze qualitative data collected about the causes and impacts of the scarcity of teachers in scientific and mathematics in Tanzanian secondary schools. Thematic analysis was done stepwise because it is a recommended data analysis method for qualitative data

(Clarke & Braun, 2013). The literature review showed that researchers are applying and promoting qualitative research techniques which can be referred to as a positive step toward a deeper understanding of social humanity occurrences (Akinyode & Khan, 2018; Braun & Clarke, 2006). This section is specifically explaining the data analysis method used in the current research study.

Similar steps of data analysis were followed in analyzing the data from the participants about the impacts of the scarcity of teachers in science and mathematics in Tanzania's secondary schools. These main ideas were presented in a thematic map also known as thematic networks. The thematic maps or networks showed the interactive model regarding the data and in this case, the main factors that were causing the scarcity of teachers in science as well as mathematics and their impacts on secondary schools in Tanzania as discovered in the current research.

During the process of collecting data, the dates, months, and years of data collection were recorded and read from time to time so that the researcher could have an in-depth understanding of the data. The data collected were compiled by the researcher according to the issues investigated to make it easier for the analysis. Both the field notes and the recorded clips will be used during the data analysis. All of the information related to the subject matter under the research was revisited to come up with systematic information to answer the research questions. The data collected was compiled using Kobo Toolbox and the Excel sheet before the analysis begins. The information from the teachers and the education officers was compiled together while the data from the students were compiled as a piece of separate information.

Thematic Analysis (TA) method was used in analyzing the qualitative data collected about the scarcity of teachers in science as well as mathematics in the study area. This analysis was done step by step where the researcher read and understand the excerpts given in the interviews and note

the issues. During the data analysis, the researcher read and re-read and understand the excerpts given in the interviews and note the issues as initial codes or themes. The thematic analysis was done according to Attride-Stirling (2001), Braun & Clarke (2006), Maguire and Delahunt (2017), and Thomas & Harden (2008). According to Attride-Stirling (2001), and Clarke and Braun (2013), the initial codes (Basic Themes) were created as explained and later refined and presented as issues (Organized Themes) about the data collected. These organized themes were further summarized into global themes which were later presented in networks that summarize the data which was the main ideas the data was telling about the interviews.

Furthermore, similar steps of data analysis were followed to analyze the impacts caused by the scarcity of teachers in science and mathematics in Tanzania's secondary schools. The Thematic Map shows the interactive model regarding the data and in this case, the factors that are causing the scarcity of teachers in science as well as mathematics and their impacts on Tanzania's secondary schools.

Moreover, to come up with integrated data analysis, the quantitative data obtained from the questionnaires were transformed into numeric ratings to allow statistical analysis to help overcome any missed information from the previous method of data analysis (Caracelli & Greene, 1993). The statistical method of data analysis was useful in the generalization of the research findings from this particular research. It helps to provide the validity of the data collected. The data obtained from questionnaires were tallied to obtain the frequency of the occurrence of a theme then the frequency was converted to percentages which were presented in pie charts based on the research question. This statistical method of data analysis was useful in ensuring that the research findings are well understood by the readers of this particular research. Based on the analysis of the information collected from the interviews and the questionnaires, the interpretation of the

information followed. The factors that are causing the scarcity of teachers in science and mathematics in Tanzania's secondary schools were sorted out. Also, their impacts were presented in a thematic map representing the main ideas and views of the research participants.

The researcher intended to collect information regarding the scarcity of science and mathematics from both the students and teachers who are the people at the grassroots. These two groups of people may have information that is similar or not with the existing literature as they are the main education stakeholders. The grouping, ranking, and clustering of participants and remarks can be used to work on the quantitative data. These statistics can be applied to prioritize topics based on problematic claims, find agreement and support for assumptions, and assess the resemblance of statements, participants, and subgroups (Wojatzki et al., 2018). As part of the current study, participants were interviewed about the lack of an adequate number of teachers in science and math in secondary schools, and tasks included recognizing claims that were implicit in free text. The statements were discovered using thematic analysis of information gathered from teachers' interviews information. To determine the frequency, or number of occurrences of a theme, the research tallied similar ones as they were mentioned by participants, and the global themes - which were the respondents' principal ideas - were totaled together. In other words, the broad themes derived from participant replies are given in succinct sentences that convey the key points and provide information on the hot-button issues in the study.

According to Wojatzki et al. (2018), it is more useful to learn about people's beliefs and opinions, the various aspects of an issue, which ones are deemed more important, and who the key stakeholders are when trying to quantify qualitative data rather than simply learning how many people support or oppose a particular position. The researcher in this case relies on creating the assertions from the qualitative data obtained from questionnaires during the analysis. Additionally,

because the sample size was greater than 50 and the participants were asked comparable questions throughout the questionnaire, it could be possible to report the information in percentage form, although this was done since it is not justifiable. Neale et al. (2014) claim that the sample size must be greater than or equal to 50 to employ percentages to semi-quantify or quantify qualitative data.

Furthermore, no generalizations about the prevalence of the teacher shortage in scientific and mathematical disciplines or its effects outside of this sample can be made from the information gained from this type of data. Therefore, it is necessary to gather, evaluate, and generalize quantitative data to reach conclusions. The research used the information collected through questionnaires to count the frequency of occurrence of the responses and come up with the percentages.

Summary

This Chapter has presented the research approaches and designs which include data collection methods, the study area, instrumentation of the research tools, the population, and samples of the research study. This particular research study was conducted in two districts (Kibaha and Bagamoyo) purposively selected from the Pwani region in Tanzania. The research used mixed research (qualitative and quantitative) methods during data collection using interviews and questionnaires tools. The research tools which were used in data collection include interview guide questions conducted with the teachers and questionnaires assigned to the students during data collection. The data collected through interviews was analyzed using the thematic data analysis method. On the other hand, the information collected from the students using the questionnaires was analyzed using frequency count and percentage.

The Chapter also discussed the study procedures and ethical assurance. All necessary ethical procedures were abided by including the approvals from different stakeholders from both the UNICAF University and the authority from the study area. Before the start of an interview, the researcher briefly explains to the participant the intentions of the research and ask the participant if they would like to participate in the research study. The researcher received all necessary informed consent signed by the participants, the research was conducted while the participants were respected, and allowed to withdraw from the research at any time during the research study.

Moreover, the Chapter discussed the qualitative data analysis in a detailed way, including the Thematic Analysis, a step-by-step data analysis procedure whereby the researcher desired to assess factors causing the scarcity of teachers in science as well as mathematics and the impacts in Tanzania's secondary schools. The Thematic Analysis process leads to summarizing the participants' main ideas from the interviews and questionnaires in a refined fashion till the major ideas are related to the research area in place and this was done according to Clarke and Braun, 2013.

The end product of the thematic analysis is the thematic network which is the summary of the main ideas obtained from the research study data collected and analyzed. The thematic network is a web-like network that represents the text evolved from the data. It grows from the basic themes into organizing themes and global themes that show their relationship. The study issue that the researcher wanted to address determined the themes and the interpretation. To arrive at the global themes the researchers have to repeatedly read the scripts of the data and understand the mind of the research participants on the subject matter.

The basic theme is the lowest level of the results in the thematic analysis process when we want to make an organizing theme, we might need to combine two or more of the basic themes. This combination of the basic themes is done to ensure that the obtained organizing theme which has more sense compared to the basic theme. Organizing themes are the middle-order of the thematic analysis which has richer meaning than the basic theme. A global theme is a superior theme that is obtained from a set of organizing themes. It is the main idea that the data is telling us about an investigated matter. It is the summary of the main issues analyzed and it reveals the meaning of the data in the scripts being analyzed. The research comes up with the main ideas of the participants which are presented in the subsequent chapter.

CHAPTER 4: FINDINGS

Introduction

Chapter 4 discusses in detail the research findings and is divided into subsections including the research results introduction part which is comprised of the introduction of the chapter; the trustworthiness of the data; data reliability and validity of the research and the research results. The study's findings include participant experiences with the level of understanding of the shortage of trainers in mathematical and scientific subjects in secondary schools, student motivations for choosing science and mathematics as a subject, causes of the shortage of science and mathematics educators in secondary schools, effects of the shortage of science and mathematics instructors, and school administration tactics for reducing the shortage of mathematics and science professionals instructors. The effectiveness of the school administration's measures for addressing the issue of a teacher shortage of trainers in both mathematics and science lessons was explored in the research.

The evaluation of the results, a discussion of the results in terms of the shortage of scientific and math instructors, and the effects on secondary schools are also included in Chapter 4. The Chapter also includes participant comments on the effects of the teacher shortage on secondary schools as well as disparities between instructors' and students' reactions to what causes the shortage of science and math teachers. Finally, a summary of Chapter 4 is provided. In general, Chapter 4 described what had been done in the field and gave conclusions regarding the results of the data analysis. It outlines the key points of the study problem as seen and perceived by the study's participants.

This section is devoted to evaluating the research's findings, that was revealed how the study examined the degree of teacher shortage in secondary schools, the viewpoints of educators

themselves on a similar issue, as well as the perspectives of students on this problem. It additionally explored the motivations of students who choose to pursue mathematical and scientific subjects. Additionally, the evaluation of this component of the research findings discussed the lack of scientific and mathematics educational professionals, low performance among students in these subjects, the problem of few graduates in these fields, students who study these subjects but choose other careers in science rather than teaching, and schools with insufficient teaching and learning facilities. Also, the teacher's response to the issue of unemployment for more than five years; low or no salary increment for teachers; students choose to study social science subjects, and students consider science and mathematics subjects as hard to study.

The current research study aimed to collect data on the factors causing the scarcity of teachers in science as well as mathematics, and the impacts on Tanzania's secondary schools. Research findings in this chapter were presented in subtitles based on the research questions. This chapter comprises the research subtitles including the trustworthiness of data; data reliability and validity; and the research results presentation. Furthermore, the research study results provide the finding presented with subtitles: the teachers' experience with the scarcity of science and mathematics teachers; the students' experience with the scarcity of science and mathematics teachers; reasons for students' choice of science and mathematics subjects in secondary schools.

Also, the research other causes of scarcity of teachers that are presented under the subtitle - choices of science subject combinations by students; factors causing the scarcity of science and mathematics in secondary schools; and impacts of the scarcity of science and mathematics teachers in secondary schools. The entire chapter 4 presents the findings based on the research questions under study. The research questions include:

1. What is the level of scarcity of teachers in science and mathematics subjects in Tanzanian secondary schools?

2. What are the factors causing the scarcity of teachers in science and mathematics in Tanzanian secondary schools?

3. What are the differences in the responses of the teachers and students on the factors causing the scarcity of teachers in science and mathematics in Tanzanian secondary schools?

4. What are the impacts of the scarcity of science and mathematics teachers on secondary schools in Tanzania?

5. What are the differences in the responses of teachers and students on the impacts of the scarcity of teachers in sciences and mathematics in Tanzania's secondary schools?

6. What are strategies that could be used to minimize the scarcity of teachers in science and mathematics in Tanzanian secondary schools?

7. How effective are the approaches used by the school management to manage the scarcity of teachers in science and mathematics in Tanzanian secondary schools?

It should be noted that the above research questions were derived from the research objectives which were presented in Chapter 1. The questions were guiding the researcher during the preparation of the research tools that were used for the data collection. The tools were the structured and semi-structured interview guide questions and the questionnaires which were used to collect data from the participants. The current chapter presents the findings based on the research

objectives which the research questions were derived from. The following are the investigation's main goals:

1. Determine the extent of the scarcity of teachers in science and mathematics in Tanzanian secondary schools.

2. Examine the factors that are causing the scarcity of teachers in science and mathematics in Tanzanian secondary schools.

3. Investigate the differences in the responses of the teachers and students on the factors causing the scarcity of teachers in science and mathematics in secondary schools.

4. Assess the impacts of the scarcity of teachers in science and mathematics in Tanzania secondary schools.

5. Determine the differences in the responses of the teachers and students on the impacts of the scarcity of teachers in science and mathematics in Tanzanian secondary schools.

6. What strategies could be used to minimize the scarcity of teachers in science and mathematics in Tanzanian secondary schools?

7. How effectively are the approaches used by the school management to manage the scarcity of teachers in science and mathematics in Tanzanian secondary schools?

In a nutshell, Chapter 4 discusses how students, teachers, and district education officers view the shortage of teachers in science and mathematics, as well as the factors that contribute to it, the effects it has on secondary schools, and the main viewpoint and recommendations from the

participants on how to reduce the shortage of teachers in science and mathematics and the effects it has on students in Tanzanian secondary schools.

Data collection involved district education officers, teachers, and students from the Pwani region, where two districts were chosen Kibaha and Bagamoyo Districts. The research data were collected and analyzed using mixed research methods using interviews and questionnaires research tools. Interviews and questionnaire tools collected qualitative and quantitative data from the participants respectively. Thematic analysis was used to examine the collected information. The thematic analysis approach is the step-by-step method of recognizing through coding, organizing, analyzing, and reporting themes within qualitative data collected from the participants (Braun and Clarke, 2006). Since the qualitative data are subjective, the researcher has to be familiarized with the data by listening to the participants, reviewing, and reading carefully the responses from the participants. The data collected were coded to identify the basic ideas or themes which were referred to as the basic themes. Re-coding was done to refine the basic themes and categorize the main ideas from the participants into a clearer meaningful pattern termed organized themes. The refinement and categorization of the themes enabled the researcher to come up with meaningful ideas named global themes. The global themes are then been used to develop thematic maps/networks which show the results of the investigated issue under the research (Braun & Clarke, 2006). In this case, the main ideas are the factors causing the scarcity of teachers in science and mathematics and the impacts on Tanzanians in secondary schools.

The findings were obtained after the thematic analysis of the data collected using interviews and questionnaires responses from the district education officers, teachers, and students respectively. The findings were presented in the form of tables that are showing how the coding and re-coding of the data were done on the specific research questions. Furthermore, the themes were created as

the basic themes which were later combined to come up with the organized themes. The global themes were then formulated by combining the organized themes. Lastly, the global themes were presented in thematic networks indicating the interaction of the main ideas obtained from interviews with teachers and district education officers. Moreover, the responses from the student's questionnaires were tallied to obtain the frequency of the occurrence of an idea and the frequency percentages were calculated and presented on pie charts. The presentation of the findings in pie charts enables the readers to clearly understand the research findings.

Trustworthiness of Data

The research findings presented in this chapter include data collected using the mixed research method where interviews and questionnaire tools were used to collect the information from the research participants. In this research, different education stakeholders including district education officers, science and mathematics teachers, and secondary students who were studying science and mathematics subjects were involved. Science in this situation encompasses mainly Biology, Chemistry, and Physics. Interviews were conducted with district education officers, and science and mathematics teachers while questionnaires were assigned to students who have been studying the aforementioned subjects.

The interview guide questions were prepared and ready for collecting data from the district education officers and the teachers who were teaching science and mathematics in secondary schools. Moreover, the questionnaires were prepared for students to respond to and they were distributed to students in the respective schools. All secondary schools which were teaching science and mathematics up to advanced level from the Kibaha and Bagamoyo districts had equal chances to be involved in the research, thus they were randomly selected from the list. In the region

in which the research study was conducted and the schools visited, the research participants such as teachers, and students were purposively selected.

A set of complete research interview guide questions and questionnaires were submitted to the Unicaf Research Ethical Committee (UREC) for approval after the supervisors' approval. All ethical procedures were adhered to by the researcher as required. Before starting data collection, the researcher visited the office of the Regional Administrative Secretary (RAS) to obtain an informed consent letter which easily the data collection during the visit to the district offices and the schools in the districts. The researcher introduced herself to the RAS and give briefly the purpose of the visit and the study. The researcher was granted a research permit which allowed her to go to the district education offices and the secondary schools selected for data collection.

The researcher visited district education offices to obtain informed consent and conducted interviews with a total of 8 education officers. Thereafter, selected schools were visited and interviews were conducted with teachers who were teaching science and mathematics subjects. Before starting the interviews, the researcher explained the purpose of the visit to the school management team. The main purpose was to obtain informed consent from each school visited. A total of eight (8) secondary schools were visited where a total of 45 teachers were interviewed and 98 students were given questionnaires to respond to. Also, a total of 8 education officers from the districts were involved in the research.

With the help of the teachers, the questionnaires were distributed to students in secondary schools visited. The students were given some time to fill in the questionnaires after obtaining their signed consent from them. The students were briefly informed about the purpose of the research, and they were told that they are free to participate if they feel like and those who were not interested were

not forced to participate. Even those who wanted to quit in the middle of the activity were allowed to do so. The completed questionnaires were collected from the schools later on the same day or the other day within the data collection period. During the visit, all of the research participants in this research study were informed that they can withdraw themselves from the research at any time or withdraw the information they provided to the researcher at any time as they wished.

During the period of the data collection, the whole world people were struggling to protect themselves from coronavirus and each person was worried about their safety. People were still in a panic about the pandemic although in Tanzania the schools were already open. To some extent, the spread of the coronavirus pandemic may behave caused effects on the data collected during this time of the research. However, the effects here are considered very minimal since the data were collected under precaution, and most of the time mobile phone was also used after the first visit to schools to ensure the maintenance of social distancing. To gather information from the teachers, the Kobo Toolbox system was employed. Moreover, precautions against the spread of coronavirus were considered such as wearing masks, hand washing, and social distance were maintained.

Data collected were compiled and analyzed in an Excel sheet. The data from the Kobo Toolbox application were downloaded to an Excel sheet to ease the reading and analysis. The data collected were analyzed using the thematic analysis (TA) method which was chosen because it is the first qualitative method of identifying the meaningful themes or patterns within qualitative data according to Braun & Clarke. These themes are the concepts or ideas that carry and summarize the major points of clear and important patterns in the collected data. Moreover, the thematic analysis method was used because it is flexible and allows the researcher to find out about the participant's opinions, views, experiences, and knowledge from qualitative data. The thematic

analysis method gives room for flexibility in interpreting the information obtained from the data. Since qualitative data are subjective, the thematic analysis relies on the researcher's judgment and it needs a high concentration on the data collected to avoid including things that are not in the data (Braun & Clarke, 2001). In this particular research, the researcher achieved the analysis by reading several times the responses from the participants and following the thematic analysis steps according to Braun & Clarke 2006.

Step one of the study process involved the researcher becoming familiar with the data by reading and rereading all of the participant information. During this step, the researcher noted all shorthand labels and enter them in a Kobo Toolbox application created by the researcher which easy the working with mobile devices and a computer. Kobo Toolbox is a free application available in the google play store which can be used for data collection using mobile and computer devices. The data collected from interviews and questionnaires were entered into a mobile device and can be accessed on a computer. Later the data were downloaded into an Excel sheet for easy sorting and getting an overview of the information gathered before starting the analysis.

In the stage that followed, the researcher coded the data based on the study question by resuming the shortened classifications, specifically as fundamental themes or "codes" to define the information content provided by the research participants. This was done by reading the responses from the participants and noting down the important information related to the research question. The reading was done repeatedly to ensure that nothing will be missed from the data. After coding all the information collected from the interview scripts, the researcher went through the data several times to build the themes or patterns that are named organized themes which are more comprehensive and meaningful than the basic themes. In the process of building the organized themes, the researcher combined some basic themes to make them one, took some of them as

standalone themes, and others that were unclear were discarded. The researcher read again the generated codes and refines more to create global themes. These global themes represented the main ideas of the participants on a particular research question. The discovered prospective global themes were now regarded as valuable information in the data about the question under investigation and the study's objectives.

After having found the list of the global themes, the researcher read once more to record how often the themes appeared or occurred (frequency) within the data to be able to later explain what it means. These frequencies were then converted into percentages to ease readers' understanding. The frequency percentages are presented in the results as pie charts (Figures 1 to 7). Wherever the percentages look high, it indicates that many participants mentioned the theme, and also this can be considered the main idea of the information collected.

The global themes were then compiled to build thematic networks or maps that show the interconnection of the main ideas from the participants. The main focus of this particular research project is the root cause of the shortage of science and math teachers and their effects on secondary schools in Tanzania, which formed the basis for the creation of these networks. Two main thematic networks or maps were made from the collected and analyzed data. The first thematic network or map highlights the reasons that contribute to Tanzania's shortage of math and science teachers in secondary education, while the subsequent thematic network or map highlights the effects of this shortage.

When examining the causes of the shortage of teachers in mathematics and science teachers, it is interesting to observe that the majority of the causes were also stated as repercussions of the shortage of those subjects. This implies that the causes of the shortage of science and math

instructors are also the effects of the shortage. This demonstrates the cyclical nature of the relationship between the causes of the shortage of science and mathematics and its effects. Using low performance as an example, which is one of the issues contributing to the lack of science and mathematics teachers, it is also demonstrated how this affects secondary schools. The diminishing number of mathematical and scientific graduates who will continue with the subject in tertiary education and become teachers is one of the factors contributing to the shortage of these subject teachers. Whenever science and mathematics teachers are scarce, teaching will not be effective, and therefore student performance also is affected negatively. Thus, poor performance leads to scarcity of science and mathematics and this scarcity causes poor performance in science and mathematics in the classroom.

Data Reliability and Validity

Reliability is an indicator of how consistent research data are when collected under the same conditions using the same data collection tools (Sürücü, & Maslakç, 2020). In other words, reliability is the ability of research tools to give similar results when applied at different times. Validity of the data is the process of determining whether the instrument used for data collection is measuring what it is supposed to measure. According to Taherdoost (2016), the research tools for data collection must be reliable to be valid. Both validity and reliability are essential to obtain beneficial results from the research study. Moreover, Taherdoost (2016), reported that the primary goal of a questionnaire in research is to collect key data in one of the most reliable and valid ways possible. As a result, questionnaire accuracy and completeness are important facets of the research method, that are regarded as valid and reliable. Furthermore, the new researchers, feel puzzled at the point when they are supposed to make a choice and implementation of the appropriate validity type to test their data collection instruments (that is questionnaire).

A questionnaire is the most commonly used quantitative research tool to collect data, and the main objective of its use is to get relevant information reliably and validly. To be sure whether a research tool used to collect data is valid, it must consistently provide the same score for the data collected. In the current research study, the interview guide questions and questionnaires were prepared in advance and administered to a few research respondents for trial to be assured that they were effective for the data collection.

According to Sürücü & Maslakç (2020), there are different types of validity in quantitative research, and most of them do not apply to qualitative research. In line with that, face validity is one of the factors that is considered when reporting validity in social sciences research. Face validity is performed by an academic team on the structure of the research measuring instruments that the research is trying to determine. According to Sürücü and Maslakç (2020), academic experts consider the following evaluation criteria: (a) the aim of every statement applies to the measuring system; (b) the statements within the scale size are clearly understood by the participants; (c) the readability of all statements in the measuring system; (d) the attractiveness of the questionnaire created; (e) the difficulty of each item applies to the level of the participants. It is not sufficient for researchers to report that the face validity of the measuring system has been determined to be satisfactory by experts. To make their research meaningful and healthier, it would be beneficial for researchers to state experts' comments on the specified criteria in their research.

In the current research, the research tools were assessed by the academic team and approved by the UNICAF Research Committee (UREC). Based on that, the current research measuring instruments and the findings are considered to be reliable and valid. Furthermore, data collected and compiled were analyzed using descriptive statistics, that is frequencies and percentages which are presented in the table and further elaborated by using pie chart figures. The validity of the data

in this research study is attested, the data have been obtained from various sources and participants that were purposively selected and were analyzed qualitatively as well as through descriptive statistics. Another part that strengthens the validity of the collected data is triangulation, which may be in terms of the origin of data, method of data analysis, and the location where the data were collected. The researcher has triangulated the location or places from which data were collected (public and private secondary schools in Kibaha and Bagamoyo districts as well as secondary school teachers and district offices), which provides evidence of the validity of the data and analysis presented.

Research Results

The researcher was interested in learning what causes the shortage of science and math teachers and what effects it has on Tanzania's secondary schools. Data collected from Kibaha and Bagamoyo districts in the Pwani region in Tanzania were analyzed to come out with those factors. The data collected from the district education office and the schools were analyzed using Braun & Clarke's steps of qualitative data known as the thematic analysis method. The thematic analysis method is a systematic analysis of the information obtained from the interviews with the participants (Attride-Stirling, 2001; Braun and Clarke, 2006; Clarke and Braun, 2013). Thematic Analysis (TA) was used to analyze data gathered from the interviews with the district education officers and the teachers in science and mathematics. On the other hand, questionnaires were used with students to capture their ideas on the issue of the scarcity of teachers in science and mathematics and its impacts in Tanzanian secondary schools and analyzed using the count of frequencies of occurrences and presented by the percentages.

During the thematic analysis, the researcher read repeatedly and comprehend the responses from the research participants that were later summarized on a table as meaningful ideas from the participants labeled as Basic Themes. These basic themes were then refined more by combining more themes to form one meaningful pattern that is referred to as the Organized Theme. The Organized Themes were further refined to form Global Themes which are the main summarized ideas gotten from the research respondents. The results were presented in Tables 1 to 9 and Figures 1 to 9 in this chapter. Tables 1 to 9 show the thematic analysis of the data while Figures 1 to 9 show the percentage frequencies of students respondents in a respective question. The analysis was done based on the research questions and also the data findings were presented following the same.

Awareness of Shortages of Teachers in Sciences and Mathematical Fields

The goal of the study was to comprehend how few teachers of science and mathematics there are in secondary schools, according to both the educators and learners. The main objective was to capture what participants experienced to determine whether or not there is a shortage of mathematics and science instructors in secondary education. The data collected from the interviews with education officers, teachers, and students were analyzed using the thematic analysis method (Table 5). Eight (8) education officers and a total of 45 teachers were interviewed during this research study. The thematic analysis of the interview data from the education officers and the teachers revealed that teachers in science and mathematics are scarce in Tanzanian secondary schools.

The data gathered about the participants' perceptions of the problem of the lack of science and math teachers in Kibaha and Bagamoyo in the Pwani area of Tanzania are shown in Table 1 along

with a step-by-step thematic analysis of the data. Table 1 details how the district education officers, teachers, and research participants felt about the issue of an inadequate number of science and math teachers throughout Tanzanian secondary schools. Thematic analysis of the responses from the teachers and the officers of the district on the research question "What is the scarcity level of science and mathematics teachers in secondary schools in Tanzania?" Explaining whether there are more, less, or a similar number of teachers in science and math compared to other courses was requested from the participants. When the education officers and the teachers respond to this question, they agree there is a high scarcity of science and mathematics teachers (92% of respondents agreed) while only (8% of respondents disagreed) disagree (Figure 2). This group of participants was asked to explain why they agreed that science and mathematics teachers are scarce, their responses were analyzed using the thematic analysis method and presented in Table 1. Generally, these were indicators of the existence of the scarcity of teachers in science and mathematics in Tanzanian secondary education.

Low academic achievement in science and mathematical disciplines is one of the indicators of the lack of mathematical and scientific teachers that educational officers and teachers have cited; few graduates in scientific and mathematics disciplines; and students joining other science and mathematics-related careers (Table 5). During the interview with the teachers, they reported that poor performance minimizes the number of students who join the high education levels as well as graduates in the sciences and mathematics disciplines at the degree level. It also affects the students joining the teaching careers. Moreover, the students tend to lack the confidence to study science and mathematics subjects as they believe that they might not successfully perform better in the end.

Table 5

Thematic Analysis: The Education Officers' and Teachers' Experience of the Scarcity of Science and Mathematics Teachers in Secondary Schools (53 Respondents were Involved).

Basic themes	**Organized Themes**	**Global Themes**
Syllabi are uncovered science and mathematics by the teachers Teachers have a high workload Ineffective science and mathematics instruction and studying methods Lack of confidence to study science and mathematics Low teachers' motivation in science and mathematics Limited experience in practicing science and mathematics Students consider science subjects hard to study Students drop out of sciences and mathematics	The sciences and mathematics syllabi are not fully covered Poor teaching methodology Students lose interest in studying scientific and mathematical fields Unmotivated science and mathematics teachers Reduction of the number of graduates in science and mathematics Low numbers of scientists in the country Students drop out of science and mathematics Students dislike science and mathematics as hard subjects to study	Poor performance in sciences and mathematical subjects Few graduates in science and mathematics teachers Students join other science and mathematics-related careers Poor performance in science and mathematics subjects

Students dislike science and mathematics subjects The decline in the number of scientists in the country Students opt to study social science subjects	Students lose interest in studying science and mathematics subjects Scarcity of teachers	Few graduates in science and mathematics subjects

The data from district education officers' and teachers' interviews were thematically analyzed, and the results showed that there are significantly fewer instructors of science and mathematics (92% of respondents agreed) than teachers of other disciplines (8% of respondents disagreed) (Figure 2). Almost similar results were obtained from the thematic analysis of data collected from students who were studying sciences and mathematics subjects. The analysis of the data collected from student respondents using the questionnaires revealed that the scarcity of teachers in sciences and mathematics subjects is higher (93% of respondents agreed) than in other subjects (7% of respondents disagreed) as shown in Figure 3. In responding to the questionnaires in some schools, the students revealed that there were not enough science and mathematics teachers while in others they said the school relies partly on part-time teachers and others were having part-time teachers only (Table 6). This shows that the secondary schools visited and studied lack a significant number of scientific and mathematical fields.

Figure 2

Teachers' Perception of the Scarcity of Teachers in Sciences and Mathematical Fields (53 Education Officers and Teachers' Respondents - Percentage Frequency)

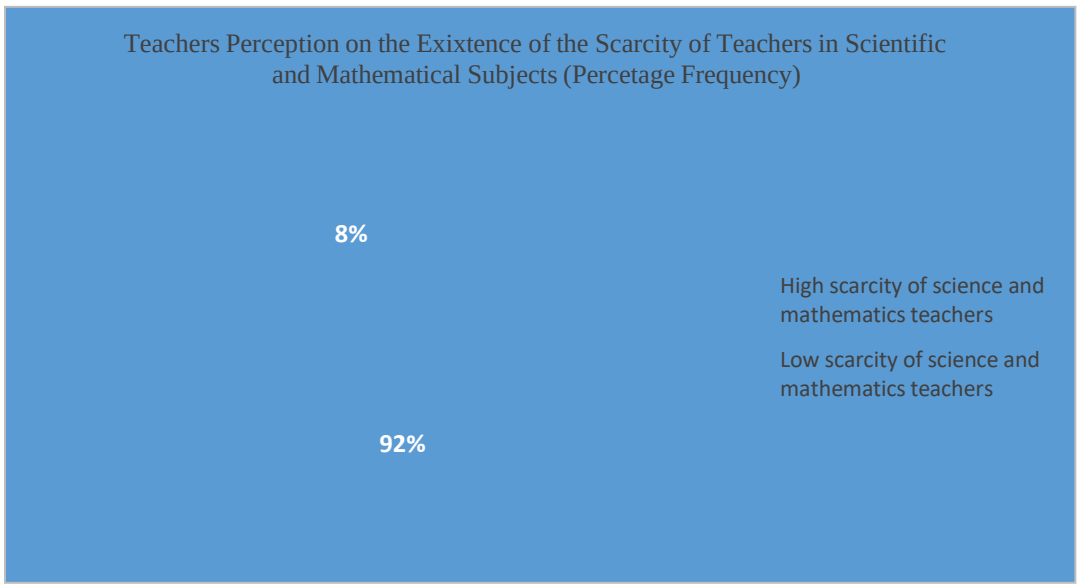


Table 6

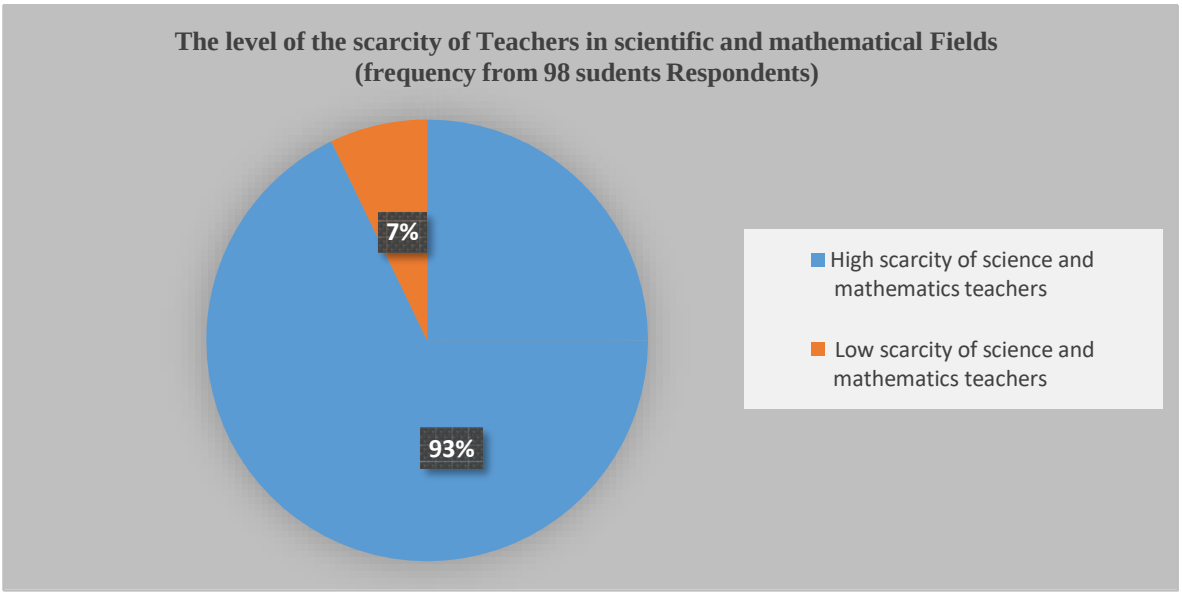
Thematic Analysis: The Students' Experience of the Scarcity of Teachers in Scientific and Mathematical Fields in Secondary Schools

Basic Themes	Organized Themes	Global Themes
No effective daily learning practice with few teachers Students missing lessons due to a lack of teachers The student worried about their achievement and future career Students poorly performed in their final examinations	Limited experience and practices Lack of student interest in studying sciences and mathematical subjects	Unsatisfactory results in the fields of science and mathematics Poor performance in mathematics and science subjects Students avoid science and mathematics subjects

Students are interested in other science careers and no teaching The low number of scientists in the country Dropout of students studying science and mathematics subjects Many students chose to study social science subjects The low number of scientific professionals maintained Students lack competence in science and mathematics lessons Students consider science and mathematics as hard subjects to study Students are deprived of the chance to study science and mathematics subjects Stress in science and mathematics subjects Inadequate science laboratory facilities Students seek assistance from outside the school Limited motivations and low salaries for teachers	Reduction of the number of science and mathematical graduate teachers Scarcity of science-related professionals Avoidance of students studying sciences and mathematical fields in schools The country lacks future scientists in the sectors that need them Limited experience and interest in sciences Unsatisfactory results in the fields of science and mathematics Low motivation among students in studying science and mathematics subjects Funding issues on extra classes outside of school Limited funding and budget availability	Few graduates in science and mathematics Poor performance in mathematics and sciences and subjects Students avoid studying sciences and mathematical fields Poor performance in sciences and mathematical subjects Lack of funding and budget for science laboratory facilities and salaries

Figure 3

The Level of the Scarcity of Teachers in Sciences and Mathematical Fields – (Percentage Frequency from 98 Students Respondents)



Reasons for Students' Choice of Scientific and Mathematical Disciplines in Secondary Education

Students still like studying science and math courses, even though there are not enough science and math teachers, as seen in Figures 2 and 3, which were reported by students as well as teachers. Subject combinations that the students were studying include Physics, Chemistry, and Mathematics (PCM), Physics, Chemistry and Biology (PCB), Chemistry, Biology, and Geography (CBG), Physics, Geography, and Mathematics (PGM), Economics, Geography, and Mathematics (EGM) and Chemistry, Biology and Agriculture (CBA). It should be noted that these subject combinations were taught in the visited schools.

The researcher investigated on what were the reasons for the students to choose to study science subjects and specifically the subject combinations. When the students were asked to explain what career, they would choose upon completion of their studies, their responses are shown in Figure 4. Most of the students responded that they choose science and mathematics subjects because they have a passion to become a doctor (29%), while others have a desire (just passion) to study science and mathematics (27%). Many of the students who were studying physics, biology, and mathematics preferred to become doctors and nurses. About 21% of the students who participated in the research wanted to become engineers while some students desired to become pilots (10%), others want to become economists (6%), a few of them want to become surveyors (4%) and very few of them want to become teachers (3%).

From the above research findings, it shows that the students were not interested in teaching careers but rather in other science-related or mathematics-related careers. If that is the case, why do we currently have some of them studying education in universities? Is it because it is the only opportunity they can find? Are they going to join a teaching career upon completion of their diplomas or degrees? Those are some questions that need answers but not in this particular research. From these results, it means if we want to minimize or resolve the issue of the scarcity of teachers in scientific and mathematics disciplines, we should start with the students who seem to dislike becoming teachers. The problem starts when the students shy away from joining teaching careers. If we want to address the issue of a lack of mathematical and science teachers within secondary schools, we must hire them every year because their numbers are periodically declining for a variety of reasons.

Figure 4

Reasons for Students' Choices of Sciences and Mathematical Subject Combinations (Percentage Frequency from 98 Student Respondents).

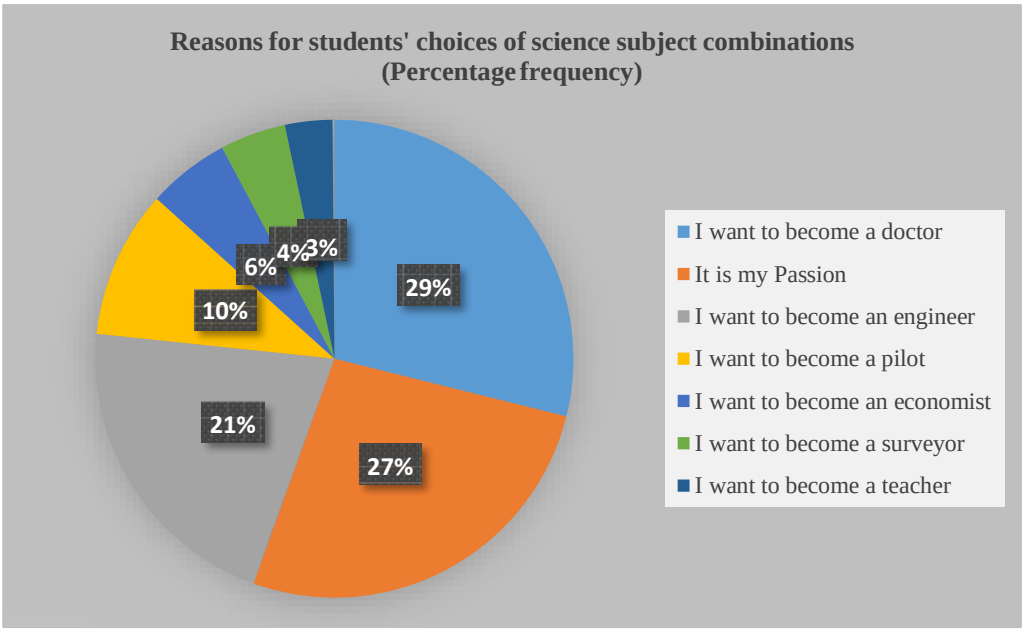


Figure 4 shows the reasons why students opt to pursue scientific and mathematical subjects regardless of the scarcity of teachers in these disciplines. The primary motivation given by students for deciding to major in studying mathematical and scientific subjects was to pursue employment in those fields, including becoming medical professionals, which happened to be the most frequently mentioned profession. The students who were studying Physics, Chemistry, and Biology (PCB) subject combination were mostly interested in becoming doctors and nurses. Some students mentioned passion or interest as the reason for them to choose a science and mathematics subject combination. They feel proud to be scientists. Many students choose to study science subjects so that in the future they become future engineers – some of them mentioned electrical and mechanical engineering, civil engineering, computer science engineering, gas, and petroleum

engineering, just to mention a few. These were the students who were studying Physics, Chemistry, and Mathematics (PCM) subjects.

Some of the students preferred to study science and mathematics subjects because they want to become pilots, so they were studying Physics, Geography, and Mathematics (PGM), while others were interested in becoming economists so they were studying (Economics, Geography, and Mathematics (EGM) and fewer want to work as surveyors. Teaching professions were the least frequently indicated among the students, which suggests that the shortage of qualified teachers in mathematics, as well as sciences, may soon become more difficult.

Causes of the Teacher Shortage in Mathematics and Science and its Impact on Secondary Education

The study examined the causes of the teacher shortage in science and mathematics as well as its effects on Tanzania's secondary schools. Research data were gathered through interviews with district education officers and the teachers who were teaching science and mathematics subjects and the questionnaires were given to students who were studying those subjects. The data were collected, compiled, and analyzed using the thematic data analysis method. The thematic analysis of collected data for the students was done separately from those obtained from the education officers and the teachers. The data obtained from the education officers and the teachers were analyzed together. Students as well as educators who were studying and teaching science and mathematics in high schools, respectively, served as the study's subjects. Using the thematic analysis, which is shown in Table 7, the study identified the variables contributing to the shortage of scientific and mathematics instructors through research interviews with education officers and teachers.

Data were collected from different education stakeholders to ensure that the current research study is valid. These stakeholders include the students who were studying science and mathematics subjects, the district education officers as well as teachers who were teaching science and mathematics subjects in secondary schools. Through these various data sources, the validity of the current research is attained. The use of multiple data source or triangulation of the data source brings about a wide range of information and help to test the validity of the research study. Also, the use of more than one data collection tool which is interviews and questionnaires with teachers and students respectively creates a more detailed picture of the research.

Moreover, questionnaires were given to students, and the data collected were coded and analyzed using assessing the frequencies of occurrence and presented in Table 8. The resulting frequencies from the tallied data from the student's responses are presented as frequency percentages in the pie chart (Figures 4 &5). Similar steps were followed to analyze the impacts of the scarcity of teachers in science as well as mathematics in Tanzania's secondary schools. The results are presented in Tables 8 & 9 as well as in Figures 6 &7.

District Officers and Teachers' Responses on the Causes of the Scarcity of Teachers in Science and Mathematics Disciplines

Teachers, education officers, and students, Tables 3 and 4 respectively demonstrate the causes of the shortage of science and mathematics teachers in secondary schools in Tanzania. During the interviews, when asked what factors contributed to the lack of science and math teachers, the teachers and district education officers mentioned low student achievement in science and math classes, a high teacher-to-student ratio, low pay for teachers, and/or salary increases for teachers. Moreover, few students who graduated in science and mathematics subjects join teaching careers

while most of the students avoid science and mathematics subjects as they consider them as hard subjects. Many of the students who were studying science and mathematics preferred to enter other science-related or mathematics-related careers (Table 7).

The findings here show that many science and mathematics students are not interested in teaching careers. One can ask, do the students who are graduating in teaching careers intentionally want to become teachers when they started the courses or it was just by chance, that they found themselves studying a teaching career? Did they study teaching because mathematics there was no other option? Did they join the education studies because of the loans from the Higher Learning Students Loan Board? Were they inspired by other teachers or parents to choose teaching careers? These questions cannot be answered at this juncture but need more investigation to get to know why the students dislike teaching careers.

Table 7

Thematic Analysis: Causes of the Scarcity of Teachers in Sciences and Mathematical Subjects in Secondary Schools – (Responses from the Interviews with 53 Teachers and District Education Officers)

Basic Themes	Organized Themes	Global Themes
Low salaries for teachers	Low salary	
The low motivation of science and mathematics teachers	Lack of motivation and promotion	Low salary and salary increment for teachers
Low or no salary increment	Low salary increment	
Lack of enough motivated science and mathematics teachers		Students avoid science and mathematics subjects as

Employment of part-time teachers in science and mathematics teachers	Few students studying science and mathematics with an education	they consider them hard subjects
Many students pass with low grades in the science and mathematics subjects	Students consider science and mathematics as hard subjects	
Students choose social science subjects	Students dislike science and mathematics subjects	Few graduates in sciences and mathematical students join teaching career
Poor support in studying sciences and mathematical subjects	Students lack interest in studying science and mathematics	Poor performance in science and mathematics subjects
Loose hope as studying becomes difficult		
Currently unemployment	Currently unemployment of enough new science and mathematics teachers	High teacher-student ratio
Few students joining sciences and mathematical subject combinations	Few sciences and mathematical graduates in the education sector	Students join other careers
Poor teaching facilities such as libraries and laboratories	Students deprived of their right to study thoroughly	Inadequate teaching and learning facilities
Fewer books and other facilities such as computers		

Teachers and district education officers who were interviewed in this research mentioned some of the factors that are causing the scarcity of scientific and mathematical teachers including poor performance in science and mathematics subjects by students, few graduates in science and mathematics in a teaching career, students study science and mathematics and joining other science and mathematics-related careers, currently unemployment situation in the country, currently no

salary increment/ low salaries for teachers, high science and mathematics teaching workload, inadequate teaching and learning facilities, and students choosing social science subject combinations Table 7.

In Table 7, which displays the thematic analysis of the data gathered, teachers and education officers expressed their perspectives on the lack of science and mathematics teachers. The research findings from the current study are these hypotheses, and they are thought to be the causes of the shortage of science and math instructors in secondary schools. The majority of educators and education stakeholders claimed that the lack of teachers in science and mathematics is due, among other things, to poor performance.

Considering there are fewer scientific and math students who can advance to the next level of study every time students perform poorly on their exams, there is a shortage of science and math teachers. The decline in the number of science and mathematics graduates causes scarcity. It is therefore revealed that when there is poor performance in those subjects, it means there is a decline in the number of science and mathematics graduates. One of the reasons why there are not enough scientific and math teachers in secondary schools is that there are not many graduates in those fields, according to the teachers. The few graduates in science and mathematics are then joined different careers while out of those few join teaching careers. The research findings enlightened that the students choose to join other science-related and mathematics-related careers. This is supported by the findings found when the students were responding to the question of why they decided to choose to study science and mathematics subjects in the preceding section.

The analysis of the data from teachers and the education officers interviewed revealed that there is a high teaching load among teachers in science and mathematics. This is evident that the number

of students is higher compared to the number of teachers teaching science and mathematics subjects. In one school, the students reported that they have one teacher who is teaching Chemistry I in both form five and form six classes. Bearing in mind that the subject has two parts, that is Chemistry I and II it shows that the subject content is already too much for the teacher. The workload goes high more when the teachers have to teach two different classes. The high teaching load affects the effectiveness of the teaching-learning process as well as the performance of the students.

Moreover, teachers revealed that there are inadequate teaching and learning facilities including computers, laboratory and their facilities, library, and books in secondary schools which is one of the challenges that affect the teaching-learning activities. The facilities' availability was varying from one school to another. Some schools were having facilities but they were not fully furnished with all the required items needed by the number of students in the school.

Since the teaching facilities are essentially affecting teachers and need for the teachers to be able to illustrate some activities during the teaching and learning process, teaching might be ineffective when the facilities are not enough and or are shared by many students. If the facilities are enough the teaching becomes effective and the learners enjoy lessons which in turn the performance becomes better. Facilities such as laboratories are needed by the students and the teachers to be able to conduct science experiments, so if it is available without enough facilities teaching-learning remains partial resulting in failures in the examinations.

Education officials and teachers stated that the lack of new teacher hiring in the nation since 2015 is what is causing the shortage of science and math instructors. There has been the only replacement of the retired teachers while the number of schools and the enrolment is increasing in

the country in the past few years ago. It is more than five years since the government stopped employing in its several sectors including education. This situation affected the teaching and learning of science and mathematics subjects in secondary schools as well. Moreover, the teachers revealed that there are no salary increments for some years as a result their salaries remain low. They consider this situation as a discouraging act and they felt demoralized. With this situation teaching the teaching process remains negatively impacted as well as the student's future careers and achievements.

Lastly, the teachers and education officers stated that students tend to change their minds especially when they join advanced secondary level. They drop science and mathematics subjects and study social sciences. The reasons might be that they feel they are not knowledgeable enough to pursue science and mathematics disciplines because in the lower classes, they did not learn effectively as a result of various reasons, maybe learning facilities, lack of scientific and mathematical teachers, or any other.

Students' Responses to the Causes of the Scarcity of Teachers in Science and Mathematics

Students were also involved in the current research to provide their views and ideas about the scarcity of teachers in science as well as mathematics in their secondary schools in Tanzania. Ninety-eight (98) students were involved, and they responded to the questionnaires regarding the causes of the scarcity of teachers in science and mathematics disciplines in their secondary schools in the study area. Teachers in a respective school assisted to distribute the questionnaires to students who were studying sciences and mathematics subjects in a selected secondary school in the study area. The information collected was coded using the thematic analysis method after a thorough reading of the responses from the students' questionnaires. The thematic analysis of the

students' questionnaires revealed that there were causes of the shortages of teachers in scientific and mathematical disciplines in secondary schools. The findings from the students' thematic analysis on causes of the lack of an adequate number of sciences as well as mathematics trainers in secondary schools from students' questionnaires are presented in Table 8.

Table 8

Thematic Analysis: Causes the Scarcity of Teachers in Sciences and Mathematical Subjects in Secondary Schools – (Responses from 98 Students)

Basic Themes	Organized Themes	Global Themes
Science subjects are considered difficult or hard to study by students	Students consider science and mathematics as hard and difficult to study	Poor performance in sciences and mathematical subjects
Few science and mathematics graduates in the education sector	Few choose to study, pass and graduate in those subjects	Students avoid science and mathematical subjects
Students opt for social science subjects		
Students who pass the subjects do join other careers rather than teaching	Low student's interest in studying sciences and mathematical subjects	Students avoid teaching careers
Many students dislike the teaching profession	Students who pass those subjects join other careers and do not choose to teach	Inadequate teaching and learning facilities
Lack of enough trained science and mathematics teachers		

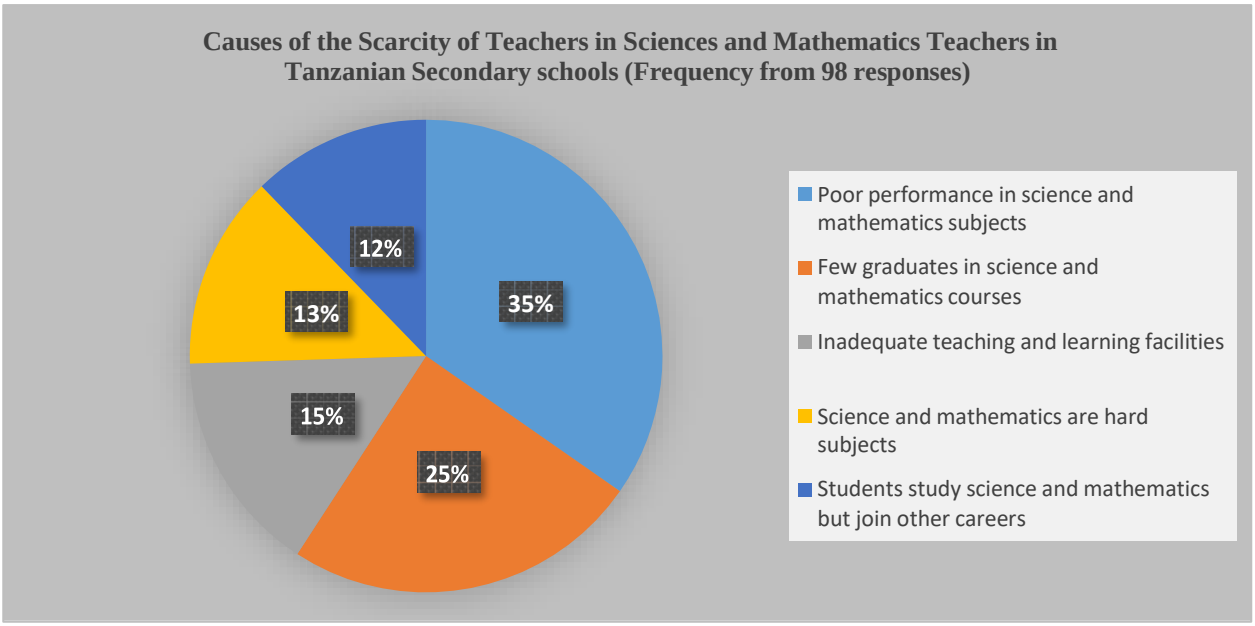
Few books, computers, and few laboratory facilities		
Lack of teaching facilities that discourage students to study science and mathematics – laboratories and library	Inadequate science teaching facilities do not favor students to study sciences	Poor performance in sciences and mathematical subjects
Lack of motivation for science and mathematics teachers Students avoid teaching careers	Teachers avoiding to pursue sciences and mathematical fields and opt for other careers	Few sciences and mathematics teachers in secondary schools

Thematic analysis results from the students' questionnaires were presented in Table 8 while the percentage frequency responses on the factors are presented in. The factors were tallied to come up with the frequency. The frequency percentages of the factors causing the scarcity of science and mathematics were calculated and presented on the pie chart (Figure 6) The summary factors causing the scarcity of science and mathematics teachers as revealed from students' questionnaires as indicated in Figure 6 include:

i. Poor performance and mathematics subjects (35%)
ii. Few student graduates in science and mathematics subjects join the teaching profession (25%)
iii. Inadequate teaching and learning facilities (15%)
iv. Students avoid science and mathematics subjects as they consider them hard subjects to study (13%)
v. And that students who study those subjects join other careers (12%).

Figure 5

The Causes of the Scarcity of Science and Mathematics in Secondary Schools – (Responses from 98 Students)



As for the teachers' findings, thematic analysis of students' questionnaires presented in Table 8 and Figure 6, discovered /portrayed the causes of the lack of enough teachers in science and mathematics trainers in secondary schools. Poor performance was mentioned the most by students as one of the causes of the scarcity of teachers in science as well as mathematics trainers in secondary schools. Other factors which were mentioned by the students, as well as teachers, include few graduates in science and mathematics courses and inadequate teaching and learning facilities. The students believed that adequate teaching and learning facilities like relevant books and a fully furnished laboratory could improve their practice in science subjects and raise interest in learning and eventually raise their performance. With practical skills, the student's performance

in science and mathematics could remain high. However, the students admitted that students were studying science and mathematics subjects but join other science-allied careers and not teaching careers.

Students' thematic data analysis disclosed that science and mathematics subjects are hard to study. This is one of the factors pointed out by students as the cause of the scarcity of science and mathematics teachers. This indicates that there is a science and mathematics phobia stereotype among the students in secondary schools and probably the community around them. If they consider science and mathematics as hard subjects the students tend to avoid studying them and as a result, few graduates are produced in the country. It was realized that students have a phobia of studying sciences and mathematical subjects to the next level, so they do not make practice since they think even if they practice, they can still fail the examinations.

The Differences in Responses of the Teachers and Students on the Causes of the Scarcity of Teachers in Scientific and Mathematics Disciplines

The thematic analysis presents in Tables 6 and 7 shows the responses of teachers and students on the factors causing the shortage of teachers in sciences as well as mathematics respectively. Both teachers and students provided some similar and dissimilar responses on the causes of the scarcity of scientific and mathematical teachers. These results are also presented in Figures 4 and 5 showing the frequency percentages of the responses of the teachers and students about the causes of the scarcity of scientific and mathematical teachers in schools visited respectively.

While certain criteria were the same for teachers and students, their reactions varied in some ways. Both studies found comparable factors contributing to the lack of scientific and math teachers, including low performance in those areas in secondary schools and a small number of students

who graduate with degrees in those fields; inadequate teaching and learning facilities; and students who study science and mathematics but join other science-related and mathematics-related careers. However, the teachers went far and revealed more factors causing the scarcity of science and mathematics teachers such as high science and mathematics teaching load; current unemployment situation in the country, and low salary or no salary increment for teachers (Tables 7 & 8, and Figures 5 & 6). The analyzed data finding gave a hint of the lack of motivation among the teachers teaching science and mathematics teachers alongside the lack of salary increment that results in low salaries for teachers.

On the other hand, the pupils indicated that math and science were challenging to study. This is one of the barriers that prevent many students from pursuing advanced secondary-level education in the sciences and mathematics. The teachers' and students' described causes appear to be the root of and maintain the dearth of science and math instructors in Tanzania's secondary schools.

The Impacts of the Scarcity of Scientific and Mathematical Teachers on Secondary Schools

Secondary educational institutions in Tanzania are impacted to some extent by the lack of qualified mathematical and scientific teachers. This study used questionnaire responses from secondary school learners in the Tanzanian districts of Kibaha and Bagamoyo to examine the impacts of the lack of mathematical and scientific teachers in secondary institutions. It also conducted interviews with teachers as well as district education officers. Thematic analysis was performed on data collected through interviews with district education officers and science and mathematics teachers to determine the impacts of the scarcity of teachers and the results are presented in Table 9. The ideas from the respondents are summarized as basic themes and further refined as organized themes which were later summarized as global themes are presented in Table 9. The global themes

are the main ideas of impacts of the causes of the scarcity of scientific as well as mathematical teachers in schools as perceived by both education officers and teachers.

Table 9 shows the thematic analysis findings from the interviews with the education officers and the teachers who were responding to the question on the impacts of the scarcity of scientific and mathematical teachers in secondary schools. Findings revealed that among the impacts of the scarcity of teachers in scientific and mathematical fields in secondary schools include low performance in sciences as well as mathematics disciplines; high science and mathematics teaching load; unfinished science and mathematics syllabi, high teacher-student ratio, and lastly low interest in studying science and mathematics subjects by students.

Some of these impacts look similar to the factors that were mentioned to cause the shortages of science and mathematical teachers in secondary schools. The results show that there is a cyclic relationship between the causes of the scarcity of teachers in science and mathematics and the impacts of the same as shown in Figure 9. For example, poor performance in scientific and mathematical subjects was mentioned as the major cause of the scarcity of teachers in science and mathematics fields as well as impacts for the same. This is a very interesting finding that indicates the continuation of this problem of the scarcity of teachers within secondary schools. The other mentioned impacts of the scarcity of science and mathematics teachers also contribute to poor performance. Another interesting aspect discovered in this research was that all of the impacts mentioned by the education officers and the teachers on the scarcity of science and mathematics are factors that intensify the poor performance of science and mathematics teachers (Figure 7).

Taking some examples of the findings, such as a high teacher-student ratio which is an impact that is caused by the scarcity of teachers in science and mathematics seems to result in deprived

performance in scientific and mathematical subjects. Moreover, high teaching loads among science and mathematics teachers may as well cause poor performance in those subjects. Similarly, the unfinished syllabi or poor syllabus coverage and low interest in studying science and mathematics subjects which were mentioned as the impacts that are caused by the scarcity of teachers, are as well cause poor performance in those subjects.

Table 9

Thematic Analysis: Impacts of Scarcity of Teachers in Sciences and Mathematical Fields in Tanzanian Secondary Schools: Responses from 53 Teachers and District Education Officers

Basic Themes	Organized Themes	Global Themes
High teachers' workload Inadequate syllabus coverage Hiring unqualified teachers Poor teaching methodology	Poor syllabus coverage Student examinations failure	Poor teaching methods due to high teacher workload
Low interest in studying science and mathematics among students High staff turnover especially in private secondary schools	Limited students' interest in science and mathematics subjects	Poor performance in science and mathematics subjects
Hiring part-time teachers Students lack enough support Teachers high turnover Students consider science and mathematics as hard subjects	High student-teacher ratio Less student attention Inadequate teaching and learning process	Students lack interest in studying science and mathematics subjects
Student failure in examinations Students drop out of science and mathematics subjects	Students drop out of science and mathematics subject combinations	Few graduates in science and mathematics

Students lose interest in science and mathematics		Poor performance in those subjects
Insufficient learning in science and mathematics	Student's lack of interest in studying sciences and mathematical subjects results in poor performance	Students avoid science and mathematics teaching careers resulting in more scarcity of science and mathematics teachers
Students lack academic support		
Less individual student attention	Poor performance in science and mathematics subjects	
Subject topics remain untaught		

Thematic analysis of the responses from the interviews with district officers and teachers was 53 respondents in total. The education officers' and teachers' interview responses were analyzed by the thematic analysis method in Table 9. During the interviews, the teachers mention the main impacts of the scarcity of teachers in secondary schools including:

1. Poor performance in scientific and mathematical classes - Teachers and education officials stated that the lack of qualified teachers in science and math in secondary schools has been responsible for the poor performances in science and math classes.

2. High teaching load in mathematical and scientific subjects - teachers and education providers responded saying the high teaching workload among teachers is a result of the shortage of science and math teachers in secondary education institutions.

3. Unfinished science and mathematics subjects' syllabi – the teachers and education officers responded that the unfinished science and mathematics subject syllabi are been caused by the lack of enough teachers in scientific and mathematical fields in secondary schools.

4. High teacher-to-student ratio - according to the teachers' and education officers' responses, the low number of qualified teachers in the scientific and mathematics field in secondary schools is to blame for the high teacher-to-student ratio in schools visited.

5. Low interest in studying science and mathematics subjects by students – the teachers and the education offices who responded to the question revealed that students' low interest in studying the subjects is one of the impacts of the scarcity of scientific and mathematical teachers in schools visited.

A total of 98 students who were taking science and math classes engaged in answering the questionnaires about the effects of the teacher shortage in those areas. As shown in Figure 6, which presents the responses to the students' questionnaire on the impacts that are prompted by the shortage of mathematical and scientific teachers in secondary schools, the impacts of the factors contributing to the shortage of mathematics and sciences educators in secondary educational institutions were subsequently added up to determine how frequently they appeared (frequency).

Poor performance in scientific and mathematics classes was found to be the main effect of the lack of mathematical and science teachers in secondary schools, according to a thematic analysis of student responses to the issue. The majority of students (51% of respondents) reported low performance in scientific and math classes as a result of the lack of enough science and math teachers, with students' avoidance of studying mathematics and scientific fields coming in second mentioned impact (20% of respondents). Additionally, the students indicated that the lack of adequate scientific and mathematical teachers is the cause of the poor interest among students in these disciplines (15%). Unfinished syllabuses (8% of the respondents) while learners seeking outside assistance (6% of the students' effects) were the least significant (Figure 6).

When the teachers are few in a school, they tend to have a high teaching load because all the subjects must be taught. As a result, the syllabus coverage might not be done within the school-allocated teaching duration. Based on this, many of the students were forced to look for alternative teachers who could help them, especially during the holidays. The students opt for assistance from outside their school to keep their performance high.

In contrast, Table 10 displays the students' opinions on the effects of the lack of scientific and math teachers in the study area's secondary schools. Ninety-eight (98) students who answered the surveys are represented in the responses. According to the findings of the thematic analysis, the primary effects of the variables contributing to the shortage of science and math instructors in secondary education include:

1. Poor performance in scientific and mathematical subjects is one of the effects of the lack of qualified mathematics and science educators in secondary educational institutions, as students and teachers both indicated.
2. According to students themselves, a particular outcome of the lack of qualified scientific as well as mathematics teachers is learners' avoidance of studying those fields in secondary schools.
3. Students opting to study social science subjects at the tertiary level is another impact of the scarcity of science and mathematics teachers in secondary schools as reported by the students during the data collection of the current research.
4. According to the students participating in the current research study, the stress in scientific and mathematics lessons is another effect brought on by the lack of qualified teachers in these fields.

5. Few graduates in science and mathematics subjects from teaching institutions that affect also the teaching career is another impact caused by the scarcity of science and mathematics teachers as reported by the student respondent in this research.

In line with the above results, the impacts of the scarcity of science and mathematics teachers seem to be more or less the same as the factors causing the scarcity of science and mathematics teachers in secondary schools. The level or rate of the impacts of the scarcity of science and mathematics teachers are indicated in Figures 1 & 2 where the education officers and teachers rate the high scarcity of science and mathematics teachers at 92% and students at 97% respectively.

Table 10

Thematic Analysis: Impacts of Scarcity of Teachers in Sciences and Mathematics in Tanzanian Secondary Schools - Responses from 98 Students' Questionnaire

Basic Themes	Organized Themes	Global Themes
High teacher turnover Students look for alternative teachers outside the school	Limited students' interest in science and mathematics	Poor performance in sciences and mathematical subjects
Infective teaching results in poor performance Student failure in examinations	Students dislike science and mathematical subjects Poor performance in sciences and mathematical subjects	Students avoid science and mathematical subjects
Low-performance Insufficient learning	Students dislike science and mathematical subjects	Poor performance in science and mathematical fields

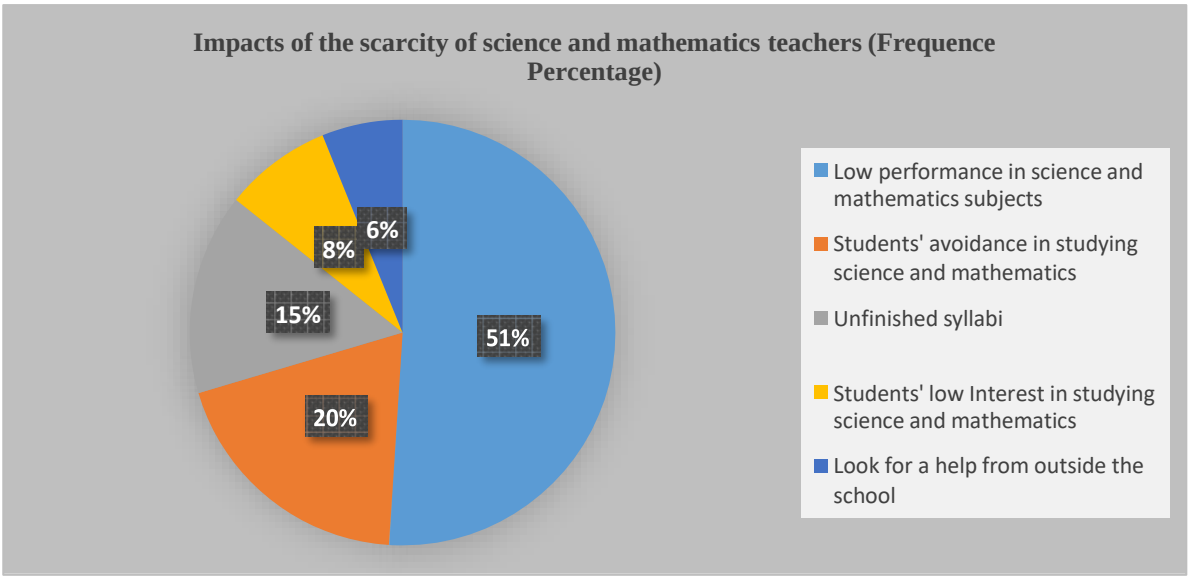
Students opt for studying social science subjects at the tertiary level Students drop out of science and mathematics subjects Students dislike teaching career	Students avoid studying sciences and mathematical subjects A low number of students studying sciences and mathematics subjects	Few students graduate in science and mathematics Few students join teaching career
Students opt to study social science subjects Sciences and mathematics are hard subjects to study	Stress in science and mathematics subjects	Low interest in studying science and mathematics subjects
Sciences and mathematics subjects are hard subjects to study Students dislike teaching career Poor performance	Low number of students studying science as well as education	Few graduates in science and mathematics teaching affect also the teaching career
Students' low interest in science Students missing lessons Insufficiencies learning Unfinished syllabus	Students dislike and are discouraged to study science and mathematics	Stress in sciences and mathematical fields Unfinished science and mathematics syllabi

From the student respondents' perspective, the thematic analysis revealed that there are some impacts caused by the scarcity of teachers in scientific and mathematical fields in secondary schools (Table 9). Impacts which were mentioned by students to be caused by the scarcity of science, as well as mathematics trainers include: poor performance of science and mathematics subjects; students avoiding science and mathematics; unfinished syllabus that cause low performance in sciences and mathematics fields; low interest to studying science and mathematics

that lead the students to opt for social science subjects even at the tertiary level; and students look for assistance from outside the school (Table 9).

Figure 6

The Impacts of the Scarcity of Teachers in Sciences and Mathematics in Tanzanian Secondary Schools (Responses from 98 Student Participants)



The Differences in Responses of the Teachers and Students on the Impacts of the Scarcity of Teachers in Scientific and Mathematical Disciplines

Teachers and students reported similar as well as dissimilar impacts of the scarcity of teachers in scientific and mathematics subjects in a secondary school of the study area. Impacts mentioned by both the teachers and students include low performance in science and mathematics subjects; unfinished syllabi; and students' low interest in studying science and mathematics subjects. However, different impacts were reported by the teachers only, including the teacher-student ratio and high science and mathematics teaching load. These are the factors that are related to the

teachers' work as employees. On the other hand, the students mentioned impacts that were also related to their everyday learning tasks such as the students avoiding studying science and mathematics subjects and they look for help from outside their school (Figure 6). The scarcity of science and mathematics has an impact on students' passion to study, whereby they tend to avoid science subjects and study other social sciences and business-related subjects. Moreover, students who like to study science and mathematics tend to look for alternative or substitute teachers outside the school. This is done during the school holidays and the substitute teachers need to be paid payment for the service offered. Therefore, the students believe that if the family cannot afford to pay for the extra classes outside that school then the students' performance is affected.

The Thematic Maps/ Networks

The researcher conducted interviews with the education officers and the teachers who were teaching in science and mathematics fields in secondary schools visited. The data collected on the causes of the scarcity of teachers in sciences and mathematical fields were compiled, summarized, and analyzed using the thematic analysis method (Tables 7 & 8). The step-by-step thematic analysis of the data from the interviews with education officers, teachers, and questionnaires from students on the factors causing the shortages of science as well as mathematics teachers are summarized in Figure 7 as thematic maps or also known as the thematic networks. The thematic maps show the interaction among the factors causing the of scarcity of scientific and mathematical teachers and the impacts on schools visited.

However, the research findings show that the factors that are causing the scarcity of teachers in scientific and mathematical fields were revealed by the teachers but not by the students and vice versa. For example, the teachers revealed that there was no salary increment and their salaries

remained low. The students did not talk about the teachers' salaries and the unemployment situation, at all. This means some of the responses were related to the activities performed by the participants. The main factors that are causing the scarcity of teachers in scientific as well as mathematics obtained from the data include a high teaching load for teachers due to few teachers and an unfinished syllabus. Other factors causing a shortage of teachers in scientific and mathematical fields include few teachers who graduate in fields of science as well as mathematics subjects, poor performance in scientific and mathematics subjects, students avoiding science and mathematics as they consider them hard subjects, high teach-student ratio, low salary, and or no salary increment for teachers, currently, there is unemployment situation in the country and students joining other science-related and mathematics-related careers (Figure 7).

Poor performance in science and mathematics affects both teachers and students. The students are most affected since they are directly affected by their performance. Thus, the situation tends to create a phobia of science and mathematics among students. As a result, the students avoid studying science and mathematics subjects as they consider that these subjects are hard to study. In doing so, many of them run away from studying such subjects and choose to study other subjects. Some of them study science and mathematics but in the long run, they look for other non-teaching careers. On the other hand, because of the scarcity of teachers in scientific and mathematical fields, there is a high teacher-student ratio. This factor affects mostly the teachers who also end up with a high teaching load. Both the high teacher-student ratio and the high teaching load have negative effects on the student's performance in scientific and mathematical subjects.

Figure 7

Thematic Map/Network Summarizing the Ideas of the Interview Respondents on the Causes of Scarcity of Teachers in Sciences and Mathematics in Tanzanian Secondary Schools

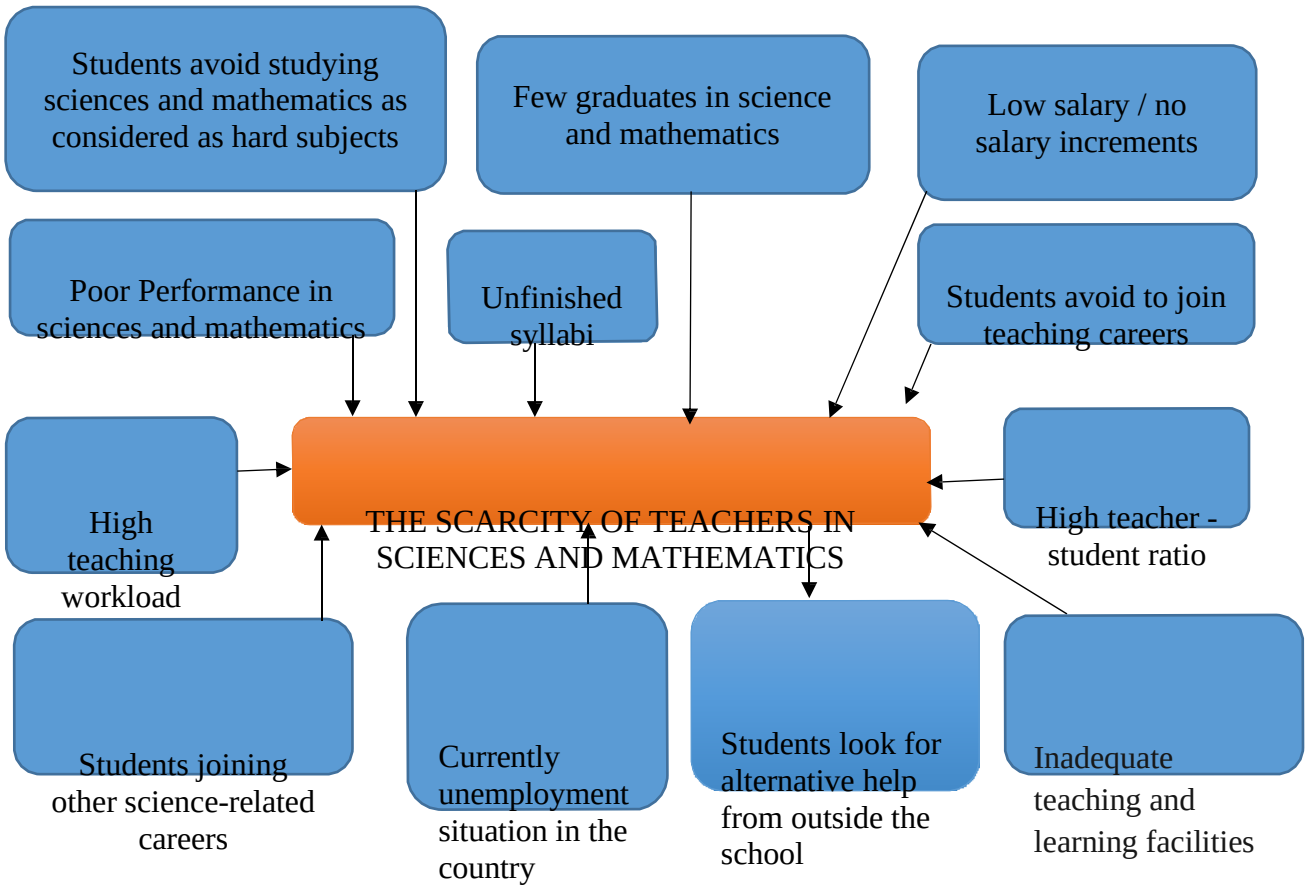
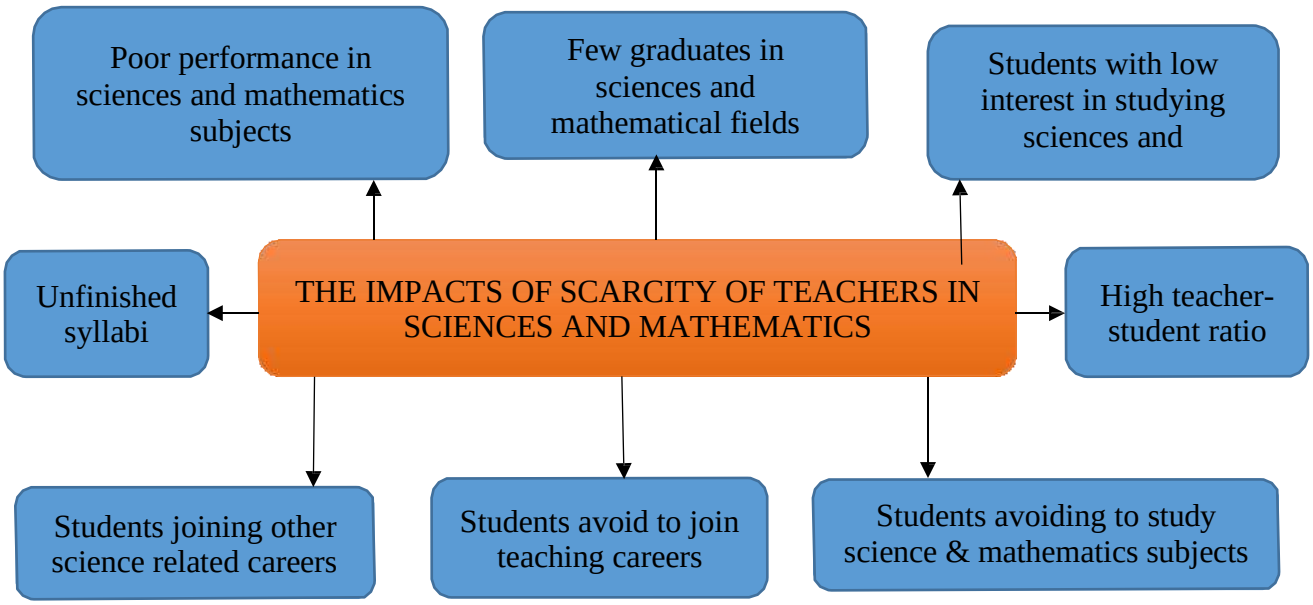


Figure 7 indicates the summary of the factors that are causing the scarcity of teachers in science and mathematical fields, mentioned by education officers, teachers, and the students in the study area. Some of these factors were mentioned by only education officers and teachers, and others were revealed by only the students. However, some were mentioned by all the participants who were involved in this research study. Figure 7 shows the summary of the causes of the scarcity of teachers in sciences as well as mathematics fields in secondary schools in Tanzania, while Figure 8 provides the impacts of the scarcity of the same.

Figure 8

Thematic Map/Network Summarizing the Ideas of the Interview Respondents on the Impacts of the Scarcity of Teachers in Sciences and Mathematics in Tanzanian Secondary Schools



The thematic analysis of the data collected in this research revealed that the scarcity of teachers in scientific as well as mathematics has some impact on Tanzanian secondary schools. The main impacts are summarized as a thematic map (Figure 8). These causes of the scarcity of teachers in scientific and mathematical fields appear to be interrelated in such a way that the causal factors are also impacts of the same in visited secondary schools in Kibaha and Bagamoyo districts. (Table 10).In responding to the question on what are the factors causing the scarcity of teachers in science and mathematics, the respondents provided some factors that were similar to the impacts when they were respondents answered the question on what are the impacts of the scarcity of mentioned teachers (Figure 7 and Figure 8). In summary, the factors that were revealed to cause the scarcity

of teachers in scientific and mathematics fields appeared to be the impacts of the same. This is summarized in Table 11 and Figure 9 in this chapter. The relationship between the factors causing the scarcity of teachers in sciences and mathematics classes and the impacts of the same on secondary schools forms a cyclic model as shown in Figure 9.

Figure 9 is a cyclic model obtained from the summary of the thematic maps/networks presented in Figure 7 shows the causes of the scarcity of scientific and mathematical teachers while Figure 8 shows the impacts of the same. The model presents the causes of the scarcity of teachers in scientific mathematical fields as inputs that created more factors (outputs) such as high teaching loads, unfinished syllabi, and high teacher-student ratio. Furthermore, the model shows the outcomes of the factors that represent the impacts. The outcomes look more or less similar to the inputs and thus creating a cyclic model. The cycle persists as it goes on and on as shown in Figure 9, where the model, in the end, produces a large impact on the education system, which is the scarcity of teachers in science as well as mathematics teachers. These impacts in turn cause more scarcity and the cycle goes on to create a cyclic relationship between them.

Table 11

Summary of the Causes of the Scarcity of Teachers in Sciences and Mathematics and the Impacts on Tanzanian Secondary Schools

Causes of the scarcity of teachers in sciences and mathematics fields in secondary schools	**Impacts of the scarcity of teachers on sciences and mathematics in secondary schools**
Poor Performance in sciences and mathematics subjects	Poor Performance in sciences and mathematics subjects
Few graduates in science and mathematics	Few graduates in science and mathematics
Students avoid studying science and mathematics as considered hard subjects	Students avoiding to study science and mathematics as they consider as hard subjects
High teacher-student ratio	High teacher-student ratio
Students avoid joining teaching careers	Students avoid joining teaching careers
Students joining other science-related careers	Students joining other science-related careers
Unfinished syllabus	Unfinished syllabus
Currently unemployment situation in the country	
Low salary / no salary increments	Students' low interest in studying science and mathematics
High teaching workload	
Students look for alternative help outside the school	

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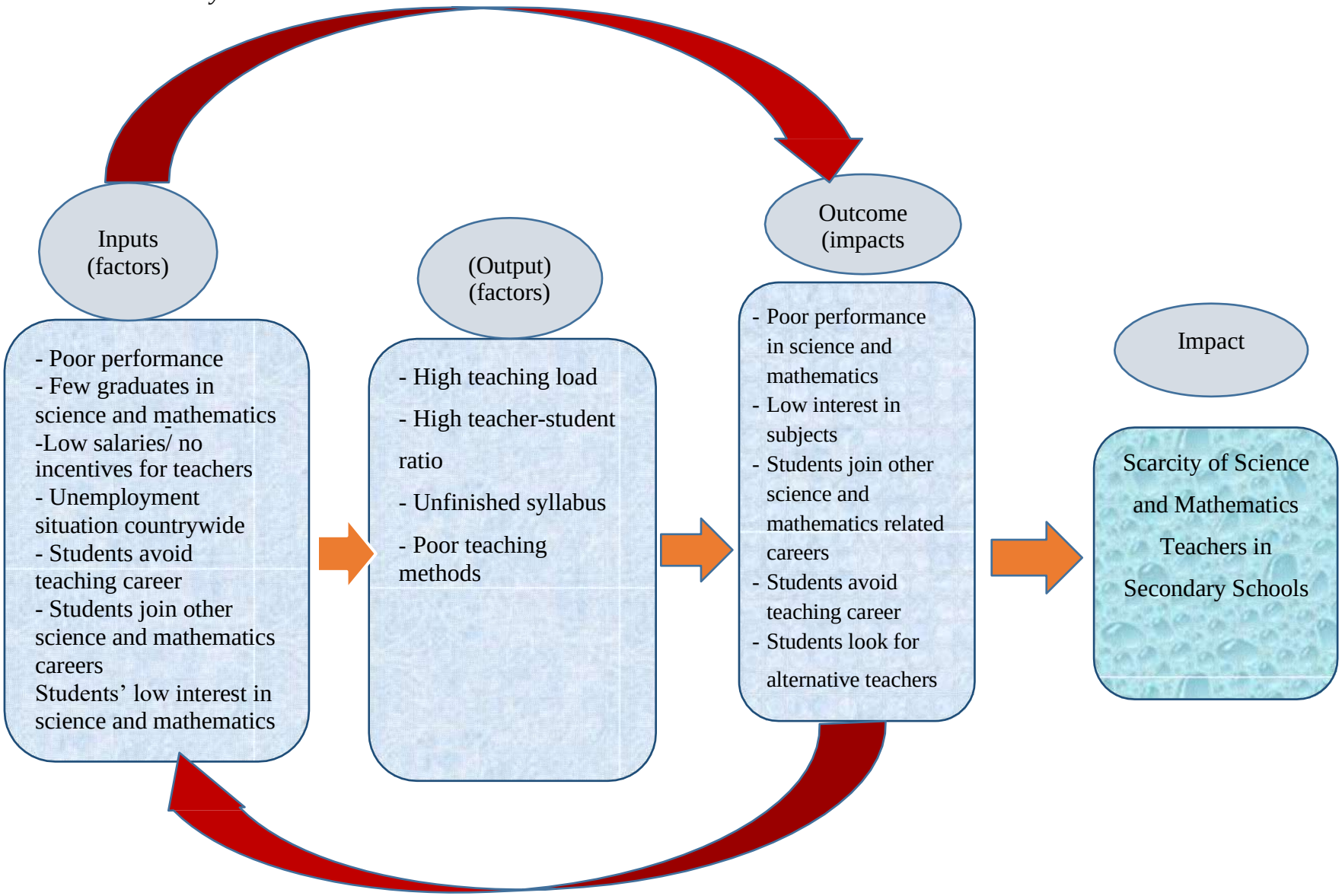
Figure 9

A Cyclic Model Summarizing the Ideas of the Respondents on the Scarcity of Teachers in Scientific and Mathematical Fields and Impacts on Tanzanian Secondary Schools



Strategies to Minimize the Scarcity of Teachers in Scientific and Mathematical Fields and the Impacts on Tanzanian Secondary Schools

The current research study investigated whether there are some efforts or strategies that were considered by the school management to ensure that teaching is been done properly regardless of the scarcity of teachers in sciences as well as mathematics classes. The study also investigated the impacts of the strategies used by the school management in mitigating the problem in their respective secondary schools. The collected and analyzed data provided findings that give light on what the school management undertook as strategies to minimize the scarcity of teachers in scientific and mathematical fields and the impacts. In this section, the research put together the main strategies and the opinions of the teachers and the district education officers. The findings of the strategies are presented in Table 12 and the opinions in Table 13.

School Management Strategies to Minimize the Scarcity of Scientific and Mathematical Teachers and Impacts in Tanzanian Secondary Schools

Moreover, interviews with the district education officers and teachers, it was revealed that science and mathematics teachers were scarce and this situation cause some impact on their secondary schools. Therefore, due to the existence of this problem, the school management, and the teachers were asked to explain what strategies they have taken to minimize the scarcity and the impacts of the scarcity of teachers in the sciences and mathematics fields in their schools. Their responses on strategies on how the schools manage to ensure that all science and mathematics subjects are taught regardless of the problem were summarized in Table 12. Some of the strategies provided by teachers who were at the school level had negative impacts on the secondary schools while others caused positive effects.

Table 12

School Management Strategies to Minimize the Causes of the Scarcity of Teachers in Sciences and Mathematics Tanzanian Secondary Schools

Basic Themes	Organized Themes	Global Themes
Employ part-time teachers in sciences and mathematics subjects	Employment of temporary teacher in sciences and mathematics subjects	Employment of temporary science and mathematics teachers
Employ teachers with science and mathematics certificates/ degrees who are not teachers	Employment of unqualified Science and mathematics teachers	Employment of unqualified teachers in sciences and mathematics
Motivate teachers of science and mathematics subjects Increase salaries for teachers in science and mathematics fields	Motivate by paying more to science and mathematics	Motivate science and mathematics by paying more and providing incentives
Employ volunteers who have science and mathematics skills	Employ skilled science and mathematics teachers	Inspire students to study science subjects and mathematics subjects
Use the available teachers effectively by conducting remedial classes and paying extra to teachers	Encourage students to join teaching career	
Encourage students to study science subjects by rewarding those who perform well Advise students to join a teaching career	Inspire, encourage, and advise students to study sciences and mathematical subjects	Encourage and inspire students to study sciences and mathematical subjects, and like to join a teaching career

Furthermore, with the education officers and the teachers, the researcher asked them to give their opinion or suggestions on how to continue teaching effectively apart from the shortages of teachers in science and mathematical interviews fields they were facing in their respective secondary schools. The respondents provided their opinions on what can be done at the school level and by the government in general. The study revealed that scientific and mathematical teachers are scarce in Tanzanian secondary schools. Moreover, some of the strategies have negative to the learners. The negative strategies mentioned by the teachers include:

i. Employing temporary science and mathematics teachers including part-time teachers and volunteers.

ii. ii. Employing unqualified science and mathematics teachers including some staff with a degree but did not study teaching (they lack teaching methodology).

The strategies such as employing unqualified and temporary teachers have negative impacts on students' studies including poor performance, students avoiding studying science and mathematics, students disliking the teaching profession, and students joining other science and mathematics-related careers (Tables 7 and 8). On the other hand, some strategies used by the school management caused positive impacts as they were motivating positively the students and teachers involved in learning and teaching scientific and mathematical fields. They suggested positive strategies including:

i. The efforts to encourage students to like studying science and mathematics subjects: the research finding revealed that students study science and mathematics because they consider that the subjects are hard to study. This perception limits most of them from liking to study these subjects in secondary schools, especially at high or advanced secondary school levels. In doing so, the result is that there are few

graduates in science and mathematics subjects. The research participants suggested that there is a need to encourage students to like studying scientific as well as mathematical subjects. Teachers, policy-makers, and parents have to come up with strategies to resolve the problem of the scarcity of teachers in the sciences and mathematics fields in Tanzanian secondary schools. The efforts to encourage the students should include sponsorships for those who perform well, trips or visits to some attractive places like national parks, historical sites, and other places where they can learn new things to improve their knowledge.

ii. The efforts to inspire students who are studying science and mathematics subjects to like teaching careers: the study revealed that the student does not like teaching careers. If this perception of disliking teaching careers then science and mathematics subjects will continue to suffer the teachers' scarcity. The current research respondents revealed that there is a need to inspire students who are studying science and mathematics subjects to like teaching careers. This can be done by their teachers, parents, school management, and the government.

iii. Several efforts have been done the government to encourage students to enter teaching careers including financial support through the High Education Students Loan Board (HESLB) in Tanzania. This board provides loans to all students who are studying scientific and mathematical subjects with education at the university level. However, it is not known if these students will enter teaching careers upon completion of their studies.

iv. Appreciate and motivate science and mathematics teachers through paying more and providing incentives: the study respondents suggested that teachers who are teaching

science and mathematics subjects should be appreciated and motivated for the work they have been doing. Motivation and appreciation can be done by raising their salaries each year to attract more of them into teaching careers. This must be taken seriously by the school management, other education stakeholders, and the government through ensuring that this motivation remains sustainable if we need to change in retaining teachers in science as well as mathematics in this teaching career.

v. Providing teachers in the sciences and mathematics brief motivations to advance their knowledge and proficiency in those fields: based on the investigation done in this research study, it was revealed that there were an inadequate number of qualified teachers in science and mathematics.

vi. To improve the situation the research study suggested that there is a need to resolve this problem in secondary schools. This can be done by providing short courses or in-service programs to existing underqualified teachers and even qualified teachers to provide them with knowledge and skills.

vii. Employ qualified teachers to raise the students' performance in scientific and mathematics subjects in secondary schools: the study revealed that in some schools there were unqualified teachers who were teaching science as well as mathematics classes. Participants suggested that both school management and the government should ensure that all the teachers who are teaching in secondary schools are qualified and that they are teaching the subjects of their specialization. In this way, the students and teachers would learn and teach more comfortably, and as a result, the student's performance could have raised.

The other issues contributing to the shortage of scientific and mathematical teachers could additionally be resolved if the issue with student performance in the mathematical and scientific disciplines could be resolved. Some of these factors when the issue of performance is addressed could have also been fixed. Thus, when the school management employs qualified teachers the students' performance could raise and increase the number of graduates in science and mathematics subjects. Also, the rise in students' performance could change the perception among students who consider that science and mathematics are hard subjects to study. Furthermore, high student performance could increase their interest in studying science and mathematics in secondary schools. Lastly, if the problem of performance would be resolved then the issue of students looking for assistance from outside the school would also be resolved.

Education Officers and the Teachers' Opinions on How to Minimize the Scarcity of Teachers in Scientific and Mathematical Teachers

The results of the study showed that in addition to the measures implemented by the administration of the school, the teachers also had some suggestions for reducing or resolving the shortage of science and math teachers in secondary schools. The viewpoints of instructors offer their firsthand knowledge of the issue of the lack of science and math teachers and how it affects secondary schools, even though they may not have had a platform to do so. During the interviews with the teachers and education officers, they voiced their thoughts on how to reduce or completely eradicate the issue of the shortage of scientific and mathematics instructors and its effects on Tanzania's secondary schools. The thoughts that were expressed may influence certain educational authorities to take action to improve teaching and learning and lessen Tanzania's shortage of science and math instructors. Table 13 presents an analysis and summary of these teachers' perspectives.

Table 13

Opinions on How to Minimize the Scarcity of Teachers in Sciences and Mathematics in Tanzanian Secondary Schools

Basic Themes	Organized Themes	Global Themes
Encourage students to like studying science and mathematics subjects Encourage more students to like science and mathematics through rewards for them	Improve interest for students to like studying sciences and mathematical subjects	The secondary school management must recognize and enhance the teachers' and students' interest in, and self-practices in sciences and mathematics subjects.
Support science and mathematics teachers' short courses Inspire students to like and join the teaching profession through support in studying	Encourage students and teachers to practice independently in the sciences and mathematics	
Promote, and provide incentives as well as motivate science and mathematics teachers	School management appreciates science and mathematics teachers	Provide incentives and motivate science and mathematics teachers
Provide priority in employing science and mathematics teachers Increase the pay for both science and mathematics teachers.	Motivated both teachers and students in teaching as well as learning sciences and mathematics subjects	Encourage secondary-level students and teachers who are studying and teaching mathematical and scientific subjects.
Employ qualified science and mathematics teachers Employ more teachers in sciences and mathematics	Improved teaching and learning of science and mathematics subjects in secondary schools by	Employ more qualified teachers, provide facilities, and emphasize online classes for sciences and

Avoid employing unqualified teachers Offering and promoting online courses for teachers in science and mathematics subjects	providing facilities and qualified human resources	mathematical subjects in secondary schools
Provision of short courses in science and mathematics skills Encourage teachers in sciences and mathematics to inspire students to like those subjects	Science as well as mathematics teachers to improv their knowledge and skills Motivate science and mathematics teachers	Increased knowledgeable and skilled number of teachers in sciences and mathematics in secondary schools through short courses (INSET)

Teachers and education officials revealed that to reduce and eliminate the shortage of mathematical and science teachers at the secondary schools level, the school administration must recognize and enhance the interest as well as self-practices of mathematics and sciences teachers as well as students in secondary educational institutions; the school administration must offer incentives for both science and mathematics teachers along with students for any outstanding work performed; and the leadership team of the secondary school must improve the quality of the scientific and mathematical subjects teachers in secondary educational institutions.

By the views shown in Table 13 above, the researcher noted a few viewpoints or recommendations made by the participants to lessen the lack of scientific and math instructors' effects on Tanzania's secondary schools. Most of the suggestions were the responsibilities of the school management and others were the responsibility of the Government of the Republic of Tanzania. The noted main suggestions or opinions from the respondents in line with those summarized in Table 13 were as follows:

i. The school management should employ many or enough science and mathematics teachers to simplify the issue of dealing with students individually and get enough time to understand their challenges and solve them. This could in turn raise the students' performance in sciences and mathematical fields.

ii. The school management in collaboration with other education authorities and the government has to find out permanent solutions like recruiting more science and mathematics teachers, employing qualified science teachers, motivating science and mathematics teachers by providing incentives, and motivation, and considering salary increments to encourage students to enroll in those subjects. At this juncture, to motivate students to enroll in and study scientific and mathematical courses in secondary schools as well as at the university level, there must be good performance in these areas.

iii. The school management should select and employ teachers who graduated and pass very well in sciences and mathematical subjects. School management teams must avoid employing unqualified and temporary or part-time science and mathematics teachers.

iv. The school management has to ensure that the schools conduct remedial classes with the weak students so that they can improve their science and mathematics subjects performance. This might be a positive strategy for the problem but to make it sustainable, the school management must motivate the teachers involved in conducting the remedial classes in schools.

v. The government of the Republic of Tanzania should ensure that science and mathematics teachers are well-trained, motivated, and retained in their careers by providing them with short courses. The in-service programs should be encouraged

especially with the science and mathematics teachers as through those programs they can improve their knowledge and skills in teaching. Moreover, the teacher training colleges should be equipped with facilities and human resources to ensure that the teachers are well-trained to meet the market demand.

vi. The government of the Republic of Tanzania should encourage more students to study scientific and mathematical subjects by allowing them to study with reduced fees in teacher's colleges and universities as well as increasing the salaries for science and mathematics teachers at all levels of education in Tanzania.

vii. The government of the Republic of Tanzania should encourage and support online teaching and learning programs for sciences and mathematical fields in secondary schools. It could be done by providing and improving teaching amenities such as libraries, laboratories, computers, the Internet, and other necessary facilities. The advantage of doing online teaching and learning is that it can be done all the time even during the time of a pandemic like a Coronavirus pandemic that can affect teaching and learning in a normal way. With online courses, the process of teaching and learning will not be interrupted by such pandemic disasters.

Evaluation of Findings

Introduction

This section of Chapter 4 presents the evaluation of the findings, which have been discovered through the thematic analysis of the data collected through interviews with education officers, teachers who were teaching science and mathematics subjects, as well as the questionnaires distributed to students who were studying science and mathematics subjects in secondary schools in Kibaha and Bagamoyo districts in Tanzania. In this section, the researcher explains what the findings obtained in the previous section mean. The section sub-titles were arranged based on the research questions and the objective of this research study.

The main sub-titles in this section cover the following topics: the experience among educational officers, teachers, and students regarding the lack of science and mathematics courses in secondary schools; the reasons why students choose to study these subjects; the causes of the lack of qualified scientific as well as mathematical teachers in secondary educational institutions; the effects of the lack of teachers in sciences and mathematical instructors on secondary schools; and educational institutions officers' and teachers' responses on these issues.

Additionally, the research study section assesses the effects of the shortage of mathematical and scientific teachers, the variations in responses from teachers and students to the factors contributing to the shortage of science and mathematics teachers, and the impacts of the shortage on secondary schools. There are also parts on thematic maps and networks, school leadership strategies to reduce the shortage of science and math teachers and its effects on secondary schools, the strategies to reduce the shortage of science and math teachers and its effects on secondary

schools, and the opinions of educators on how to reduce the shortage of science and math teachers in secondary educational institutions.

Level of the Scarcity of Teachers in Scientific and Mathematics Fields in Secondary Schools

This subsection summarizes the level of the shortages of teachers in the sciences and mathematics fields as perceived by the education officers and the teachers. It is also highlighting and discusses the level of scarcity of science and mathematics from students' perspectives. In general, these education stakeholders (education officers, teachers, and students) revealed that there is a high scarcity of teachers in sciences and mathematical fields in secondary schools and this scarcity has impacts on those schools and particularly the students. Detailed information on the findings is given in the proceeding sections. The findings obtained here are supported by the scholarly works of other researchers including Projest, (2013); Ndalichako & Komba, (2014); Magano, (2014); King'aru, (2014); Michael, (2015); Ngema, (2016); Kamagi, (2017) and Lyimo, Too, & Kipng'etich, (2017); and The Citizen, (2019) who also reported the existence of the scarcity of science and mathematics in Tanzania. These scholarly works also found that science, as well as mathematics teachers, are scarce in secondary education in Tanzania.

The findings support the research by Garcia & Weiss (2019), which found that teacher shortage is a real, serious issue that is getting worse than we had anticipated. According to Garcia & Weiss (2019), there is a teacher shortage that affects teachers, pupils, and the public education system as a whole. Lack of qualified teachers endangers students' ability to learn, staff instability lowers teachers' effectiveness, and frequent teacher turnover consumes money that may be used more wisely elsewhere. Due to the teacher shortages, it is more challenging to build a solid reputation along with professional teaching, therefore prolonging the problem. Furthermore, the fact that the

shortfall is divided so unevenly across pupils from various socioeconomic backgrounds puts the United State educational system's mission of delivering a good education to all children in jeopardy (Garcia & Weiss, 2019).

Teachers' Perspective on the Level of Scarcity of Teachers in Scientific and Mathematics Fields

The researcher set out to learn more about how few science and math instructors there are in secondary schools by interviewing teachers and education officers. The lack of science and math teachers has intensified and now poses a serious threat to the educational system. In Tanzania, there has long been concern about the lack of scientific and math instructors. Through several changes and policies, the government has attempted to lessen the issue (Osaki, 2007; Komba & Ndalichako, 2014). Despite these reforms and initiatives, the issue appears to be getting worse every year. The results of the current study suggested several reasons that contribute to Tanzania's secondary schools' lack of science and math teachers.

The study looked into the degree of teacher shortage in secondary schools to ascertain the shortage of science and math teachers. When asked to rate how scarce teachers of science and mathematics are in their experience, 96% of education officers and teachers came to the consensus that there is a severe shortage of both. Only 4% of the participants disagreed, admitting that the shortage of science and math teachers is not severe.

According to the current study's findings from education officials and teachers revealed that few graduates are interested in teaching professions. The majority of graduates who studied science and mathematics prefer to work in other fields that also involve these topics. Secondary schools have been negatively impacted by the lack of math and science teachers, which has also resulted

in subpar or bad performance in those disciplines. According to the most recent data, there are fewer graduate teachers created and the majority of them choose to pursue other scientific-related occupations, whereas the need for science and math instructors grows as student enrollments rise. Poor performance in those disciplines is primarily to blame for the issue of a lack of science and math teachers. Ingersoll and Perda (2009) provided similar findings that their shortage of teachers and explain further that an increase in the scarcity of science and mathematics teachers is partly caused by several teachers' retirement time, and also few are replaced.

In this particular research, it was revealed from the interviews with teachers that the teacher's experience with the scarcity of scientific as well as mathematics is caused by the perception that students regard sciences and mathematical fields as hard to study. Several researchers reported similar findings that the problem of shortage/lack of science teachers is a common answer to the question of performance in examinations (King'aru, 2013; Kihwele, 2014; Saga, 2014; Kapur, 2014). The current research study discovered that many students lose interest and dislike science and mathematics subjects and opt to study social science subjects, while others who decide to continue to end up with poor performances. This scenario intensifies the shortage of scientific and mathematical teachers and the impacts on secondary schools. Serious actions are required to improve schools' number of teachers, teaching and learning facilities, and motivate students to study science subjects. According to Michael (2015), there were common factors that are repeatedly spoken to cause poor performance including the deficit of science teachers, inadequately furnished science laboratories, learning and teaching tools, and low interest in studying science and mathematics by the students.

Student's Perspective on the Level of Scarcity of Scientific and Mathematical Teachers

The research investigated the students' perspective on the levels of the scarcity of teachers in the sciences and mathematics fields in secondary schools. Analysis of data collected from students through questionnaires was analyzed using the thematic analysis method. The research findings revealed that students' experience with the scarcity of teachers in science and mathematical courses did not differ much from the teachers' perspective. Most of the students (98% of respondents) agreed that teachers in sciences and mathematics are scarce in secondary schools. The students admitted that they have experienced poor performance in those subjects, missing lessons in science and mathematics due to scarcity of teachers, and students losing interest in studying science and mathematics subjects. Some of the students have decided to avoid science and mathematics lessons, while others were seeking assistance from outside the school. The experience of the students on the scarcity of teachers in sciences and mathematics leads the students to have limited passion and low interest in studying science and mathematics subjects which later causes poor performance among learners in those subjects. The problem has caused few students to graduate in science.

Ingersoll & Perda (2009), and Kihwele (2014) in their studies, reported similar findings where fewer students were studying sciences and there was poor performance in the examinations which was caused by the shortage of teachers. The findings in this research revealed that the students were facing difficulty in learning science and mathematics due to inadequate science laboratory facilities which were caused by the lack of funding. Similar findings were reported in the study by Projest, (2013). The issues of funding were mentioned by the students when they were looking for assistance from outside the school. They said that when teachers are scarce, thus they opt to seek

help from other teachers outside the school and they have to pay for the services. Those who were unable to pay for the service remained unattended.

The students were studying outside the school, especially during the school vacation. However, the research is daunting about the quality of the teachers who were teaching the students outside the school. the issue of the outside the school teachers' qualifications and skills is questionable and needs to be investigated. Moreover, the education authority has a role to take the lead to stop the activity if it is found to be detrimental to the student's education.

Reasons for Students' Choice of Sciences and Mathematics Subject Combination

The study investigated the reasons why students study science and mathematics in secondary schools. The research findings revealed that students have different intentions when they choose to study science and mathematics subjects. Most of them were interested in science and mathematics-related careers like becoming doctors, engineers, economists, pilots, nurses, and others were studying just for passion (feels proud to be scientists) but not to become teachers. The thematic analysis of the students' data showed that very few students who were studying science and mathematics would like to join teaching careers while most of them were interested in becoming doctors and engineers. The students preferred to work as civil engineers, gas and petroleum engineers, electrical engineers, mechanical engineers, and computer science engineers.

The findings obtained from the students and the teacher's experience with the scarcity of teachers in the sciences and mathematics fields indicate that many of the students were not interested in becoming teachers. This indicates that if action is not taken to address the shortage of teachers in mathematics and scientific fields, the issue will worsen annually and become a significant educational burden for secondary schools. The findings show that this problem of the scarcity of

teachers in science, as well as mathematics, is perpetuated. Therefore, immediate intervention is necessary and more efforts are required to ensure that science and mathematics subjects are effectively been teaching in secondary schools. The teachers should be motivated to inspire the students to like teaching careers as one way of raising the number of teachers in sciences and mathematics in secondary schools.

Evaluating Causes and the Impacts of the Scarcity of Teachers in Sciences and Mathematical Fields in Secondary Schools

The evaluation of findings in this section is divided into two parts where the first part evaluates the responses from education officers, and teachers on the factors causing the scarcity of teachers in science and mathematics courses and the second part evaluates the students' responses on the same issue. The impacts of a teacher shortage in mathematics and science disciplines on secondary education are further addressed in this section. The education system runs smoothly if all essential requirements are met. These requirements include teaching and learning infrastructure, experienced educators, and an environment that is conducive to teaching and learning.

Resources for teaching and learning, such as adequate instructional supplies and equipment, cleaning equipment, rational student-to-teacher ratios, laboratories, library, appropriate support staff, employee retention, and the type of classroom instruction. Limited resources and a high number of students in a classroom demoralize the teachers during the instructional process and cause poor performance in the respective subjects being taught.

Evaluation of Teachers' Responses on the Causes of Scarcity of Teachers in Sciences and Mathematics Fields

Data were collected using the mixed research method tools which were interviews and questionnaires and analyzed using the thematic analysis method and percentages respectively. The thematic analysis of the interview scripts from education officers and the teachers on responses discovered the factors causing the scarcity of teachers in science and mathematics courses in secondary schools. Thematic analysis of data from the education officers, and science and mathematics teachers revealed that some factors that were causing the scarcity of teachers include: poor performance in science and mathematics subjects; few graduates in sciences and mathematics subjects; students studying science and mathematics but joining other careers; high teaching workload; inadequate teaching and learning facilities; current unemployment situation in the country; no salary increment as well as low salary for teachers; and students choose social science subject combinations.

Current Unemployment Situation in the Country

The current research revealed that there is an unemployment situation in Tanzania in recent years. The replacement has been done only to replace the retired staff, the ones who died, and those who dropped their teaching jobs. The current unemployment situation in the country was mentioned by most of the teachers as the factor that was causing the scarcity of teachers in sciences and mathematics in secondary schools. This was revealed during the thematic analysis of the teacher's and education officers' responses to the interview sessions conducted. Since 2015 there was no new staff employed but rather there is the replacement of the ones who have retired or died. Other researchers have reported that there is no employment but there is the replacement of the teachers

who leave the profession for some reasons such as retirement, pursuing other jobs, and other personal reasons (Kapur, 2014). Furthermore, the number of teachers is maintained or declined while the number of students increases each year.

Moreover, in recent years, the government enacted a policy in 2014 that allowed free education from pre-primary to lower secondary schools (United Nations Children Fund [UNICEF], 2016). With this policy, the number of students in secondary schools increased while the number of teachers either decreased or remained constant. Bearing this in mind one can conclude that teachers are scarce especially in science and mathematics when the teacher-student ratio is taken into consideration. The current research suggests that to achieve education goals, - the management must employ well-trained, skilled, and qualified teachers. These teachers must be supplied with all necessary teaching and learning resources so that they can teach effectively and improve students' performance.

If there is an increase of students at each level but the number of teachers remains the same, the available teachers will be overloaded and the process of teaching and learning will become inefficient. In line with this, students are the ones who suffer the consequences. Their performance could remain poor if the situation will not be rectified. Therefore, the school management and the government need to work together to resolve the problem of unemployment in secondary schools.

Poor Performance in the Subjects of Science and Mathematics

From the conceptual framework and the literature review, it was indicated that almost universally, it is widely assumed that many countries are experiencing a teacher shortage, particularly in mathematics and science, owing to a lack of new teacher recruitment. It is also widely believed that a scarcity of mathematics and science teachers is a significant cause of poor academic

achievement, which affects the economy and even national security. The results reveal this research shows that school staffing issues are prevalent; that is, many schools are having difficulty filling entire classrooms with eligible individual science and mathematics teachers.

The thematic analysis of the data collected from the education officers and the teachers in the current research shows that teachers of science and mathematics are scarce in secondary schools. One of the causes of the lack of science and math teachers in secondary schools has been identified as students' poor performance in these areas. In many nations around the world, poor performance in science and math classes has been a problem (Ngema, 2016). According to Ngema (2016), this challenge will continue unless the cause is unveiled and solved. Poor performance challenge is one of the causes of the scarcity of teachers in the science and mathematics fields. The current research findings showed that many other factors contribute to poor performance including high teacher workload that leads to poor teaching methods as well as a high teacher-student ratio.

Also, the availability of teaching facilities contributes to students' performance. Students believed that if everything is provided to them in the schools including well-furnished libraries with textbooks, well-equipped laboratories, and computers their performance could improve. Where there are inadequate facilities such as a library with textbooks, a computer laboratory with computers, and laboratory facilities, teaching and learning face a challenge. The teachers who teach science and mathematics end up struggling to deliver the subject matter effectively and as a result, it affected the students' performance.

Depending on how many students are in the class, the teacher and students' interactions will vary. Thus, the teacher-student ratio affects students' performance. If this ratio is high, then the students' performance might be affected negatively and become poor, and vice versa. Moreover, with a high

teacher-student ratio it becomes difficult for the teachers to attend to the individual students (Ngema, 2016). Also, the high teacher-student ratio affects negatively the teaching method in the classroom. All of these contribute to students' low performance in secondary school science and mathematics classes.

The reasons why there are not enough science and math courses offered in secondary schools were discovered through a thematic analysis of the questionnaire responses from the students. The main findings from the students' questionnaires on the causes of the scarcity of teachers in science and mathematics among other factors, low performance contributed to a large extent. Poor performance causes a decrease in the number of science and mathematics graduates. If most of these graduates join other science and mathematics careers, then very few are expected to become teachers.

The main common reasons that contribute to poor performance in science and mathematics include poor teaching methodology in those subjects as well as a negative attitude towards science subjects among students. Moreover, the lack of teaching and learning facilities such as computers, equipped laboratories, and well-furnished libraries with textbooks contributed to poor performance. Like in the teachers' responses, there were high responses of students who said that poor performance is the main factor that causes the scarcity of teachers in science and mathematics in Tanzanian secondary schools. King'aru (2014), in a related study, reported similar factors that contributed to poor performance in science subjects. According to UNICEF (2018), the quality of Tanzania's education is lower than the neighboring countries and 21% of the teachers have insufficient knowledge to teach their subjects. Therefore, with the already existing scarcity of adequately trained teachers especially in science and mathematics, the extra enrolment will decrease the level of teaching and learning quality (UNICEF, 2018).

Few Graduates in Scientific and Mathematics Disciplines

Another problem that has been identified as contributing to the dearth of science and mathematics instructors in secondary schools is the insufficient number of graduates in these fields. The research findings obtained in the thematic analysis of the interviews with education officers and teachers revealed that there were few graduates in science and mathematics subjects. However, many of these graduates were not joining the teaching career. The research findings show that many students were not interested in teaching but rather have a passion for other science and mathematics-related careers. Such other science and mathematics careers include doctors, nursing, pilot, and engineers just to mention a few. During the interviews with the teachers, it was noted that because of the few graduates in science and mathematics and the fact that many of them join other careers with very few joining the teaching profession, then the scarcity of teachers in science and mathematics continues to persist in Tanzanian secondary schools in Tanzania.

The research findings from the students' questionnaires as obtained from thematic analysis also revealed that there were few graduates in science and mathematics teachers. Most of the students believed that science and mathematics are hard subjects to study and pass. They explained that due to the nature of these subjects, they need more practical and more time with their teachers. If the teachers are scarce, then their performance is affected. Due to this situation, some of the students tend to shy away from studying these subjects and in the end, very few students graduate in science and mathematics courses.

The students believed that even those few graduates in science and mathematics do join other related careers and not teach. Moreover, it was realized in this study that most of the students show no interest in a teaching career. This explains why secondary schools need science and math

instructors. To save the future of mathematics and science courses in secondary schools, this research study contends that action should be taken. Students should be inspired to like and join the teaching career. This can be possible if the improved salary and increment for teachers are worked on.

On the other hand, when the students were asked why they choose to study science and mathematics, their responses were to join other science and mathematics-related careers. Very few of them showed the intention of joining a teaching career. This suggests that if there is no intervention, the shortage of science and math teachers will last for a very long time and will only become worse as more students enroll in secondary education. The increase in the number of students in secondary schools is caused by the Education for All movement as well as the introduction of the free education policy in Tanzania.

Students Studying Science and Mathematics but Join Other Careers

The current research study revealed that students do study science and mathematics but they join other careers is one of the factors that are causing the scarcity of teachers in science as well as mathematics subjects. Thematic analysis of the interview data from the education officers and the teachers who were teaching sciences as well as mathematics fields in schools visited exposed that the students prefer studying science and mathematics to work in other science and mathematics-related professions. This is a challenge in the education system. If many students are not interested in a teaching career, then one might want to know about those who are currently studying for their diplomas and degrees in science with education, are they interested in teaching? Did they intentionally like to join teaching careers? Are there any other circumstances that lead them to land on studying science or mathematics with an education? This requires further investigation to bring

about why there are some students studying science and mathematics with education at the tertiary level each year but yet the scarcity of teachers in science and mathematics still exists. This investigation is necessary as it could give way forward on how to handle the scarcity of teachers in the science and mathematics fields.

Moreover, current research findings are in line with the research results by Saks, Soosaar & Ilves conducted in 2016 in Estonia. According to Saks et al. (2016), the average age of teachers is rising, and young people are less interested in pursuing a teaching career. In their research study, the findings revealed that, while students admire teachers' work, they regard it as a difficult, underpaid, and low-challenging profession. Although students appear to have a good comprehension of the teacher's job, acknowledging the struggles does not drive many among them to continue down this route and seek a career as a teacher. The beneficial variables that prompted students to explore teaching – sharing expertise and working with children – aligned with other social purposes previously identified in studies. Males' reactions were marginally dominated by altruistic and intrinsic incentives, contrary to previous findings (Saks et al., 2016).

Furthermore, Saks et al. (2016), reported that another finding in the current study was the importance of good role models in students' households. While earlier studies have found no link between students' interest in teaching and having a teacher in their household, the current data suggest a weak link between the two. Having a teacher-family member as a role model inspires a drive to emulate them and contribute to the growth of the young in the same way. Despite the findings of multiple studies, students confessed that excellent experiences with respective instructors at school, as well as having teachers in their very own households, served as positive examples, encouraging them to pursue a career as a teacher.

This discovery leads to the realization those instructors' views and messages about their jobs when working with students are critical, since they may impact students' future career plans. Students see that the expectations placed on instructors and the pay they receive for their efforts are not in sync. This wage discovery is a significant aspect in selecting whether or not to pursue teaching as a vocation. The participants in the current study, like the previous authors, cited an increase in wages as one of the most critical improvements to undertake. Another factor that deters students from pursuing a career as a teacher is the high workload (Saks et al., 2016).

Furthermore, Kapur (2018), reported that the proportion of teachers who report at work and who also intend to stay in the classroom for as long as they are able is strongly related to administrative support, resources, teacher voice, and influence over policy inside their schools, and adherence to standards and practices within the schools. There are significant differences in the working conditions of teachers in high and low-income schools (Saks et al., 2016).

Inadequate Teaching-Learning Facilities

Inadequate teaching-learning facilities are one of the factors mentioned to cause the scarcity of teachers in sciences and mathematics in many of the schools visited. The research findings from the interviews with education officers and teachers showed that in some secondary schools, there was a deficit in teaching and learning facilities. If there are inadequate facilities, the teaching and learning process will not be effective and as a result, this might affect negatively the students' performance in the examinations. The respondents mentioned some facilities which were lacking in secondary schools like a well-furnished library with all necessary textbooks, lack of a well-equipped laboratory, computer, and other digital facilities. Moreover, to teach effectively the teachers, require teaching and learning facilities as well as qualified teachers (Kapur, 2014;

Nghambi, 2014). All of these facilities are very necessary for teaching - learning science as well as mathematics subjects. Moreover, Kapur, (2018), revealed that certain physical conditions that make teaching possible in the working environment conditions of schools, such as proper furniture, chairs and tables, heating and cooling equipment the weather conditions. Furthermore, teachers are more advantaged groups seem to have more manageable working conditions, such as smaller class sizes and lower pupil loads, and much more control over school decision-making.

Students need to read a wide range of science textbooks and do a lot of practice so that they can improve their performance. Based on that, the number of science and mathematics graduates was as well affected. However, UNICEF 2018), reported that the government has introduced a single-book policy to solve the textbook shortage challenge in schools. These books are centrally produced, procured, and distributed to schools. Nevertheless, there is a delay in the procurement and delivery of these textbooks, thus the shortage persists (UNICEF, 2018).

In the current study, the analysis of the students' questionnaires uncovered that in some schools there were inadequate teaching and learning facilities including textbooks, well-trained technicians, and laboratory facilities just to mention a few. These responses were not homogeneous to all schools visited. Some schools were lacking enough textbooks, and another one missing enough laboratory facilities or well-trained laboratory technicians. The inadequacy of these facilities results in student graduates who are well trained and end up with poor performance in their examinations. Students believed that they need to practice more and read a variety of science and mathematics books so that they could improve their performance.

Several other researchers did more or less similar studies and revealed similar findings where there was a poor supply of teaching facilities in schools (Nghambi, 2014; Projest, 2013; Saga, 2014). In

line with this, other researchers reported similar results in their research studies. Projest (2013), found in his research study that the students reported that there was an inadequate number of textbooks, both textbooks and supplementary books. Moreover, these students believe that enough variety of textbooks, adequate laboratory chemicals, and equipment could improve their knowledge and skills in science and mathematics subjects. Projest (2013), argued that human resources including enough qualified science and mathematics teachers could enable the students to receive sufficient assistance in those subjects as well as improve their performance. Michael (2015), in his research study, revealed that there were not enough mathematics teachers, so those who were available were overloaded. Thus, Projest (2013) and Michael (2018), in their research studies, reported that there were some unqualified teachers in the schools assessed.

In the current study, students in some of the schools visited explained that they need more practice and experiments in science subjects to have enough knowledge and skills. The students added that some of the teachers were not qualified in the subject matter that they were delivering in those schools. Moreover, the results of the current research revealed that the interviewed teachers were teaching more than three classes.

Similar results were reported by UNICEF (2018), that Tanzania has inadequate teaching facilities and infrastructure, so the introduction of the new policy in recent years that introduces free education from pre-primary to lower secondary poses an extra strain in the classroom. More classrooms are required for pre-primary and lower secondary schools and it requires a large investment to construct. This means each level of education might have suffered the need for teachers since these levels feed each other.

While providing free education is a good idea, the government and policymakers must devise wideband strategies to combat the negative effects of free education, such as a lack of enough qualified teachers in Community Secondary Schools; in general, and especially, the Tanzanian government should give more teachers to Community Secondary Schools. This provides teachers more time to mark students' homework and satisfy the requirements of individual students, which will increase students' academic progress. Moreover, the teachers' workloads are larger, according to the research, which impedes effective teaching-learning. The scarcity of science teachers is more pressing than the scarcity of art teachers. As a result, teachers do not have enough time to grade assignments and assist students who are having difficulty studying. As a result, it is suggested that the government and policymakers devise methods to combat teacher inadequacies in Tanzanian Secondary Schools.

Low Salary or No Salary Increment for the Teachers

Low salary or no salary increment for teachers was one of the factors reported to cause the scarcity of teachers in the sciences and mathematics fields. The education officers' and teachers' interviews data analysis has revealed that since 2015 there has been no salary increment so the teachers' salaries have remained unchanged for a long time. The teachers feel discouraged and unmotivated and this might have contributed to poor performance in science and mathematics examinations for their students.

As discussed in the previous section about the issue of unemployment the students did not mention unemployment as a cause of the scarcity of science and mathematics teachers since this is also more related to teachers and education officers. However, the students reported that the negative aspect that hinders the students to like the teaching profession is the low salary paid to the teachers.

These findings match the similar findings by Saks et al. (2016), in their research study. This is one of the reasons why the students showed a negative attitude toward teaching careers. Moreover, Kapur (2014), also reported that the factors that cause the shortage of teachers should have been worked on including minimizing the teachers' turnover, increasing salaries, and more importantly improving teachers working conditions.

According to Kapur (2014), the options for reducing teacher turnover include increasing allowances, building houses for teachers, creating a climate that allows teachers to obtain loans from financial institutions, and holding workshops and seminars for training. The strategies' success was limited because the strategies' implementation was of poor quality. Financial limits, corruption among officials, a teacher shortage, and disobedient children are among the obstacles the schools face in decreasing teacher turnover (Kapur, 2014).

Science and Mathematics are Hard Subjects to Study

In the current study, the students revealed that the choice to study social science subjects is another factor causing the scarcity of teachers in scientific and mathematics fields in secondary education. Teachers and education officers when they were responding to the question on the causes of the scarcity of teachers in science as well as mathematics, they said that students choose to study social science subjects as the perception that science and mathematics are hard subjects to study. With such an attitude, the students feel comfortable studying social subjects which they considered simple and they were also sure of performing better.

The students also avoid science and mathematics subjects and opt to study social science because they want other careers related to those subjects like lawyers, accounts, journalism, and others. This trend of many students' choice of social science subjects does have negative effects on science

and mathematics subjects. Despite that some students qualified to study science and mathematics upon completion of their form II class, they join social sciences instead of sciences. When they're promoted to form III class they tend to change and choose another subject rather than scientific and mathematics courses.

The Differences in Responses of the Teachers and Students on the Causes of Scarcity of Teachers in Scientific and Mathematics Fields

There were differences in responses between the teachers and the students as shown in the research findings in this particular research. The differences were reflecting their daily activities. The instructors (teachers) responded according to teaching and learning activities and the issues of remuneration, performance, and motivation, while students' main responses were based on the learning process and performance. This means that the teachers were responding as workers and the students were responding as learners. The responses of both the teachers and students on the causes of the scarcity of teachers in science and mathematics were summarized on the thematic maps as indicated in Figure 8. The figure summarizes the general findings from the teachers, education officers, and students.

Like the workers, the teachers revealed that some factors differ from students' responses including the issues related to remuneration, employment, increments, and workloads. On the other hand, the students revealed some of the factors that were caused by the scarcity of teachers in science as well as mathematics are summarized in Figure 8.

Participants' Response on the Impacts of Causes of the Scarcity of Teachers in Scientific and Mathematics Fields

The study examines the root causes of the shortage of science and math teachers as well as its effects on Tanzania's secondary schools. The effects of the lack of qualified science and mathematics in secondary schools are assessed in this section. According to the current study, Tanzania's secondary schools' student performance is impacted by Tanzania's dearth of scientific and math educators. Thematic analysis of the data collected through interviews and questionnaires from the education officers, teachers, and students revealed some of those impacts. The data was collected from Kibaha and Bagamoyo districts in Tanzania. Thus, the findings being reported are based on the Pwani region from the two districts.

From the education officers' and the teachers' perspectives, the major impacts revealed include poor performance in science and mathematics subjects; unfinished syllabi; high teacher-student ratio; high science and mathematics teaching load; and students' low interest in studying science and mathematics subjects. On the other hand, research through student questionnaires revealed that secondary schools are affected by the lack enough qualified scientific and mathematics teachers. Low performance in science and math classes, students' avoidance of studying such subjects, incomplete syllabi, students' lack of enthusiasm in studying those subjects, and students seeking assistance from outside the school are some effects. The evaluation of the impacts is discussed in detail in the subsequent sections.

Poor Performance in the Disciplines of Mathematics and Science

According to the study and analysis of the data gathered through surveys and interviews, the main effect of the shortage of science and mathematics teachers is subpar performance in the subjects.

Poor performance was the most mentioned impact by the education officers and the teachers as well as the students. This specifically contributes to lowering the number of professionals in mathematics and science fields and subsequently teachers. With the low performance in science and mathematics subjects, it means that very few students will proceed with these subjects up to the tertiary level. Based on that and the fact that many students who are studying science and mathematics join other careers and do not teach, then the effects worsen due to the shortage of science and mathematical teachers in high secondary schools. However, there's a chance that a lack of mathematical and scientific teachers is not the sole factor contributing to poor performance. In addition to the dearth of scientific and math teachers, perhaps may be additional factors playing action in the issue.

According to UNICEF (2018), there is a language barrier to education in secondary schools whereby the students do use Kiswahili in primary schools, and when they join secondary schools, they use English as a medium of instruction as well in examinations. The transition from Kiswahili to English is believed to contribute to difficulties in learning among students which later may result to drop out. Currently English is still the language of instruction in secondary schools, which is a problem that needs to be solved. To work on resolving this language problem the schools should ensure that the teaching of English as a subject should be given more weight in the timetable to make it effective and efficient in the classroom. Reading and oral exercises for students should be emphasized in schools to increase the student’s language skills (Mlay, 2010).

However, the current research study suggests another research to investigate the poor performance concerning the language barrier in secondary schools in Tanzania. It suggested that this future research should assess teachers' language competence as it is assumed that these teachers might be the reasons why the students’ language skills are poor. If the teachers are the reasons for language

problems then resolving the problem should start with teachers. In-service training for teachers should be organized even at the school level to improve teachers' language and teaching methods skills (Mlay, 2010).

Students Avoid Studying Science and Mathematics Subjects

During the data analysis of the students' questionnaires, the research findings showed that many students avoid studying science and mathematics subjects. In doing so the problem of scarcity of science and mathematics teachers increases with time since the number of students who graduate in these subjects becomes fewer with time as well. Moreover, these few graduates prefer to join other science and mathematics-related careers and not teaching. The teaching careers are then affected the most as many of the graduates avoid working in the teaching careers.

The current research study revealed that science and mathematics are subjects to study and this makes the students dislike studying them. In line with this, the students dislike the teaching career, thus even those who study teaching tend to look for other science-related or mathematics-related careers upon completion of their degrees. The research revealed that the students dislike teaching careers because of the teaching remuneration and they consider the other careers as well-paying jobs.

Ieren and Innocent (2017) explained that mathematics teachers lack inspiration, suffer poor salaries and incentives, face negative attitudes from the students towards mathematics, and miss support from their parents. Poor motivation for both teachers and students diminishes the interest and achievement in mathematics performance. In summary, the inadequate of qualified teachers has affected the students' performance and lower interest students in mathematics (Ieren & Innocent 2017). Thus, using poor methods of teaching, impacts appear in performance and cause student

phobia and hatred of mathematics subject which increase the lack of interest in such subject in both students and teachers. In such situations, students tend to avoid studying science and mathematics subjects.

High Science and Mathematics Teaching Workload

High science and mathematics teaching workloads are one of the impacts which were uncovered during the thematic analysis of the education officer and the teachers.

The findings from the study showed that, in certain schools where there were shortages of science and math teachers, the available educators shared the number of classes on the schedule and ended up with a heavy workload. Since it is more of a teacher-based activity, the analysis of the interview responses from the education offices and the instructors revealed this, which did not show up in the analysis of the replies to the questionnaire from the students.

Similar results were found in Projects' (2013) research study, which found that a shortage of instructors in secondary schools increases the burden on teachers and has an impact on how the curriculum is implemented. In normal circumstances, for the teachers to be able to plan, prepare and teach effectively they should have up to 24 lessons per week. If they have more than 24 lessons per week, they are overloaded. In the current research study, some teachers revealed that they were teaching more than 26 lessons per week.

This research, therefore, suggests that the issue of scarcity of teachers in science and mathematical fields should be solved so that the teachers have a manageable number of students and lessons per day to allow more interaction between them. By doing this, both the performance of learners in mathematics as well as science classes and the overall number of graduates would consequently

improve. If this pattern continued, the shortage of science and math trainers would gradually worsen until it is eliminated from secondary schools.

Unfinished Syllabi

Both the analysis of interviews for the education officers and the teachers as well as the questionnaires for students shows that another impact of the shortage of teachers especially in the field of science and mathematics was the unfinished syllabi. This impact is related also to the teacher's teaching load which was reported to be high among the science and mathematics teachers. Since the schools possess few science and mathematics teachers compared to the syllabus content to be covered per subject per the time given does not match, it affects classroom learning and the teaching process. Thus, the teachers tend to teach as much as they can but some fail to cover up the syllabi. This implies that with few science and mathematics teachers, covering the syllabi is a problem. There is too much to share among teachers from the science and mathematics syllabi among a few existing teachers in secondary schools and as a result, the syllabi remained unattended.

Moreover, other factors such as the high teacher-student ratio hinder the teachers from interacting with individual students. Even if the syllabus would be covered, the teaching may be inadequate due to other challenges like the availability of textbooks, laboratory facilities, and classroom infrastructures (UNICEF, 2018). The government took efforts to train more teachers, especially science and mathematics teachers by providing loans to students for funding their studies through the Higher Student Education Loan Board (HSELB). This is a good strategy, but still, it is not clear whether all of those graduates will enter into teaching careers in the future.

High Teacher-student Ratio

In the analysis of the education and the teachers' interviews, it was revealed that a high teacher-student ratio is one of the impacts of the shortage of scientific as well as mathematics teachers in secondary education. The teachers believe that a low teacher-student ratio gives more room for interaction with an individual student while with a high teacher-student ratio it is not easy for a teacher to be able to help the individual student. In the current research, the thematic analysis of the teachers' interview responses revealed that there is a high teacher-student ratio. This means there is truncated effectiveness in teaching and learning science and mathematics subjects (Evarist, 2019).

According to Evarist (2019), the less the teacher-student ratio (small class) the more classroom practice interaction becomes. If the class is small, it provides more room for feedback, student satisfaction, and discussion with their teachers. The current research findings revealed that one of the impacts of the scarcity of teachers in science and mathematics is the high teacher-student ratio which affects both students and teachers. The teachers are affected in terms of commitment and morale, while students were affected by their performance. Since these teachers cannot invalidate large classes in their schools, they should plan techniques for effectively delivering quality education in such situations (Evarist, 2019).

Koc and Celik (2015) found in their study that the interaction between teachers and students in terms of social and academic aspects is an important determinant of academic success. The interaction can be affected but the teachers' and students' behavior as well as student-teacher ratio in the classroom. A low teacher-student ratio encourages the teaching process, students' engagement, class activities, and therefore students' learning. However, the effectiveness of the

teachers depends on the quality of the teacher (qualification) and how the teacher inculcates knowledge in students. The high teacher-student ratio affects teacher commitment and morale in teaching in the classroom.

Several studies found that the teacher-student ratio affects the academic performance of the students (Estome and Lyonga, 2020; Nghambi, 2014; Saga, 2014; The Citizen, 2022). Moreover, teachers' load and class size have some negative impacts on the student's performance as well as interest in effectively studying. This means that teachers are encouraged to teach effectively when the class is manageable and that they can be able to assist the individual students. Based on the above discussion intervention is quite an important issue at this juncture. Thus, this study suggests that more teachers should be employed especially science and mathematics teachers to decrease the teacher-student ratio so that the students' performance could be enhanced. As the students' performance becomes high many of them could join the tertiary level.

According to Lyimo et al. (2017), based on the information presented, analyzed, and discussed, in their research study, it is concluded that teachers' workloads are heavier, which reduces the effectiveness of instruction; there is a severe shortage to accommodate, the demand for a sharp rise in secondary school enrollment, and scientific teachers are in higher demand than art teachers. The teacher-to-student ratio is approximately equal to 50, with some schools having a ratio of at least 1:80, which is significantly higher than the optimum ratio (1:40). When the teacher-to-student ratio is higher than typical, teachers are unable to mark schoolwork, return them on time, or even counsel pupils who are having learning difficulties. Lyimo et al. (2017), suggested that the government and policymakers devise methods to combat teachers' inadequacy in Tanzanian Community Secondary Schools.

According to Citizen (2022), it is reported that the current challenge in education is the rapidly growing shortage of qualified teachers against the rapidly increasing numbers of students at both primary and secondary schools in Tanzania. According to a National Bureau of Statistics study report on the subject, as reported in Citizen in February 2022 the total number of primary and secondary school teachers in 2017 had decreased by 4.01 and 1.7 percent, respectively, by 2021. In contrast, the number of primary and secondary school students increased by 19 and 52 percent, respectively, over the same five-year period. The trend of rising student enrollment, particularly in secondary schools, results in a greater shortage of teachers, notably in the fields of science and mathematics.

In other words, the teacher-to-pupil ratio has risen from the recommended normal of 1:45 to 1:50 in 2017 and 1:62 in 2021 and it is continuing to rise while thousands of college graduates (future teachers) are unemployed (The Citizen, 2022). In general, public/government schools are more affected by teacher shortages than privately owned/operated schools, because the latter's employment and related terms are usually more appealing. Indeed, the government is already working on solutions to the problem, including better working conditions/environment and terms for teachers in particular, as well as workers in general. We advocate for a faster response to the connected issues before things get out of hand.

Students' Low Interest in Studying Science and Mathematics Subjects

Students' low enthusiasm in studying scientific and mathematical courses is one of the repercussions of the scarcity of science and mathematics in secondary schools as indicated in the current study. Thematic analysis of educational authorities and the teachers as well as the responses to the student questionnaire indicated that a shortage of mathematical and scientific teachers

caused the students' low interest in pursuing science and mathematical subjects. Students' attitude toward science and mathematics about these subjects lowers their interest to study. There is a negative perception of science and mathematics among students based on the fact that they believe that these subjects are hard to study and pass. This perception lowers the students' interest in studying science and mathematics subjects and causes few graduates in the education system. Thus, if students' interest in studying science and mathematics subjects is low if they are promoted from one class to another they will continue with such altitude.

Students' low interest in studying science and mathematics may also be caused by the language of instruction. According to Mlay (2010), the issue of students using Kiswahili as a medium of instruction in primary schools, and as they enter secondary schools, they used English as a medium of instruction is a problem. Mlay, (2010) argued that barrier is one of the problems that hinder students' performance in secondary schools. Moreover, the literature showed that the student's educational background is very essential for the student's performance in the subsequent classes (Irene and Innocent, 2017; Michael, 2015). Since the education levels feed one another then, resolving the issue of scarcity of science and mathematics teachers in secondary schools must be addressed through all stages of education from pre-primary to tertiary education since levels feed one another (Kapur, 2018). This means that students at all levels must be prepared and equipped with science and mathematics skills as a prerequisite to enrolling in those subjects at all levels.

Several researchers in the field of science education, have been interested in attitudes toward science for decades (Elliniadou & Safianopoulou, 2022). According to their findings, the key reason is that kids' attitudes influence their future goals and science job choices, especially from their early years of schooling. With growing recognition of the importance of scientific knowledge, several governments around the world are concerned about the declining number of students who

desire to study science. Even in the curriculum, it appears that interesting science programs are required. This is to guarantee that a STEM program has a positive influence on students' attitudes, self-efficacy, and achievement. They claimed that their findings are positive and demonstrate disparities in students' attitudes toward scientists, self-esteem, stereotyped attitudes, and perceptions of the environment. Elliniadou and Safianopoulou (2022) indicated that following the intervention, there is a need to encourage and expose disparities in students' notions about scientists, self-esteem, stereotypical beliefs, and opinions on the value of scientific knowledge to their lives and the environment. The current study also finds it important to encourage students to like science and mathematics for the sake of the future of their lives and the nation at large. To make sure that there are enough trained teachers who can contribute to helping teaching-learning of scientific and mathematics topics thrive via improvements in student performance, at the same time the issue of students disliking teaching careers should be addressed seriously.

Students Look for Assistance from Outside the School

During the thematic analysis of the students' questionnaires, it was revealed that students studying outside the school are one of the impacts caused by the shortage of teachers in science and mathematics. The students who have a passion for science and mathematics said that to improve their performance they decided to look for help from outside the school. This means that they look for teachers outside the school, especially during the school holiday. In doing so there are some costs they incurred to get to be taught outside the school. Most of the students believe that without seeking assistance from outside the school they will not be able to pass their examinations. Thus, the students do seek assistance from outside-of-school teachers' during the school holidays.

However, it was not known whether these teachers who were fetched outside the school were competent or not. Also, the students were unable to explain whether these teachers were qualified,

underqualified, or unqualified teachers. Thus, it is questionable to what extent this option was beneficial to the students. From them, they believed that they would be able to pass their examinations if they opt for substitute teachers outside the school. According to Magano (2014), the presence of underqualified or unqualified teachers in secondary schools has negative impacts on students' performance. Also, the unqualified teachers do not have teaching qualifications although they might have degrees in other subjects but not education. Underqualified teachers do not have teaching qualifications but they are assigned to higher levels that do not match the education level they possess.

Therefore, if these unqualified teachers teach the students outside the school, then this practice causes negative impacts on the student's performance in the respective subject. Thus, the government, school management, and parents should be aware of this and stop the students from taking the option of studying outside the school during holidays as an alternative strategy for solving the shortage of teachers in science and mathematical fields.

Students were also supported by their parents in terms of finance to support them to be able to study outside the school during the vacation. It also questions the quality of the subject matter which was provided outside the school. Furthermore, it is not known whether these teachers were using the relevant syllabus material or they were teaching outdated materials. Further investigation is needed to find out more about the programs which the students undertake outside the schools during the school holidays.

The Differences in Responses of the Teachers and Students on the Impacts Caused by the Scarcity of Teachers in Scientific and Mathematics

The study investigated to see how the teachers and students responded to the impacts of the lack of mathematics and science trainers in the secondary educational institutions that were visited. Both students and instructors concurred that secondary schools lacked sufficient numbers of science and math teachers and their effects. The answers provided by the teachers and students to the questions about the effects of the shortage of mathematical and science teachers were identical. Both studies found that the dearth of scientific and mathematics instructors has a detrimental effect on secondary schools' student performance, curriculum coverage, and interest in studying these topics.

On the other hand, the education officers and the teachers pointed out that the scarcity of teachers in science as well as mathematics teachers has an impact on secondary schools and some of the impacts mentioned were related to teachers' everyday activities including high science and mathematics teaching load and high teacher-student ratio. The students also provide some of the impacts related to their everyday learning process including students avoiding studying science and mathematics subjects and those who have a passion for science and mathematics seeking assistance from outside the school from the substitute teachers during the school holidays

Effectiveness of the Approaches Used Minimize the Scarcity of Teachers in Sciences and Mathematics Fields

The researcher looked into the methods the administration of the school employed to lessen the effects on secondary educational institutions of the teacher shortage in science as well as mathematics. The research study discovered some practical strategies that the school

administration employed to address the shortage of mathematical and science educators in the different schools they attended. To learn more about those techniques, the researcher created two questions. One question dealt with methods for reducing the shortage of scientific and math instructors, while the second asked respondents for their thoughts on ways to lessen both the effects and the shortage. The strategies are described in more detail in the paragraphs that follow.

Strategies Used to Minimize the Scarcity of Teachers in Scientific and Mathematics Fields and its Impacts on Secondary Schools

The study looks into the strategies employed by school administration to lessen the effects on secondary schools of the teacher shortage in science and mathematics. The majority of participants said that school administration employed initiatives to lessen the shortage of science and math instructors in secondary schools to maintain teaching progress. Apart from the obstacles faced by teachers of science and mathematics in educational institutions, it was found that instruction went on as normal. The teachers revealed in some schools that there were some strategies used to keep teaching normal including hiring unqualified or underqualified teachers. Some of those teachers were degree holders but not in education. The school management was trying to ensure that at least there is a teacher in the class and the students were busy. However, most of these teachers were temporary and or not full-time teachers. Most of these teachers were science and mathematics part-time teachers who were given short-time contracts. The season that these teachers were working temporarily was because they were teaching in other schools or other words, they were teaching in more than one school.

Although the hiring of the temporary teachers was serving the purpose at that specific time it was not an effective solution to the problem. The temporary teachers were reported to be not reliable

since they teach and leave the school as soon as they finished their lessons. Thus, whenever they were needed by the students for some assistance, they were absent from the school campus. Moreover, students considered these temporary teachers not to be serious about teaching. This means if the students want to consult the teachers after the lesson, it is impossible since they leave the school after the lesson. Thus, one can conclude that this strategy is ineffective, and therefore the school management needs to think of hiring full-time teachers.

Projest (2013) did a related study and found that schools with shortages of teachers employed temporary teachers. Some of them were advanced secondary school graduate students who were not trained to teach. Projest (2013) revealed that some of these teachers were engineers who were teaching Physics and Mathematics. The untrained teachers lack teaching methodology and pedagogical skills so they may not be able to deliver the subject matter effectively. Thus, this strategy which was chosen by the school management might have negative impacts on secondary schools since the teachers employed were not competent enough to teach those subjects.

On the other hand, there were some positive strategies taken by the school management including providing incentives for the science and mathematics teachers and even other teachers whose students performed well in their examinations. This was revealed during the interview with teachers in some schools. By providing the incentives the teachers feel more encouraged to work more and raise the students' performance. Moreover, the teachers suggest that there must be some remedial classes for the identified weak students to boost their performance. The current research realized that in some schools visited they were conducting remedial classes for the weak students and the class who were about to sit for the final national examinations. The teachers admitted that remedial classes raised the students' performance in general.

Opinions on How to Minimize the Scarcity of Teachers in Sciences and Mathematics Disciplines and its Impacts on Secondary Education

The study offers opinions from the research subjects on how to lessen the shortage of science and math teachers throughout secondary educational institutions. When asked for their advice on how to reduce the impacts of the lack of science and math teachers and their shortage, education officials and teachers gave responses that were aimed at students, school administration, and the government. This implies that both school administration and the government, as well as the students, have duties to reduce the repercussions of the lack of scientific and mathematics teachers. Additionally, teachers must work together to reduce the shortage of science and math instructors in secondary schools. To lessen the shortage of science and math teachers and their effects on secondary schools, school administration, and the government both have various duties that may differ or be comparable.

A study by Saga (2014), suggested that the school management should motivate science and mathematics teachers especially when they do extra workload. The current research study revealed that in some schools visited the teachers were given extra payment for the extra period they taught regardless of the subject taught. This motivation encouraged the teachers to work harder to improve student's performance. It was also discovered in the current research study that in some schools, the teachers were paid incentives at the end of the year based on the national examination results. This is another way of motivating the teachers and pushing them to work hard to improve students' performance.

Moreover, the current study comes up with some opinions from the participants' responses that the government should employ more science and mathematics teachers in their schools. Private

school management should as well employ qualified and well-trained science and mathematics teachers in their secondary schools. These suggestions are as well supported by a similar report by Saga (2014). Moreover, employing more science and mathematics teachers could minimize the teacher-student ratio and allow more teacher-student interactions with the individual student in the classroom. Moreover, with the employment of enough science and mathematics teachers, the workload for the teachers would become low and give teachers more relief to plan and work effectively and improve students' performance. In line with this, the improved performance and employment of enough qualified and well-trained teachers would encourage more students to like and study science and mathematics subjects as well as teaching careers in the future.

The enrolment of the students should be done according to the available teaching resources in schools (Saga, 2014). This means that during student enrolment, they should not consider only school capacity, but also the availability of teachers, teaching facilities such as libraries with textbooks, laboratories with chemicals and equipment, and enough classrooms. The school management should supply the school libraries with multiple copies of textbooks as well as supplement-books books and laboratories with materials needed for experiments such as chemicals and equipment necessary for laboratory work (Evarist, 2019). These teaching materials should be replaced whenever they are out of stock to ensure that teaching and learning continue. The school buildings and equipment should be repaired as necessary and the consumables should be replaced on time.

Summary

After conducting the research analysis of the data collected from the participants through interviews and questionnaires the information was summarized in Chapter 4. Chapter 4 presents

the research analysis of data and the finding of the research study. The chapter started with an overview or an introduction of the chapter. The research study aimed at investigating the factors that are causing the scarcity of teachers in science and mathematics fields and the impacts in Tanzanian secondary education. The current study was conducted in the Pwani region in Kibaha and Bagamoyo Districts. In the beginning, the researcher investigated why students do choose to study science and mathematics subjects. The research starts by wanting to know why they did choose to study science and mathematics and summarizes the main motive behind studying the subjects. The research employs mixed research method techniques during the data collection and interpretation. Data analysis from the students' responses revealed that the students do choose to study science and mathematics because they want to become doctors or nurses. This means that they wanted to take the careers that in one way or another work in the health sector. Some of them wanted to become dentists, others doctors while some wanted to become nurses.

Moreover, some of the students were just studying science and mathematics as a passion. These students explained that they just felt proud to be scientists. On other hand, some students were studying science and mathematics because they wanted to become engineers including electrical engineering, mechanical engineering, computer science engineering, gas, and petroleum engineering, just to mention a few. Other responses showed that some students were studying science and mathematics subjects because they wanted to become pilots, economists, or surveyors while very few wanted to become teachers.

The finding indicates that many of the students who study science and mathematics want to undertake science and mathematics-related careers and just a few would like to take teaching careers. Thus, these findings showed that the students dislike teaching careers. This is the reason why teachers in sciences and mathematics are scarce in Tanzanian secondary schools.

When the data from the teacher interviews were analyzed, the research findings revealed that the factors that are contributing to the shortage of mathematical and science teachers have been poor performance in those subjects, a limited number of graduates in those fields, students who are interested in those fields but choose to pursue other careers instead of teaching, high teachers' teaching loads which rendered the instruction ineffectiveness, and the presence of unsuitable teaching and learning environments.

On the other hand, the data analysis of the students' questionnaire indicated that the factors that are causing the scarcity of teachers in sciences and mathematics were poor performance in science and mathematics subjects; few numbers of graduates in science and mathematics courses; inadequate teaching and learning facilities; students' perception that science and mathematics are hard to study; as well as students study science and mathematics subjects but in the end, join other careers and not teaching. These results are more or less similar to the findings obtained during the interview with teachers and the education officers.

According to the results of the current study, the issues that teachers, district education officers, and students identified as contributing to the shortage of science and math teachers are largely the same. In other words, there is a similarity in the factors mentioned by the teachers and the education officers as well as the students which are causing the scarcity of teachers in scientific and mathematics fields in Tanzanian secondary schools. This also showed the validity and reliability of the data collected from the triangulated sources of the data source. The triangulated sources of data were used to ensure that there is a wide range of information that could be justified as valid and reliable.

The global themes that were obtained from thematic data analysis were tallied to get the frequencies which were converted into percentages that were presented in the pie charts. Presentation of the results in pie charts makes the reader able to understand and interpret the obtained information from the data. This was done to make a better understanding of information obtained from the research participants.

The research analyzed the impacts of the scarcity of teachers in scientific and mathematics fields in Tanzanian secondary schools. The interview data for teachers and education officers were done separately from the students' questionnaires. This means that the data from the teachers and the education officers were analyzed together while students' data were analyzed separately. For the teachers and the education officer, the findings showed that the impacts of the scarcity of teachers in science, as well as mathematics, were low performance in science and mathematics subjects; high teachers workload among them in science and mathematics; unfinished science and mathematics syllabi; high teacher-student ratio; as well as students' low-interest in studying science and mathematics subjects.

On the other hand, the data from the students revealed that the impacts of the scarcity of science and mathematics are low performance in sciences and mathematics fields; students avoiding studying sciences and mathematics courses; unfinished science and mathematics syllabi; students' low interest in studying science and mathematics subjects; and the students look for alternative help from outside the school.

Concerning the effects of the teacher shortage in science and mathematics, both instructors' and students' results are identical. The two thematic maps/networks (Figures 8 and 9) show the causes and effects of the dearth of science and mathematics, respectively. The causes and effects of

science and math shortages are similar. The shortage of science and math teachers and the effects on secondary schools are caused by these two things—the revealed causes and the impacts—which feed off one another and create an endless cycle relationship between them. This endless cycle is termed here as a cyclic relationship model. The primary reason for the problem's continuation is this cyclical relationship between the causes of the shortage of teachers in the sciences and mathematics and its effects. This cyclic relationship needs to be broken to be able to minimize or eliminate the problem of scarcity of teachers in secondary schools. To intervene in the cyclic relationship between the cause and impacts of shortages of teachers in science and mathematics fields, it needs teamwork among all education stakeholders. These stakeholders have to act against these factors which are causing the scarcity of science and mathematics at their specific positions or levels. These stakeholders include the students, the school management, teachers, parents, and the government. However, to go about solving the problem need further investigation on how to break the cycle.

The study found that students are not very interested in learning math and science. Thus, it is necessary to motivate learners to become teachers and like teaching the fields of mathematics and sciences to increase their interest in these disciplines and their study of them. Students should also quit ignoring science and math classes and start working hard to improve their grades in these subjects in secondary schools. On the other side, the survey found that secondary schools lacked sufficient resources for teaching and learning, including textbooks, computers, and well-equipped labs, as well as an insufficient number of scientific and mathematics teachers.

Additionally, it was discovered that the repercussions of the scarcity constituted the elements driving the shortage of scientific and math teachers. In general, there is a cyclical relationship between the causes of the teacher shortage in science and math and the consequences. To resolve

the problem the school management should ensure that there are sufficient human resources and teaching and learning facilities such as enough science and mathematics teachers, a library furnished with necessary textbooks as well as supplementary books, laboratories with enough facilities adequate school environment that is friendly to teachers and students in teaching and learning.

The study discovered that teachers were experiencing low payments, and a lack of salary increments, while there was a high teaching load, a high teacher-student ratio, and facing a lack of teaching facilities, just to mention a few. To minimize the problem the study comes up with suggestions from the teachers. Some of these suggestions need the teachers to participate in resolving the problem. It was discovered that instructors play a significant part in reversing the negative effects on secondary school students of the factors contributing to the shortage of mathematical and science teachers. Teachers need to be conscious of their role modeling for their students. As a result, they should try to assure high performance and inspire and encourage students to pursue professions as teachers. By doing this, the cycle between the causes of the shortage of science and math teachers and its effects on secondary schools would be broken.

CHAPTER 5: IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

Introduction

The implications of the research findings are finally discussed in Chapter 5, accompanied by suggestions for application for learners science and math teachers, school administration, and government officials. The recommendation for additional research is also presented in Chapter 5, together with the research's result. In this section on the study's implications, it was explored why students choose to major in science and mathematics as well as how teachers and students feel about the lack of scientific and math instructors in secondary schools. The study also covered the implications of the causes that contribute to the shortage of science and math instructors as well as the effects of this shortage on secondary schools. According to the study's findings, students and teachers had slightly different reactions to the causes that contributed to the shortage of science and math instructors in secondary schools. This chapter talks about these minor variations in responses. The chapter covered the implications of the research findings of the school administration's strategies for reducing the shortage of mathematical and scientific teachers within secondary schools, as well as opinions on how these strategies have done so.

The research study provided the recommendation for the application of the research findings to specific education stakeholders including the students, science and mathematics teachers, the school management teams as well as the government. Each education stakeholder has a role to play at the level they belong to. Furthermore, the research study recommends future research in the areas in which the current research finds that there be gaps that need investigation.

Last, but not least Chapter 5 presents the conclusion of the dissertation in summary on the causes of the shortage of science and math instructors and how it affects Tanzania's secondary schools.

The conclusion also expressed how the research findings responded to the research problem. Moreover, the chapter conclusion presented how these findings have contributed to the existing literature about science and mathematics teacher shortages, as well as how they affect Tanzania's education in secondary schools.

In short, Chapter 5 summarizes the research findings, conclusions, and recommendations for application in resolving the scarcity of science and mathematics teachers and the impacts on secondary schools in Tanzania. In this chapter, recommendations for future research are also provided. The main purpose of this research study was to investigate the factors causing the scarcity of science and mathematics teachers and the impacts on secondary schools in Tanzania. The problem of the scarcity of science and mathematics has persisted in the country for a long time, apart from many reforms and interventions made by the government through its Ministry of Education, Science, and Technology.

Although the government has devoted many efforts to employing more science and mathematics teachers, there is still a scarcity of science and mathematics teachers in Tanzania. The current research through literature review discovered that some unknown factors were maintaining the problem of the scarcity of science and mathematics teachers and the impacts on secondary schools. The research was conducted in Kibaha and Bagamoyo districts in some selected secondary schools to find out the factors causing the scarcity of science and mathematics teachers. The implications, recommendations, and conclusions presented in this chapter are based on the research questions, which were derived from the research objectives of the current research.

The research used mixed research methods to find out the factors causing the scarcity of science and mathematics teachers by using interviews and questionnaires during the data collection. Data

were collected from eight secondary schools and two district education offices in the Pwani Region. The region was purposively selected based on the three years (2016, 2017, and 2018) national examination results. The region was ranked among the top ten schools that were performing well in those national examinations. The schools were randomly selected from a list of all schools with advanced secondary school levels.

The research took into consideration that this research involved humans, so all ethical dimensions were taken care of. The research considered obtaining informed consent from the research participants. All research participants received a brief explanation of the study's goals, importance, and methodology, and they were free to decide whether to participate in the research or not. They were also informed that they were free to quit the research at any time if they thought there was a need. The research participants' names and other personal information were highly considered private with high respect. Therefore, no names or personal information regarding the participant appeared in the research report.

Chapter 5 presents the implications of the research study and comprises discussion sections based on the research questions. These sections were organized well to draw the logical conclusions of the specific research question. The sections discuss the motivations behind students' decision to study science and mathematics, the experiences of students and teachers with Tanzania's inadequate number of mathematical and scientific teachers, the causes of this shortage, the effects of this shortage on secondary schools, and the divergent perspectives of students as well as teachers on the effects of this shortage. the different responses from students and teachers regarding the detrimental impact of a teacher shortage in science and mathematics on secondary schools, as well

as the methods the administration has used to lessen the teacher shortage in these subjects. Teachers' opinions regarding these methods have also been acquired.

Chapter 5 also provides recommendations for the application of the research findings in the education sector that are presented in the subsequent section. In this section, the researcher explains the meaning of the research findings and the importance of the research study's conclusions in addressing the issue of Tanzania's secondary schools' shortages of science and math instructors. Despite all of the government's efforts, it was discovered that secondary schools are still lacking in mathematical and science teachers. The results of the current study are intended to aid attempts to address Tanzania's long-standing problem of an inadequate number of science and math teachers. The results were in line with Weiner's theory of attribution, where internal and external factors, in this case, cause failure or success in the performance of scientific and mathematical subjects, which is related to the availability of a sufficient number of science and mathematics professors.

Weiner's theory of attribution states that three categories of traits can be used to assess the explanations that individuals typically give for success or failure: First, success or failure may have internal or external causes. That is, we might be successful or unsuccessful as a result of elements that we attribute to ourselves or elements that come from our surroundings. Second, there are two possible causes for success or failure: stable or unstable. If we expect the cause to be stable, the outcome will most likely be the same if we take the same action again. If it is unstable, the result most likely will not be the same the next time. Third, you may or may not have any control over the factors that lead to your success or failure. a factor is considered a controlled aspect to be one

that we believe we can alter at will. We consider a factor to be uncontrollable if we do not think it will be simple to change.

According to the attribution theory, we frequently attribute internal or external factors as the root causes of success or failure. In other words, we succeed or fail as a result of elements that we attribute to ourselves or elements that originate outside of us. The degree to which we may influence success or failure is a factor. In the case of scarcity of science and mathematics teachers, some causes emanated from students themselves while some are from the school environment. The internal factors that are causing failure in science and mathematics subject's success from students include a lack of interest among learners in both mathematics and science because they perceive these fields difficult to study, students avoid studying science and mathematics, and students avoid joining teaching careers. On the other hand, external factors include inadequate teaching-learning facilities like libraries with books, well-furnished laboratories, and enough qualified teachers.

The attribution theory makes the crucial premise that we interpret our environment in a way that helps us preserve a positive sense of who we are. That is, to feel the best about ourselves, we will give reasons for our accomplishments or failures. For instance, students are more likely to credit their efforts or skills when they succeed academically than they are to blame outside forces, such as a lack of resources, ineffective teaching strategies, inexperienced instructors, etc. when they fail. According to Weiner's attribution theory, students are most likely to blame internal and external factors, such as not working hard or having a negative attitude toward mathematics and science, for their high failure rates in mathematics and science (Weiner, 2022). External factors

include that mathematics and science are challenging subjects, teachers are incompetent, there are no science laboratories for experiments, and students are not taken seriously by their teachers.

As a result, students, teachers, and the school environment all play a role in both, the causes and consequences of the shortage of mathematical and scientific teachers. Moreover, based on the research findings, this research has contributed to the existing literature by unveiling the causes and the impacts of the scarcity and science and mathematics teachers which was the knowledge gap. The study could be a useful starting point to help to minimize the problem. The current research study also provides recommendations for future research.

Implications

The primary goal of the research project was to examine the causes of the teacher shortage in mathematical and science subjects as well as its effects on Tanzania's secondary schools. The research was conducted in Kibaha and Bagamoyo Districts in Pwani Region. The research respondents were the district education officers, science and mathematics teachers, and students. The researcher employed qualitative and quantitative research methods using interview guide questions with education officers and teachers, and questionnaires were distributed to students. Before conducting data collection, the literature review for the related studies was conducted. The research data were analyzed using the thematic analysis method. The researcher followed the thematic steps in a systematic way for rigorous analysis of the data and interpretation of the research study findings. At the end of the thematic analysis, networks were produced. The networks are aimed at exploring the understanding of the subject matter and not resolving it.

The research findings' implications are presented based on the research questions and the objectives of the research study mentioned in Chapter 1. The organization of the section about the

research implications in this chapter explains the meaning of the research findings and how various education stakeholders may use them to address the issue of the shortage of teachers in mathematics and science and the impact it has on Tanzanian secondary education.

Reasons Why Students Choose to Study Scientific and Mathematics Fields

The purpose of the study was to determine why these students choose to study mathematical and scientific subjects at secondary levels. According to findings of this study, some secondary school learners in the visited schools choose to major in mathematics and science fields for a variety of reasons. The results showed that few students intended to become teachers; instead, they preferred to study mathematical and scientific subjects to pursue occupations in such fields, such as those of doctors, engineers, pilots, and nurses. Most of the student respondents explained that the intention to study mathematics and scientific subjects was to become doctors as well as nurses. Others planned to study science and mathematical subjects so that they could become engineers, specializing in mechanical engineering, electrical engineering, computer science engineering, and petroleum and gas engineering. Moreover, the current research findings revealed that some students were studying science and mathematics because they were feeling proud about becoming scientists, but not in their teaching careers. Very few students preferred to become teachers maybe for some unknown reason inspiration from their family members.

In the current study, it was revealed that students consider a teaching career as a low pay job with a low or little reputation as well as very tasking with large loads in society. The students were concerned with the teacher-student ratio which was affecting them negatively during the teaching and learning process as well as in the final academic performance. Based on that, if the students dislike joining the teaching careers then they contribute to a large extent to the shortages of teachers

in mathematics and science as well as the impacts on the secondary education system. These findings are supported or justified by a study conducted elsewhere by other researchers. Saks, Soosaar & Ilves (2016), in their study, found that the students dislike the teaching profession for the reasons that salaries paid to teachers were too low and that teachers' job was made unpleasant due to misbehaving students. Moreover, Garcia and Weiss (2020), reported that low compensation, a demanding school environment, and a lack of professional development assistance and recognition are all issues that cause instructors to leave or discourage young people from entering the teaching field, as well as making it difficult for schools to retain and attract highly qualified teachers. We should provide additional support and funding to high-poverty schools, where teacher deficits are much more of a concern, to address these factors for all schools.

Apart from teaching, teachers become overworked with other activities including making sure that the student's behaviors are controlled. This situation makes the teaching workforce shrink as young people do not find the teaching career attractive to pursue. Saks et al. (2016) revealed also that some reasons which discourage students to consider the teaching profession was a big teaching workload and a concern about salary which is the main factor individual consider in deciding whether or not to choose teaching as a career option. Generally, students perceive that teaching is a low-paying job, with a low reputation in society and that they always see their teachers as role models. Therefore, with this perception, the students lose interest to join a teaching career and opt to join other science-related or mathematics-related careers.

Saks et al. (2016) in their study, concluded that students have a rather adequate understanding of a teacher's job, and they realize the difficulties and problems associated with teaching, something that does not inspire many of them to follow this path and pursue a teaching career. However,

some positive factors influenced students to consider the teaching profession including passing on knowledge and working with children who are having fun. However, one can consider this as a very minor reason for deciding to pursue a teaching career for young people.

According to Saks et al. (2016), another finding revealed in their study was connected with positive role models in students' families. In a study, Saks et al. (2016), found that having a role model as a teacher-family member creates the aspiration to resemble these individuals and contributes to the development of offspring similarly. Students admitted to having positive experiences with their teachers at school as well as having teachers in their own families work as positive role models, which might persuade them to grow to be a teacher. This finding leads to the recognition that the reflections and messages that teachers put forward about their careers when working with students are very significant as they may influence students' future career choices.

These findings are in line with reviewed literature where many scholars have reported similar results in Tanzania and in other countries (Michael, 2015; Ndalichako and Komba, 2014; Ngema, 2016; Osaki, 2007; Saks et al., 2016). To rectify the situation, the student's perception of teaching careers must be changed. This perception could be changed through their teachers, who have to reflect on their positive experiences that could inspire and encourage the students to join teaching careers. The findings support similar observations by Saks et al. (2016), who reported that students do view teachers as role models, so the teachers have to reflect on their feelings and satisfaction with the teaching career to encourage and inspire students to consider a teaching career.

Students and Teachers' Experiences on Shortages of Teachers in Scientific and Mathematical Fields

The current research study focused on Tanzania's secondary schools' experiences with a shortage of scientific and mathematical teachers, as well as their effects. The research investigation found that there are not many teachers in the field of mathematics and scientific disciplines in secondary educational institutions in the current research location. The investigation of these causes was done in selected secondary schools where teachers and students were involved. Both the students and the teachers involved in the current research revealed that due to the high shortage of mathematical and scientific teachers, secondary schools were severely impacted. Current findings are supported by the literature where many scholars report similar results in similar or related research in areas (Michael, 2015; Ngema, 2016; Projest, 2013). The current research findings support the existence of the shortages of teachers in sciences and mathematical fields as well as the impacts on Tanzanian secondary education. The existence of the scarcity is verified by the persistence of high teaching loads among teachers, high teacher-student ratios, and unfinished syllabi, just to mention a few.

Other scholars reported similar results in their research study. Manyengo (2021) reported that, in 2019 that the pupil-qualified teacher ratio in public primary schools, was 55:1 while in public secondary schools, it was 23:1. In contrast, the ratio was 25:1 in private primary schools and 19:1 in private secondary schools At the primary school level, the current pupil-teacher ratio of 55:1 does not apply evenly throughout all schools, districts, or regions. However, the PTR varies by location, geographically, and whether a certain area is urban or rural.

There is a complex issue concerning a shortage of mathematical and scientific trainers that has to be resolved, but it can only be cleared up if a series of other problems are also solved in the

education system. To minimize or eliminate the problem needs to involve different education stakeholders and institutions. The school management must improve the school teaching environment to attract teachers by improving their salaries, providing housing, and resolving the problem of teacher turnover rate. The school's management should as well stop hiring underqualified teachers to minimize the teachers turnover rate. To lower the turnover rate, schools need to significantly change the management and conditions of schools in such a way that qualified teachers are attracted to the system. They need to increase science and mathematics salaries. The schools need qualified science and mathematics teachers who have knowledge and skills in the subject matter to be able to implement the school's curriculum in the classroom and laboratory.

The long-term solution to the scarcity of teachers in science and mathematical fields is to improve teachers' working conditions by providing special salary increments to attract more of them to join the teaching career. This can be accomplished effectively if such change is implemented through policy and systematic change in students' perception of teaching careers. Moreover, the study suggests that both government and school management to take a role in formulating salary policies that would attract qualified teachers to secondary schools.

Developing the policies is one side of the coin but the implementation of the same is another side when it comes to the policy-makers and the teachers respectively. The school management teams should advocate for the implementation of a comprehensive set of policies made by the government, including those tailored to local needs and circumstances, to address our emerging teacher shortage and ensure that students are taught by committed and competent teachers. These policies should consider teacher training colleges when the teachers are trained.

However, because teachers are unsatisfied with their work or salaries, supportive school environments must be created in which teachers believe administrators support them and that their opinions are considered when decisions are made. The current research shows that the issue of the shortage of mathematical and science teachers is complicated and calls for cooperation among those involved with educational institutions to take action at their respective levels. The reasons for that are the elements that are resulting in an inadequate number of science and mathematics teachers having a cyclic relationship with the impacts of the same and making the situation difficult to resolve.

Factors Contributing to the Shortage of Scientific and Mathematical Teachers

Like in other countries, the scarcity of teachers in scientific and mathematics fields in secondary schools is a growing crisis in Tanzania (Lyimo et al., 2017). The current research study was investigating the factors causing the scarcity of teachers in mathematics and science and its impacts on the secondary education system. The current research study revealed that factors were causing the scarcity of trainers in scientific and mathematical fields in secondary education, including poor performance in science and mathematics subjects, high teacher-student ratio, low salary, and salary increment, and few student graduates in science and mathematics who chose to teach careers, students avoided science and mathematics as they consider them hard subjects to study, and most of them join other careers. Some of the revealed factors were: high teaching load among science and mathematics teachers, students opting to seek alternative assistance from outside the school, the current unemployment situation in the country, students joining other science and mathematics-related careers, unfinished syllabi, and inadequate teaching and learning facilities.

Moreover, in the current research study, poor performance was the most mentioned factor by both teachers in the scientific as well as mathematical fields. Findings are supported by other the study conducted by other scholars who find that there was poor performance in mathematics subjects which was caused by poor students' background and inadequate self-practice (Michael, 2015). Whenever performance becomes poor in the fields of mathematics and scientific subjects, very few students are promoted to the next level of education. In the long run, the numbers of graduates become very few at the tertiary level.

Increasing the students' performance needs to involve teamwork among the students, the school management, and the government who have to take some actions. Students have to put more effort into self-practice in science and mathematics subjects. Self-practice should include efforts in reading, practice in solving mathematics problems and performing laboratory science activities (Michael 2015). Students should like science and mathematics subjects and join teaching careers; the school management to create a proper teaching-learning environment; provide teaching-learning facilities; school management is accountable; the government has to provide a good education policy.

The school management has to provide adequate teaching and learning facilities to enable the students to act on their side and do their part to improve academic performance. These facilities should include the school libraries that are well-furnished with all necessary textbooks and supplementary books as well as the laboratories with well-equipped facilities such as chemicals, equipment, and specimens. The facilities that are to be put in place should also consider improvements in online teaching and learning for science and mathematics so that students can continue with their studies during harsh periods such as the coronavirus pandemic (Olanrewaju & Mremi, 2021). Students will require computers with an internet connection to enable them to study

online. Governments and international institutions must adhere to principles and implement changes so that not only children and youth may reclaim their promised destiny, but all education stakeholders can play a part in making it a reality.

On the other hand, this catastrophe has sparked innovation in the education industry. With radio and television in take-home packages, we've seen creative techniques to ensure education and training continuity (UNESCO, 2020). Likewise, the education disturbance has had and will continue to have far-reaching consequences outside of the classroom. Educational institution closures restrict the supply of important services to individuals and communities, such as accessibility to healthy food, restrict the ability of many families to work, and decrease the student’s ability to study.

According to UNESCO (2020), online training solutions were established as a result of swift responses from governments and stakeholders all around the world, including the Global Education Coalition organized by UNESCO, to support education continuation. We've also been reminded of the critical role of teachers, as well as the fact that the government and other relevant stakeholders owe a continuing duty of care to educators. Everyone must act quickly to keep a learning crisis from becoming a generational disaster. Education is more than just a basic human right (UNECSO, 2020). It's an enabling right with ramifications for all other human rights.

Focus on attempting to address learning losses and trying to prevent dropouts, especially among marginalized groups; provide skills for future employment programs; promote the teachers' preparation and the teaching-learning process; expand the notion of the right to an education to include connectivity; remove the barriers to connectivity; enhance data and learning to track;

intensify articulation and adjustability across levels and training. Even with teacher shortages still learning would continue online, especially for higher secondary school classes.

Concerning UNESCO (2020), report the COVID-19 crisis has had an unparalleled impact on schooling. It has slowed progress toward international education goals and unfairly harmed the poorest and most vulnerable people. Despite this, the education community has shown resiliency, setting the groundwork for a comeback. There is still a danger of a downward spiral, with learning loss and exclusion as a negative feedback loop. However, every negative spiral of worsening socio-economic circumstances suggests the inverse of a positive spiral, one that would lead to the future of education we desire: one of inclusive change in education delivery, individual and collective fulfillment in all areas of life through investment in education (UNESCO, 2020). Education stakeholders could rely on boundless energy and untapped resources to restore not only education's vital functions but also Site core goals. Moreover, education authorities and curriculum developers should make use of this chance to identify new approaches to the learning issue and apply a set of solutions that were previously thought to be difficult or even impossible to implement (UNESCO, 2020).

Moreover, the current study suggested that the school management and the government need to employ a sufficient and qualified number of teachers in sciences and mathematical fields to teach in secondary schools. Manyengo (2021) reported that in 2019 the pupil-qualified teacher ratio (PTR) in public primary schools was 55:1 while in public secondary schools, it was 23:1. In contrast, the ratio was 25:1 in private primary schools and 19:1 in private secondary schools At the primary school level, the current PTR of 55:1 does not apply evenly throughout all schools, districts, or regions. However, the PTR varies by location, geographically, and whether a certain area is urban or rural. The indication here is that shortly secondary schools will face high student-

teacher ratios due to the changes in student enrolment in primary schools which also feed secondary schools. The change in student enrolment is caused by the free education policy and Education for All movement.

Also, the government needs to encourage more students to study science and mathematics subjects and to enter teaching careers by providing financial support in their studies and increasing the teachers' salaries by providing increments each year. The government and the school management have to introduce short courses or in-service training programs for science and mathematics teachers to improve their competencies, knowledge, and teaching skills. These in-service and short courses should be considered necessary options for teachers to be able to adapt to innovations in the changing world of science and technology. With the in-service and short courses, the teachers could upgrade their knowledge and skills and remain updated academically.

Impact of the Scarcity of Teachers in Scientific and Mathematical Fields on Secondary Schools

The research study investigated how Tanzania's secondary schools were affected by a shortage of qualified mathematical and science teachers. According to the results of the present study question, there are not enough scientific and mathematical teachers in secondary schools, which affects the students. The results of the study showed that there were consequences of a shortage of teachers in sciences as well as mathematics in secondary education. Both teachers and students agreed that there were impacts that were affecting teaching as well as the learning process in secondary schools and specifically the students were most affected. The impacts revealed in the study include poor performance in mathematics and science subjects; fewer students graduating in science and mathematics subjects; high teacher-student ratio; high science and mathematics teaching load;

unfinished syllabi; students joining other science and mathematics-related careers; students avoiding teaching careers; and students' low interest in studying science and mathematics subjects.

The impacts revealed by the current research were almost similar to the factors which were responsible for a shortage of teachers in scientific and mathematical fields in secondary school settings. The results imply that the factors that are contributing to the shortage of teachers in mathematics and science in secondary schools eventually appeared as the repercussions of the teacher shortage in those areas. The problem creates a cyclic relationship whereby the factors which were causing shortages of teachers in mathematics and science were also the impacts of the same scarcity. If the causes appear as impacts, then there is a serious need for intervention to resolve this problem shortly. It is strongly recommended that the government and other stakeholders involved with educational matters take the appropriate steps to address the shortage of scientific and mathematical teachers. to take necessary actions against the scarcity of science and mathematics teachers. This means school management has to take action. Students must take action to reduce the shortage of scientific and mathematical teachers. In addition, the government needs to do more to address the shortage of scientific and mathematical teachers and the impact it has on the secondary education system.

With the country's policy of free education from pre-primary to lower secondary school education, enrolment has increased, and this may result in more teacher-student ratios that may lead to poor teaching methods, which would affect students' academic performance. This means that, in the future, the scarcity of science and mathematics teachers might double. School enrolment is also raised due to the Education for All movement which is also been implemented in Tanzania. The literature showed that many reforms and policy improvements were made to improve students'

performance, yet science and mathematics continue to be in short supply. As a way to increase the number of these cohorts, the government is currently offering loans to student teachers majoring in science and mathematics at tertiary institutions. However, it is unclear how this will affect Tanzania's secondary schools or address the shortage of science and mathematics teachers. Reasons for the doubt are not known whether these teachers would like to enter into teaching careers or they would opt to join other science and mathematics-related careers.

Differences in Responses of Students and Teachers to the Causes Leading to the Shortage of Teachers in Mathematical and Scientific Fields

The current research study investigated the factors which are causing the scarcity of teachers in mathematics and science through interviews with teachers and questionnaire responses by students. The study revealed that both the teachers and the students responded to the question which was asking about what was the cause of the scarcity of teachers in science and mathematics fields in secondary education. The research findings showed that there were differences in responses between teachers and students in some of the revealed causes of the scarcity of teachers in science and mathematics arenas in secondary education. The differences in the factors were based on their daily activities in the respective school. For example, the teachers revealed that there had been low or no salary increments for quite some years, a factor that was not an issue of concern to students. Other issues of concern that were mentioned by only the teachers were the high teaching load, the high teacher-student ratio, and the problem of employment. The teachers disclosed that a high teaching workload has resulted from an inadequate number of teachers in mathematical and science teachers whereby those existing were teaching many lessons per

week. Some were having two or three subjects in science and mathematics, causing the low quality of the subject being taught.

Moreover, the classes were crowded and as a result, the teacher-student ratio become high. This hinders effectiveness in teaching as well as learning processes. Teachers were facing problems when trying to interact with individual students in the classroom and this also causes poor classroom management. Some individual students are left unattended and, in the end, they perform poorly in the examinations. Moreover, crowded classrooms affect negatively the ability of the teacher to service the classroom. Also, the current research study revealed that there has been no employment of the new teachers but rather the government was allowing the replacement of the teachers who drop out due to some reasons like death, retirement, dropout due to family problems, and early teachers' retirement.

Teachers' low salaries have an impact on the supply of teaching staff, including the allocation of teachers across the country, as well as the quality and quantity of people preparing to become teachers. Salaries appear to have an impact on teacher attrition as well as teachers are more likely to leave when they work in schools with lower salaries. Better pay of salaries would also entice them to return to schools and classrooms.

According to the present research study, salary increases have not been provided to teachers for more than five years. This situation has continued to keep teacher salaries low. Despite all the evidence that teacher salaries influence recruitment and training, a teacher's salary across most of Tanzania is insufficient to support the teachers. According to the current study, the deficiency of enough science and mathematics teachers is caused by the lack of sufficient remuneration. This

has been revealed from the data analysis collected from the teachers, education officers, and student participants involved in the current research study.

According to the current research study, the school management's essential criteria for hiring and continuing to support teachers have an impact on teachers' decisions to join, stay in, or change careers. However, employment in public secondary schools is done by the government in Tanzania, and in privately owned schools the hiring of new staff is done by the school management team. The hiring of a new teacher is been done each year to replace the retired teachers and the ones who drop from their teaching career for some other reasons. This means that a good number of teachers are still not employed. Late employment of teachers poses a negative impact on teacher recruits, retention, and student performance based on the duration of hire. Because of outdated technology, limited ability to send information, and limited time for applicants' demo lessons during the recruitment period, schools and management may engage in poor hiring practices in private schools. However, in government or public schools, the applicant's demo lesson is not applicable in Tanzania.

On the other hand, students claimed that the shortage of teachers in mathematics and science fields was a result of their understanding that many students shunned such disciplines due to how difficult they are to learn. However, students who had a passion for the subjects also revealed that they were looking for assistance from outside the school to compensate for the missed lessons in the class due to an inadequate number of teachers in science and mathematics. Although, students could not tell the qualification of that teacher and this remains a questionable issue that needs to be investigated. The students also mentioned that they choose to study science and mathematics

because they wanted to join science-related or mathematics-related careers and not teaching careers.

According to these research findings, there are not enough mathematical and scientific teachers and if this could not be minimized or reduced the shortage of teachers in such scientific and mathematical fields could not be resolved. The issue of high teacher-student and high teaching load should be addressed by employing more science and mathematics teachers in secondary schools in Tanzania. Having adequate teachers will resolve many of the issues that were revealed in the current research study, including the improvement of student's performance in science and mathematics subjects. Also, based on the current study findings, teachers and students revealed that the scarcity of science and mathematics teachers was caused by poor performance in the mentioned subjects. To minimize the poor performance, the school management has to hire enough qualified science and mathematics teachers and provide the schools with sufficient teaching and learning facilities. Moreover, the school management has to ensure that the syllabus coverage is a task done completely. Also, weak learners have to be assisted by providing enough remedial classes to improve their academic performance.

Differences in Student and Teacher Reactions to the Impacts of Scarcity Teachers in Scientific and Mathematical Fields

The current research investigation found that secondary educational institutions have a shortage of mathematical and scientific teachers which has an impact on the students' performance in those subjects. The current research findings showed that there were some differences in the responses of the students and the teachers regarding the impacts of the scarcity of science and mathematics teachers in secondary schools. These differences in responses were based on the daily activities

performed. The teacher's and employees' responses were related to their teaching processes, while the students responded about the learning process side as learners. For example, the teachers revealed that one of the impacts of the scarcity of science and mathematics teachers was that students avoided studying science and mathematics subjects and the situation where students looked for assistance from outside the school, especially during the school holidays. The students were avoiding to study science and mathematics subjects as they consider them hard subjects except for those who had a passion to become scientists. The student who had a passion for science and mathematics went further to look for substitute teachers outside the school to ensure that they perform better in the end.

On the other hand, the teachers' responses were different from the students' responses on the impacts of the scarcity of science and mathematics teachers where a high teacher-student ratio, and there was students' low interest in studying science and mathematics subjects were affecting the teaching process. The study revealed that there were teachers who were teaching big classes in some schools due to the scarcity of science and mathematics teachers in secondary schools. In doing so it was difficult for a teacher to be able to interact with each student in the class. This caused some of these students to remain behind as a teacher continue teaching and at the end of the school, they achieve poorly academically.

Both the teachers and the students responded that a shortage of mathematical and scientific knowledge among teachers affects student performance, which is the result of unfinished syllabi, and also caused a low interest in studying science and mathematics subjects by the students. Generally, the impacts mentioned have future direct effects on the education sector and specifically the performance of the students who are studying science and mathematics subjects.

Some effects of the scarcity of science and mathematics teachers that were revealed only by teachers, while others were revealed only by students. The impacts revealed by the teachers on the impacts of the scarcity of teachers in science and mathematics include the high teacher-student ratio and the problem of high teaching load among teachers. Whenever there is a high teacher-student ratio, it affects the teachers' possibility of assisting individual students during class interaction. In that case, some students may not be able to understand the subject matter. On the other hand, the students revealed that the impact of the scarcity of science and mathematics teachers was that students looked for assistance from outside their school and many of them avoided studying science and mathematics subjects.

Such findings imply that the scarcity of teachers in sciences and mathematics subjects affects the entire education sector, the teachers, and students who have a passion for studying such subjects. The impacts mentioned were also similar to the factors that were causing the scarcity of trainers in science and mathematics subjects. It implies that, if the problem of the scarcity of teachers is not resolved, then it will keep persisting and many students continue to be affected. The students will not be able to achieve their goals in the future. Science and mathematics test scores will continue to be low, the number of graduates will remain low, and the scarcity of teachers in sciences, as well as mathematics, will persist.

From the current research findings, the students who had a passion for science and mathematics studies revealed that to ensure that they perform well in their examinations; they have to look for alternative teachers from outside the school. This was done during the school holiday and they have to pay for the service. The bad side of this strategy was that it left students who could not afford to pay for alternative teachers with poor performance in science and mathematics subjects.

Moreover, it is not well known how competent the alternative teachers from outside the school were. Thus, these alternative teachers' competence is questionable. Another query is the quality and content of the subject matter that the students obtained from the alternative teachers from outside the school. The researcher, and perhaps the reader, would like to get informed on the competence of the alternative teachers and the quality of the subject matter they teach; thus, it poses a need for future research on this.

School Administration's Strategies and Their Effectiveness in Reducing the Scarcity of Teachers in Sciences and Mathematical Fields

The current research study investigated the strategies that were taken by the school management to keep teaching science and mathematics apart from the observed teachers' scarcity. Based on the findings in this research study, there is a shortage of scientific and mathematical teachers, which was brought on by a number of the issues described in the section above. It was revealed in the research that schools were ensured that they would continue to teach all subjects, even with a scarcity of teachers in sciences and mathematical fields.

Furthermore, the school management had some strategies they had been using to minimize the impacts of the scarcity of teachers in sciences and mathematical fields and ensure that teaching and learning are moving on. Some of the strategies included hiring more science and mathematics teachers, although some of them were unqualified teachers. These were either teachers with a degree or diploma but without a teaching profession. In some schools, the school management used part-time teachers who were hired temporarily to save the purpose while looking for full-time teachers. The hiring of unqualified and temporary teachers has negative results on the student's performance in the long run. These teachers might not be either very effective or competent in

teaching. The impacts go to the students and affect their performance and future careers. As the performance decreases the students keep losing interest to study science and mathematics subjects, as well as getting discouraged and this affects their decision to join teaching careers. in the situations like this, some students decide to join other subjects and shy away from studying science and mathematics subjects.

The research findings found that in some schools, the school management provided incentives to the teachers who were giving good results based on the student's performance in final or national examinations. This is extrinsic motivation to teachers that might not effectively solve the problem permanently but rather temporarily solved it. At some point, if the school management promises to give incentives based on performance, then it must be fulfilled. If it fails to provide an incentive for some reason, then the teachers could not be rewarded, the teachers feel demoralized and this could negatively affect students' performance as the teachers could not effectively teach. Thus, the study suggests that the school management should maintain the promises made to the teachers, or rather, they have to stop promising them.

Moreover, the research revealed that school management should encourage and inspire students to like and study science and mathematics subjects. It can be done by hiring permanent and qualified science and mathematics teachers who can change the students' performance. These teachers have to undertake in-service courses to improve their knowledge and skills, especially in mind that there currently changing world of science and technology. The school management and the government have to work on strategies to ensure that the courses could be effectively taught if they were delivered online to save time and other expenses associated with traveling from one place to another.

Teachers' Perspectives on Approaches to Address the Shortage of Teachers in Mathematics and Scientific Fields

The research study investigated how to mitigate the shortage of mathematical and scientific teachers and its effects on secondary educational institutions. It also examined the viewpoints of teachers and education administrators. The research findings indicated several viewpoints on ways to lessen the shortage of mathematical and science teachers and the impact that it has on Tanzania's secondary educational institutions, as mentioned by the education administrators and the teachers. These opinions or suggestions were mostly directed at the school management and the government in general.

The research participants revealed that school management should ensure that they hire many science and mathematics teachers to solve the problem of a high teacher-student ratio and enable the teachers to deal with students individually. With an adequate number of science and mathematics teachers, the teacher could be able to have small classes and able to familiarize themselves with their students, know their challenges and so that it could be easier to assist them. In doing so, the student’s performance in science and mathematics subjects would rise and encourage more students to join.

Moreover, the school management has to work in partnership with other education authorities to work out permanent solutions like training and employing more science and mathematics teachers. These teachers may be supported financially in their studies so that they can study. During the period for employing new teachers, the school management should consider employing qualified science and mathematics teachers. The school management should take it seriously to motivate science and mathematics teachers by providing incentives and considering salary increments to

encourage them to teach effectively and, in turn, attract more students to enroll in sciences and mathematical subjects. The incentives as well as motivations for teachers, must be a continuous strategy to avoid the negative effects of discontinuity.

Furthermore, the school management should avoid employing unqualified and part-time or temporary science and mathematics teachers and concentrate on those who are qualified in their respective subjects. To help the students from seeking assistance from outside the school during the school holiday, the school management should conduct remedial classes with the weak students so that they can improve their science and mathematics performance. This is a positive strategy that can be made stainable in solving the problem of performance in secondary schools. The school management must motivate and reward the teachers involved in conducting these remedial classes.

On the other hand, the government of the United Republic of Tanzania (URT), through the Ministry of Science, and Technology, should ensure that enough science and mathematics teachers are well-trained, motivated, and retained in their careers. Moreover, the government should introduce in-service and short courses for science and mathematics teachers. By providing the teachers with short courses and in-service programs, they will be encouraged and motivated to work effectively and change the students' performance in science and mathematics subjects.

Furthermore, it was suggested in the findings that the government of Tanzania should encourage more students to study sciences and mathematical subjects by reducing fees for science teachers in colleges and universities as well as increasing salaries for teachers in sciences and mathematical fields in Tanzania. The Tanzanian government should encourage as well as support online education for teachers in sciences and mathematical fields in secondary educational establishments. This can be done by providing and improving teaching amenities such as libraries,

laboratories, computers, and other necessary facilities. The benefits of doing online teaching are that it can be done at any time, even during a pandemic, such as the recent Coronavirus pandemic. With online courses, the process of learning will not be interrupted by disasters and learning would take place online.

Recommendations for Application

Introduction

This sub-section of Chapter 5 summarizes the research recommendations for application. The major goal of the written piece work is to make suggestions for how to deal with Tanzania's secondary schools' shortfalls in mathematical and scientific teachers. The primary goal of the current research project was to look into the causes of the shortage of mathematical and science teachers in Tanzania and how it affected secondary schools. Apart from many reforms and interventions made by the Tanzania government through its Ministry of Education, Science and Technology regarding the scarcity of science and mathematics teachers, the current research study has revealed the problem persisted in secondary schools in the country even at present or to date.

One of the government’s efforts to resolve the problem was to employ more science and mathematics teachers but in Tanzania, there are still not enough science and mathematics teachers. Through the literature review, the current research discovered that some factors were causing the scarcity of science and mathematics teachers and the impacts on secondary schools.

The research was conducted in Kibaha and Bagamoyo districts in some selected secondary schools to examine the factors causing the scarcity of science and mathematics teachers. Mixed research methods were used for data collection where interviews were employed to investigate the causes

contributing to the shortage of teachers in mathematics and science and quantitative methods used questionnaire tools during the data collection. Eight secondary schools and two district education offices from the Pwani Region were randomly selected from a list of all secondary schools advanced. The region was purposively selected based on the three years national examination results.

The research study involved humans, so all ethical aspects were taken into consideration during all research stages. All the participants involved in the study were briefly informed about the study's objectives along with the significance of the study, and also they were informed that they were free to decide whether to participate in the research or not and that they were free to quit the research at any time if they thought there was a need. The research considered obtaining informed consent from the research participants. The research participants' names and other personal information were highly considered private with high respect.

This part of Chapter 5 presents the recommendations for the application of the research findings which were obtained based on the research questions. The sections are organized well to draw the logical recommendations of the specific research question and for the specific cohort. The sections include recommendations for the students, the teachers who were teaching mathematics and science in secondary schools, school management, as well as the government. Moreover, in this section, the researcher mentioned and explains what can be done by different groups of people including teachers, students, school management, and the government to minimize the problem of the shortage of teachers in mathematics and science and as well as the impacts that have persisted on secondary schools in Tanzania.

The recommendations for application are made here based on the cohort of people involved in the current research study. The cohorts include students who were studying science and mathematics subjects, teachers who were teaching science and mathematics subjects, school management, and the government. These recommendations are reported here based on the current research findings and the framework in Chapter 2.

Recommendations for Students

The insufficient number of teachers in the fields of science and mathematics in secondary schools is based on the current research findings showing that the students have a role to play to improve science and mathematics subjects. This research found that the factors that are causing the scarcity of teachers in science and mathematics are on the students' side including the low interest in studying science as well as mathematics subjects, poor performance in scientific and mathematical fields, the student's perception that science and mathematics are hard subjects to study and the student's lack of interest on the teaching profession.

The student's interest in studying science is one of the factors that are affecting the availability of science and mathematics teachers. When students have a low interest in studying science and mathematics, they tend to run away from choosing the subjects and most of them join other subjects. Moreover, the low students' interest in studying science along with mathematics subjects, lowers the student's general performance in such subjects. This trend, in turn, has impacts in secondary schools where the number of student graduates in science and mathematics subjects declines and as a result a very low number of students graduates.

The findings of this investigation show that the next graduating class of high school students has little interest in pursuing their studies in the education field. It is vitally important to provide the

students with a situation in which they can deal with the many ethical difficulties they will face. As a result, the relevance of science education and why it is critical to stimulate students' interest in science and technology as a priority for Tanzania's economic progress and to promote a better quality of life for the nation.

It was also revealed in the current research that there were a low number of student graduates in science and mathematics who also dislike studying teaching career and as a result, the issue of scarcity of science and mathematics teachers increased each year. The research findings indicated that most of the students were less interested in becoming teachers. These students considered that a teaching career was the last option to think of if they fail to join other science and mathematics-related careers. Many of the students involved in this research explained that they have a passion to become doctors, pilots, engineers, computer scientists, and others. There were very few students who showed an interest to become teachers.

Moreover, the current research study found that students' poor performance was one of the factors which were causing the scarcity of teachers in mathematics and science fields. Both students and the teachers agreed that the number of student graduates in mathematics as well as science and mathematics subjects was low as a result of poor performance in the same subjects. This means that if the number of students who were studying science and mathematics was low and most of them were looking forward to joining other careers and not teaching, it also means that there are increasingly fewer mathematical and scientific teachers working in secondary schools.

The current research found that students perceived that science and mathematics were hard subjects to study. The students' perception that science and mathematics subjects are hard subjects has reduced the number of students who were studying the same. It was also revealed that the

student's perception regarding the two subjects also was one of contributing causes to the dearth of mathematical and scientific teachers in the secondary education system.

From the literature, it was also found that people in the community (parents) perceive similarly to the students. If the students perceive that science and mathematics subjects are hard to study then many of them dislike these subjects and choose to study social sciences subjects that, they consider easy to learn. The students explained that science and mathematics subjects were hard to study because of the shortages of teachers in science as well as mathematics. The study suggested that parents should encourage and motivate their children to like science and mathematics by providing them with all the necessary needs to pursue the courses.

From the research findings, it was revealed that the impacts of the scarcity of science and mathematics were also some of the factors that were causing the scarcity of teachers. This means the existing scarcity of teachers in mathematics and science was causing some impacts on secondary schools and in turn, the impacts affected the teaching and the performance of students, which intensified the scarcity of teachers in mathematics and science in secondary schools. For example, a factor like the students' perception that science and mathematics subjects were hard to study minimized the number of science and mathematics student graduates as many of them join social science and very few of them joined teaching careers while others join other professions but not teaching. In the long run, this problem of the scarcity of science and mathematics teachers continued to be retained and maintained. This circle of cause and effect goes on and on and causes a cyclic relationship between the causes of the scarcity of teachers in mathematics and science and the impacts in Tanzanian secondary schools. This cyclic relationship enhances or helps to keep the problem to continue persisting in secondary schools until the necessary interventions are properly implemented.

Moreover, the findings showed that the students who were studying science and mathematics subjects were not interested in a teaching career but rather in other science and mathematics-related careers, such as pilots, doctors, and engineers just to mention a few. Such students' passion for studying science and mathematics and pursuing other closely allied jobs reduces the number of teachers in the educational system. As a result, there are consistently too few mathematics and science teachers. Based on the findings of the current research study the researcher recommends the following to students:

i. The students were less interested in studying science and mathematics subjects and this had an impact on their general performance in those subjects, then few of them continued with science and mathematics to the tertiary level. The current study recommends that the students should learn to like all subjects and that the schools need future teachers in the future. Thus, they should study science and mathematics subjects and choose to join teaching as their future career. These students should be encouraged at the school level and at home to join the teaching career. This can be done at the school level through their teachers who have to cover the syllabi and teach the students effectively to improve their performance. Through this, the students would intrinsically become motivated to like the subjects and be in a position to join the teaching professions.

ii. The current research study also found that students dislike the teaching career. Therefore, this study recommends that students understand that teaching is a profession like any other one so they join teaching careers and work to educate our future generation. They should also consider that a teacher is a career that produces all other careers. This can be done through their teachers who must be role models to them.

iii. In the case that the students considered that science and mathematics are hard subjects to study, the research study recommends that the students should understand that all subjects are equal and there are no hard subjects. And that what is required in studying is effort, passion, and following what their teachers are teaching them. Through their teachers and the school management, the students should learn that education is necessary to themselves, the society and that in the future the school needs teachers. Teachers form the base of all other professions.

iv. For the students to improve their performance they should join different science and mathematics subject group discussions and clubs that are been supervised by the school management specifically the teachers. Based on these aspects the school management has to create different groups of science and mathematics subject clubs which will be supervised by competent subject teachers. In doing so more students would join and perform better in science and mathematics subjects.

v. The study strongly suggests that students offer better perceptions and constructive criticism about their teachers' teaching approaches for teachers to better align their teaching methods with the student's learning styles. It is recommended that to enable students efficiently and successfully, they must be adaptable and use strategies outside of their comfort zone to meet the requirements of the dynamic environment. Preparing students to be guided in mathematics using learner-centered methods, is an extremely effective method of instruction. Students must not be underachievers by failing to practice daily encouraged to engage in classroom activities to have a fun and satisfying learning experience.

Recommendations for Mathematical and Scientific Teachers

Research findings revealed that teachers also contribute to addressing the causes of the shortage of mathematics and science teachers in secondary education. These factors include failure to finish the syllabus, poor performance, students' low interest in studying science and mathematics subjects, high teacher-student ratio, high teaching load, students avoiding teaching careers, and choosing other science and mathematics-related careers.

It was revealed in the current research study that there was a high teacher-student ratio which was one of the factors causing the scarcity of teachers in mathematics and science as well as impacts the scarcity of mathematics and science of the same subjects. The high teacher-student ratio caused poor performance in similar subjects and as a result, very few students opted to continue with mathematics and science subjects up to the tertiary level. If most of them join science and mathematics-related careers and only a few of them join the teaching profession, then the scarcity of teachers in sciences and mathematics increases and remains high.

Moreover, the research found that whenever there was a teacher-student ratio, there was a high teaching load for teachers. Based on that, the student performance becomes poor, resulting in more of them avoiding teaching careers and increasing the scarcity of science as well as mathematics teachers in secondary schools in Tanzania. Moreover, these factors have impacts on Tanzanian secondary schools.

The current research study revealed that most of the impacts were more or less similar to the factors causing the scarcity of mathematics and science teachers making a cyclic relationship between them. It is this cyclic relationship between the causes of the scarcity of teachers in mathematics and science along with the impacts of the factors that hinder the efforts that are used by different

stakeholders to minimize the problem. The current research study recommends the following to teachers:

i. The current research found that the students have a low interest in science and mathematics as well as a low passion to become teachers. Teachers are responsible to motivate these students to like science and mathematics subjects by reflecting positive perceptions and working as role models so that they could enable students to like those subjects. The teachers have to be creative and get the student's attention and increase their interest in science and mathematics studies. The negative attitude toward science and mathematics subjects should be discouraged among students by inspiring them to like the subjects as the other subjects. This can be done from the lower levels of education since these levels feed each other. Thus, as the students grow with positive perceptions it will not change much easier for them to dislike science and mathematics subjects. However, this might need further investigation shortly to ascertain the possibilities.

ii. The teachers have roles to influence each student to participate effectively in theory and practice that enable the students to understand science and mathematics subjects and help to reduce failure in examinations. The teachers have to use multiple and modern resources and engage all the students in the learning process by giving each student chance to participate in the process. During the learning process, a teacher should make the science and mathematics subjects part of students' life by relating each lesson to real life. In doing so they could reduce failure in examinations and increase the students' performance and on the other hand, reduce the effects on Tanzania's secondary schools of a shortage of scientific and mathematical teachers.

iii. According to the study, several of the schools that were visited had teachers of science as well as mathematics who were underqualified so they were not competent in teaching the given subject. Thus, this research study recommends that teachers have to attend upgrading or in-service courses to improve their teaching skills and knowledge in science and mathematics and acquire innovation in this changing world of science and technology. Through in-service and upgrading the teachers, then the teaching process could as well improve and the student's performance would increase. In the long run, science and mathematics would not suffer poor performance in our secondary schools.

iv. Science and mathematics teachers should be using different teaching methods and other teaching devices to complete the syllabus. If a teacher completes the syllabus, on-time students could be able to revise and, in that way, students could also be able to perform better in their examinations. Moreover, the use of different methods of teaching the subjects could become much easier for students to understand and use the knowledge gained in responding to the examination questions and raise their performance.

Recommendations for the School Management

The research study examined the causes of the teacher shortage in science and mathematics as well as its effects on secondary schools. The study found that some of the factors need to be rectified by the school management. It was revealed in the research study that some schools were lacking adequate teaching and learning facilities including laboratory facilities, libraries furnished with textbooks, and other teaching and learning facilities. The teachers provided their opinions and suggestions that are here considered as recommendations for the research application. The school management has to work to improve student performance and reduce the issue of an inadequate

number of scientific and mathematical teachers at their secondary educational institutions. The school-based factors that are causing the scarcity of science, as well as mathematics, should be addressed at the secondary school level. The following are recommendations for application to the school management:

i. The school management has to enhance the atmosphere in which science and mathematics are taught and learned in their respective schools. Schools should have all the important science and mathematics teaching and learning facilities. Libraries must be in place and be furnished with textbooks and supplementary books, e-books for each level in the schools.

ii. Moreover, the schools must have science laboratories equipped with all necessary equipment, chemicals, models, and specimens to improve the teaching and learning process. These laboratory materials must be of good quality and quantity. It is recommended that school administrators ensure the availability of teaching materials and facilities for the implementation of various teaching techniques that are connected with instructional practices and students' learning in classrooms. Effective teaching and learning cannot take place in the absence of those instructional materials. Other necessary equipment or a tool like computers, should also be available at the school level to ease the teaching and learning process. Schools should ensure that students can use properly the available resources such as libraries, computers, and laboratories.

iii. Curriculum implementers specifically the teachers should employ modern techniques of teaching including the use of computer programs such as Microsoft PowerPoint and other teaching aids during the teaching and learning process.

iv. The school management has to increase teachers' overall pay by providing housing incentives as well as provide opportunities for career advancement that include increased pay, involvement, and appreciation or motivation. To attract prospective teachers to the fields and locations where they are most needed, offer in-service scholarships, and loan forgiveness programs, and also create teachers' residencies by proving houses with facilities in schools.

v. The school management has to improve hiring practices or guidelines to achieve that decisions would be made as soon as possible with the best available candidates and based on the best information available. This can be achieved through the use of local employment options, such as high school career opportunities and instructional models. Timelines for releasing volunteers or teaching practice students teachers or retirement should be revised so that the process of hiring new staff can begin as soon as possible when they leave. The school management has to create instruction and hiring channels for both new and experienced teachers, while also tracking and lessening teacher turnover and removing unwanted barriers.

vi. Also, allowing teachers to transfer from one district to another the issue of scarcity of teachers should be considered. The school management has to employ enough qualified science and mathematics teachers to help make sure that learning, as well as teaching, are effective in the schools they attend. Consequently, the issue of the teacher-to-student ratio would also be addressed.

vii. The school management could provide career guidance and counseling sessions with students to ensure that they understand most of the careers including the teaching profession. Students should be informed of the importance of a teacher in society.

viii. Furthermore, the school management should encourage and motivate the teachers to improve the efficiency of the teaching along with the learning process as well as to help guide future improvements of the student's achievements. Incentivize career development approaches and school re-design to promote cooperation and collaboration among teachers and students. The school management should emphasize teamwork among the students and teachers to be able to achieve in the end.

ix. The school management has to provide remedial classes for science and mathematics subjects in their respective schools to improve the student's performance. The emphasis on remedial classes could put more emphasis on the weak student so that they can improve their performance. Teachers are advised to link classroom science and mathematics topics with students' real-life situations, give a clear explanation of the concepts, give clear examples, prepare the lessons adequately, provide adequate exercise and homework, provide test and group work, also give feedback and lastly show the sense of humor when responding to the student's queries.in doing so the students could like science and mathematics subjects as well as the teaching careers.

x. The school management has to introduce discussion groups for the students to be able to practice science and mathematics subjects. This can be done during extracurricular activities but must be supervised by the teachers. It can also be done and achieved by providing remedial classes to weak learners. This remedial activity could also be done through various competitions, exhibitions, and invitations to guest speakers.

xi. The school management and the teachers have to motivate the best students performers in their respective schools to encourage the students to put more effort into science and

mathematics subjects. Through motivation and rewarding the best students, the students would improve academically and in terms of knowledge and skills.

xii. Strategies must be put in place to revise the curriculum and syllabus regularly and must involve all education stakeholders including the curriculum implementers to incorporate any necessary changes. With the innovations and changes in science and technology, the need to revise the curriculum and the syllabus is inevitable. This can give different education levels an improvement that goes hand in hand with innovations.

xiii. It is also strongly advised that school management should provide more in-service seminars, training, and workshops for teachers and other professional development programs with a focus on how teachers can align their preferred and used instructional strategies with the learning preferences and capabilities of their students.

xiv. Furthermore, even if the teachers are already having degrees in the profession of teaching, teachers are encouraged by their school heads to pursue postgraduate studies in addition to improving their teaching skills and knowledge. Finally, heads of science and mathematics departments must be given the authority to manage science and mathematics classroom instruction. They must be given all guidelines and training materials. Furthermore, they can be given authority to spend money on high-quality in-service programs, especially for science and mathematics teachers as well as continue to improve the quality of high-quality administrators who work to involve teachers in decision-making and promote positive school cultures.

Recommendations for the Government

The research study investigated the opinions of the participants on how to minimize or eliminate the issue of an inadequate number of teachers in science and mathematics and the effects it has on secondary schools. The teachers also offer their recommendations and viewpoints on what the government should do to lessen the impact on secondary educational institutions of the teacher shortage in mathematical and scientific subjects. The research presented recommendations based on the existing research findings on reducing the shortage of mathematical and scientific teachers. Moreover, the recommendations which are provided here are based on findings in general. The current study revealed that government has a role to play in improving science and mathematics teaching in secondary schools and encouraging many students to join teaching (Croft et al., 2018). The current research study revealed that teachers' salaries were low. What is paid to teachers discourages many students from joining the teaching career (Saks et al., 2016).

The current study revealed that in some schools there were unqualified science and mathematics teachers. To address the issue of an inadequate number of scientific and mathematical specialists, these teachers were hired to teach such subjects. The shortfall of using the unqualified teachers was that they cannot teach effectively as they lack skills for preparing the lessons and were able to teach as well as exercise teachers' ethics. To the government, the research study recommended that:

i. Science and mathematics teachers' salaries should be increased to encourage them to work effectively and also to encourage the students to join the teaching career. Bearing in mind that science and mathematics teachers are likely to get high-paid jobs when they join other related careers, then the government has to raise their salaries to retain them and attract

more students to join the career and this could increase more science and mathematics teachers in secondary schools.

ii. Boren (2022), reported a use of a blueprint model to resolve teachers shortage in USA states in a report for the Southern Reginal Education Board (SREB) which might be useful to other countries. According to Boren (2022), to develop a new teacher workforce blueprint, the leaders need to take four important action steps including understanding the country's specific shortage issues, collaborating to create a comprehensive redesign blueprint, putting the plan into action, and committing to long-term systemic change, and making a continuous investment in the state's future. Moreover, four elements are required to renovate the policies and practices to attract and retain sufficient teachers workforce, including pathway and preparation, licensure policies, professional support and mentorship, and compensation structures and packages. The study recommendations to the government of the United Republic of Tanzania use the blueprint model which may address the issue of the lack of scientific and math instructors and its effects on secondary schools, the teaching profession must be elevated.

iii. The government and school management have to focus on engaging qualified teachers and providing the existing teachers in the schools with in-service training programs. The provision of in-service training would upgrade the teachers and provide them with new knowledge, skill, and innovations. With the new knowledge, skills, and innovations, the teacher's ability to teach would improve and as a result, raises students' performance in science and mathematics subjects.

iv. The government has to increase the provision of funding support for students who are studying science and mathematics with education in terms of scholarships and loans.

Currently, the government of Tanzania, through the Higher Education Students' Loans Board (HESLB) provides loans to science and mathematics students who are needy at the tertiary level. This study recommends that the government support all students who are studying science and mathematics subjects with an education regardless of their financial capacity. In that way, many of the students who graduate in science and mathematics subjects could join teaching careers.

v. Moreover, to ensure that all necessary teaching and learning facilities are in place – including furnishing all science laboratories with equipment, chemical, and others, school libraries are to be equipped with textbooks and supplementary books, journals, and e-books. With all these facilities and if there were more qualified science and math teachers, student performance might improve. The scientific and mathematics curricula should be covered, teaching and learning should be effective, and the student's interest in science and mathematical subjects should be increased by encouraging and rewarding them so that they might eventually want to pursue a career as teachers.

vi. The governments could provide in-service scholarships and loan forgiveness programs to attract prospective science and mathematics teachers to the fields and locations where they are most needed. These types of programs might be effective if they could pay for all or a significant portion of tuition; focus on hiring teachers for disciplines and institutions with high demand; hire academically capable and dedicated teachers; and commit recipients and fulfill the commitment to teach and remain in the career.

vii. The current research study suggests that policymakers, particularly school authorities, and teachers, should develop comprehensive methods for preparing students to use e-learning. As a manner of being proactive with student education, these techniques might involve

giving students with internet access as well as gradual instruction in the usage of e-learning before a crisis such as a pandemic. Given the realities of the internet age, kids will almost certainly be required to study something via e-learning at some time during their adult lives, and equipping them with the necessary abilities today will benefit them as working adults in the future.

viii. The current research study suggested that the government and the school management have to come up with a strategy on how to improve reading materials like textbooks, and journals, and encourage the students to read. Furthermore, the study suggested that the government and the school management build libraries and laboratories to make scientific classes in secondary schools easier to study.

Summary

The study revealed the existence of the cyclic relationships between the causes of the shortage of teachers in mathematics and science and how it affects Tanzania's secondary schools as the major causes of the scarcity of science and mathematics teachers. To solve the problem, recommend that this cyclic relationship needs to be intervened to minimize the scarcity of teachers. Moreover, the study suggested that to break the cycle, the government has to set up a proper education system with good policies that favors the students and the teachers, ensure proper implementation of the policies, and provide support to schools, teachers, and students through funding where necessary. The government should encourage and introduce in-service and short courses for teachers especially science and mathematics teachers to improve their competence, knowledge, and pedagogical skills. The government through its Ministry of Education Science and Technology should introduce e-learning and online programs for teachers and students. These provisions would improve the student’s performance and break the cyclic relationship between the causes of the

shortage of teachers in mathematics and science and the manner in which it affects Tanzanian secondary schools.

Recommendations for Future Research

Introduction

The research study aimed at investigating the causes of the shortage of teachers in mathematics and science and how it affects Tanzania's secondary schools. This study was conducted in the Kibaha and Bagamoyo Districts where eight secondary schools which were teaching science and mathematics among other subjects from lower to upper secondary school levels were selected randomly from the list of all schools.

Qualitative and quantitative data collection methods were used, where interviews and questionnaires tools were used for data collection respectively. Thematic analysis was used to analyze the data collected from the study area. The thematic analysis was done and revealed the research findings based on the research objective and questions. However, in the course of doing the thematic analysis and interpretation, some research gaps were realized. These gaps need to be bridged to bring a more comprehensive understanding of the research problem. Therefore, the research came up with some recommendations for future research which are discussed in the subsequent section.

Research Recommendations for Future Research

The research study and its conclusions in some way added to the body of information regarding the dearth of science and math instructors in Tanzania's secondary schools. To fill up some of the gaps in our understanding of the shortage of scientific and mathematics teachers as well as how to

lessen its effects on secondary schools is important. As a result, suggestions for further study are offered here based on information about the causes of the shortage of scientific and math instructors in Tanzania and its effects on secondary schools. The current research study made several discoveries regarding the causes of the teacher shortage in science and mathematics as well as the effects on the secondary schools it visited.

The research study discovered that the following factors contributed to the shortage of mathematics and science instructors within secondary schools: students' poor performance in scientific and mathematics courses; their avoidance of science and mathematics because they perceive it to be a difficult subject to learn; high teacher-student ratio; unfinished syllabi; high teaching load; few students graduates in science and mathematics; inadequate teaching and learning facilities; students join other science and mathematics-related careers; no current employment of new teachers in the country; and students avoiding to join teaching career.

The research study also showed that secondary schools are affected to some extent by a shortage of science as well as mathematics. Poor performance in scientific and mathematics disciplines is one of the main effects of the shortage of mathematics and science instructors, according to the study; low interest in studying science and mathematics among students; students looking for assistance from outside the school; students joining other science and mathematics-related careers; high teachers students ratio; unfinished syllabi; students low interest in science and mathematics subjects; and few student graduates in mathematics and science subjects.

To solve the issue of the shortage of scientific and mathematics teachers and its effects on secondary schools in Tanzania, the findings above indicated the areas that require action. Since most of them share characteristics with the variables that lead to a shortage of science and math

instructors in secondary schools, it has been noticed that the repercussions of this shortage also contribute to the shortage of teachers. These are intriguing findings, where it was found that the causes of the shortage of math and science instructors were also the effects of that shortage. According to the study, there is a cyclical relationship between the causes of the shortage of science and math instructors and the effects of that shortage. This is a major contributing factor to the shortage of mathematics and science teachers in secondary education, despite numerous government interventions.

The Tanzanian government has made good efforts to help students who are studying science and mathematics with education by assisting them with loans at the tertiary level. Since the research study found that many science and mathematics students dislike undertaking a teaching career, then more efforts are required to encourage and ensure that these student teachers join the teaching career upon the completion of their studies. For those who decide to join the teaching career, there is a need to find ways to retain them in the teaching post. It may include motivating and encouraging them by providing the new teachers with attractive salaries and other incentives.

Although, the current research study revealed some of the ways that contribute to reducing the shortage of mathematical and scientific teachers during thematic analysis in the proceeding chapters yet more research is recommended to investigate how best students could be motivated and encouraged to like science and mathematics subjects and join the teaching career. The teachers involved in the current research study suggested that to encourage the students to like the teaching career, science, and mathematics teachers have to work as role models so that more the students could view the teaching career as attractive as other science-related careers. In that case, the teachers have to teach in such a way that all subjects look simple and easy to learn among all

students in the classroom. The study recommends further research on how to make the mathematical and scientific disciplines more appealing to pupils.

The research study investigated the opinions of the teachers on how to make the process of teaching as well as learning better, whereby teachers suggested that the government and school management have to initiate and provide in-service teacher preparation programs for both science and mathematics. The main purpose of in-service training programs is to improve the teachers' qualifications to enable them to teach effectively, especially in the study of mathematics and sciences. Therefore, current research recommends future research to find out how to implement in-service training for science as well as mathematics teachers without interfering with the daily routine of secondary schools.

The study also found that there was a problem of inadequate facilities in secondary schools that was affecting the teaching as well as learning process in secondary education. Most of the school-required facilities that were reported to be improved in the current study include fully equipped laboratories with necessary chemicals, equipment, and specimens, and well-furnished libraries with textbooks, and e-books. However, the research did not find out to what extent these facilities are lacking in the schools. Moreover, the research did not find out how to address the problem of facilities in secondary schools. Therefore, the current study recommends future research to examine the extent to which the inadequacy of these facilities affects the teaching and learning of science and mathematics subjects in secondary schools. Also, the study recommends future research to find out how to address the issues of inadequate facilities in secondary schools in Tanzania.

Since the current research has unveiled the factors that were driving the shortage of science and mathematical teachers, which may be solved by different stakeholders including the students, the teachers, the school management, and the government at a large scale. This research study did not cover everything necessary to resolve the problem. Some gaps need further research to be able to accomplish the proper solution to the problem at hand. The research investigation was carried out only in secondary schools from two districts in an urban location. Consequently, the findings might not be the same when similar research is conducted in another rural-urban setting. Therefore, it is suggested that another similar research study should be conducted in other districts found in rural locations to get information on how the shortage of mathematical and scientific trainers is caused by certain variables in such settings. On the other hand, the research suggests that a similar study should be conducted in both rural and urban locations for comparison purposes. Also, similar research is suggested to be conducted in rural locations.

Among other efforts to improve the education sector, in recent years, the government of Tanzania has decided to support students who are studying sciences and mathematics fields with education at tertiary education levels by providing them with loans, specifically intending to increase the number of teachers in science and mathematical fields in secondary education institutions. These loans have been provided to students through Higher Education Student Loan Board (HESLB) where the students do apply for the loan. However, the applicants for such loans must qualify to get it and among other qualifications is that it requires the students to be the needy. The needy here means orphans, students who come from poor families, and they must be approved by the local government leaders. However, it is not known whether these students would like to join the teaching career upon completion of their studies. Therefore, the current research study recommends further research study to find out whether the student teachers who are beneficiaries

of the government loans enter teaching careers upon completion of their degree studies from university.

In other words, the current study suggests further research be conducted to find out whether or not all the graduates in science and mathematics with education in various universities in Tanzania will join the teaching profession upon completing their studies. On the other hand, the research should come up with several graduates in education in the year and the number employed by the public secondary schools out of that number. Moreover, it is recommended that research has to be conducted to find out the procedures used in supplying teachers in science as well as mathematics fields in our secondary education. The analysis should take into account how many science and math teachers are employed at large in the secondary education system about the demand for each school.

Some students are studying science and mathematics with education at the university level whom we expect to see in their teaching careers. Many of these students are receiving education loans from the government through its Higher Education Student Loan Board (HESLB). It is assumed that maybe many of these students join the university to study education because of the availability of this funding. Therefore, further research is needed to find out if the students who are studying science and mathematics subjects with education and they're receiving government loans are interested in a teaching career or if they joined the course at the university level because it was the only remaining opportunity for them to join the university.

Moreover, since the recent research investigated the causes of the scarcity of teachers in science as well as mathematics in both government and private secondary schools, the research calls upon further comparative research on the same between the government and private secondary schools

in Tanzania. The results might be different between private and government secondary schools since each of them has different management, different sources of funding, and capacity in terms of infrastructure and other teaching and learning facilities. Future research is also recommended to investigate similar research problems in private and government schools separately.

The current research study employed both qualitative and quantitative research methods to collect, compile and analyze data collected from the study area. It is assumed that using a different research technique might reveal some different or similar findings. Therefore, the research recommends further similar research but using different research methods such as quantitative research methods only. In doing so the research results revealed might appear similar or different.

Furthermore, the research was conducted during the Coronavirus pandemic time, so the findings might have been affected in one way or another by the situation. Many of the participants involved in the research were in fear and panic as any other people throughout the world together with the investigator. It should be clear that the respondents struggled to work with the fear of the Coronavirus pandemic throughout the time of data collection and therefore, they were not in normal working circumstances. Based on that the researcher recommends that similar research should be conducted in the same area after the Coronavirus pandemic ended.

The current research study targeted to collect and analyze the information from the district education officers, science and mathematics teachers, and the students who were involved in science and mathematics in one way or another. Thus, the findings in the current research come from the education officers, teachers, and students who were directly involved in the study and teaching of scientific and mathematical disciplines. The research assumed different findings could have been realized if the research could involve science, mathematics, and social science teachers

and students. The researcher recommends that another similar research be conducted but focusing on the social science teachers for comparative purposes. Also, future research may be conducted to involve both science and social science teachers to find out if there are differences in responses on the causes and impacts of the scarcity of teachers in sciences as well as mathematical fields in secondary schools.

The research's findings reported in this research are based on the current research study area. It is assumed that the findings may be specific to this particular study area. Using similar research techniques and research tools and conducting this research in another region might give similar or different findings. From that perspective, the researcher recommends for further research be conducted in another region and make a comparison of the findings. By doing so the research findings generalization would as well be justified.

The current study included both boys and girls who were studying sciences and mathematics in secondary education in the study area, or at least one of those. Different research findings could come up if the research could be done with either boys' or girls' secondary schools, if separate research could be done but, in the same research study area. Thus, the research study recommends that there is a need to conduct comparison research between girls and boys in secondary schools to find out what are the differences in responses between boys and girls on the factors causing the scarcity of teachers in science and mathematics fields and their impacts on secondary education arena.

The current research study revealed that government has a role to play in improving science and mathematics teaching in secondary schools and encouraging many students to join teaching. The current research study also revealed that teachers' salaries were low. In other words, what is paid

to teachers discourages many students from joining the teaching career. However, we still have many students in colleges and universities who are studying science and mathematics subjects with education. Based on that, there is a need of investigating how many of them join the teaching career and how many of them are retained as teachers in sciences and mathematics fields in secondary schools. In terms of future research, it may also be researched how many people from this cohort went on to teacher education programs and whether some of them began their teaching careers in schools. Given the fact that students' lack of interest in teaching and their negative view of teachers' reputations, it would indeed be interesting to look into teachers' perspectives – how they think as teachers, what signals they send to their students about their field of work, and how they reflect their well-being and job satisfaction.

Moreover, this research found that many students dislike joining the teaching career and instead they prefer other science and mathematics-related careers. The current research presumed that the main reason might be the stereotype that exists among people in the society that teaching is a low pay job, that has no chance to develop. There is a need for further research to justify if it is that low salary discourages students from joining the teaching profession.

Furthermore, the research found that there were no salary increments for the teachers which cause their salaries to remain unchanged for a long time. The situation discourages and demoralizes the teachers, especially science and mathematics teachers. The present research suggests future research to find out why there were no salary increments for the teachers.

Furthermore, with the implementation of the free education policy and education for all movement, the number of students in a lower level increased. It should also be remembered that the lower levels feed the higher levels of education. However, it is not known if the high levels can

accommodate the student who is upgraded to those levels (colleges and universities) in the country. The current research found that there is still a high teacher-student ratio and also a high teacher workload among teachers in secondary schools. From those observations, the research recommends further research on the impacts of the free education policy on science as well as mathematics teachers in Tanzanian secondary schools. Thus, this study recommends further research to be conducted to investigate the higher levels' capacity to be able to accommodate the students in the lower levels.

The research study found that there is no employment in the country since 2015. This means that there were no new people who were employed but rather there were the only replacements of the teachers who were retired, died, or for some reason dropped their teaching careers. The reason why there was no new employment was not investigated during the current study. Therefore, the research recommends that there is a need for future research to investigate the reasons why there has been no employment for several years.

The study discovered that whenever science and mathematics teachers were scarce, the students that were passionate about science along with mathematics were working to complete their courses of study by searching for alternative teachers outside the school. However, the current research study could not investigate the qualifications of such teachers. There are two suggestions in the study, that these teachers might have been teaching but they were underqualified to teach the levels they were teaching, or that the methodologies used to teach were insufficient and not the one approved by the Ministry of Science and Technology of Tanzania. Thus, the quality assurance in teaching and learning outside the school was not properly monitored and supervised. This research study suggests future research on the quality of teaching activities that were undertaken outside the school. The qualification of the teachers from outside the school could also be investigated.

To verify that the use of modern teaching and learning facilities may motivate students to join teaching careers, computer-based materials should indeed be designed and tested to see how they affect student motivation and attitude toward science and mathematics subjects. The researcher recommends that the use of these resources may improve students' performance in science or another subject and also motivate them to join teaching careers. It is unclear, nevertheless, how much this would alter the student's perspective on mathematics and scientific courses. To determine the veracity of the above statement, more research is required.

The research study found some schools employed unqualified or underqualified teachers in science and mathematics fields in secondary schools. This action of employing un(der)qualified teachers hurts the students' performance as stipulated in the literature. Based on that, the study suggests that there is a need to research to find out why school management does employ underqualified or unqualified teachers. Furthermore, the research study suggests to the school management that un(der)qualified teachers must be eliminated from the education system. The school management should employ or appoint qualified teachers in all secondary schools regardless of whether the schools are government or privately owned. This would encourage the learners to perform better.

Summary

In summary, this section highlighted the areas that still need some research in the future. All the gaps that the research study and questions arise that were not covered need to be worked on to solve the entire problem. The main issues to be addressed in future research include determining the ways of encouraging students to like and join the teaching career; investigating how in-service training could change teachers' qualifications; finding out to what extent the teaching and learning facilities are lacking in secondary schools; conduct similar research to find out the differences in

responses between girls and boys; with regards to scarcity of science and mathematics teachers. The study also suggests similar future research in another region in Tanzania, being in a rural location or both rural and urban settings for comparison purposes.

Moreover, the study suggested that future research be conducted to investigate whether the government loan students beneficiaries join the teaching career; examine if the students who were sponsored by the government decided to study education because it was the only existing opportunity or otherwise; the study suggested future comparison research on the similar problem between the government and private secondary schools; conduct research on why there is the employment of new teachers but rather the replacement is been done; conduct similar research using quantitative or both (triangulation) research method; future research with population that involves both science and mathematics and social science teachers and students; and conduct similar future research after the Coronavirus pandemic.

Furthermore, the research suggested future research on how the stereotype that exists in a society that teaching is a low pay job has affected students in the decision to join the teaching career; to research the impacts of the teaching activities that are taking place outside the school, and lastly, conduct a research on the impacts of the education for all movement in secondary schools; the study suggests further study into how Tanzania's secondary schools are affected by a scarcity of teachers in mathematics and science as a result of the country's free education program.

Conclusions

The researcher summarizes the entire dissertation in this final portion of Chapter 5 of the research study based on the study's findings and what those findings indicate about the study's goals. The purpose of the research project was to examine the causes of the shortage of science and math

instructors in Tanzania as well as its effects on secondary schools. The study revealed the causes of the teacher shortage in the fields of science and mathematics as well as its effects on secondary school students, which are discussed in this part. The section also explains how the research findings responded to the research problem and, lastly, highlights the contribution of the research to the existing literature and everyday practice in the education arena.

The study was conducted to accomplish the research goals under the topic of the causes and impacts of the shortage of teachers in scientific and mathematical fields in secondary education. The primary goals of the research study were to determine the extent of the dearth of mathematical and science teachers in Tanzania's secondary schools; investigate the reasons behind the shortage of mathematical and scientific teachers in upper secondary schools; look into how the teachers' and students' reactions to the reasons for the shortage of math and science educators in secondary school differ; and evaluate the impact on secondary schools of an inadequate number of mathematical and scientific teachers; find out how differently teachers and students react to secondary schools' struggles with an inadequate supply of mathematics and science teachers; and to determine the effectiveness of the ways used by the school administration to manage the shortage of mathematical and science teachers in Tanzanian secondary schools.

Also, to determine the strategies utilized by the school administration to reduce the shortage of science and mathematics teachers in secondary schools in the country. To achieve the intended objectives, the researcher was guided by the research questions which were used to develop the research tools, including interview questions and the questionnaires. The research aimed at answering the specific questions and when answered the main research problem is as well answered. These research questions, which originated from the main objectives, state, "What is the scarcity level of science and mathematics teachers in secondary schools in Tanzania? What are

the factors causing the scarcity of science and mathematics teachers in secondary schools in Tanzania? What are the impacts of the scarcity of science and mathematics teachers on secondary schools in Tanzania? What are the differences in the responses of teachers and students regarding the impacts of the scarcity of science and mathematics teachers in secondary schools in Tanzania? What are the strategies that could be used to minimize the scarcity of science and mathematics teaching in Tanzania?"

The current study was conducted in the Kibaha and Bagamoyo Districts, where eight secondary schools that were teaching science and mathematics, among other subjects, from ordinary to advanced level secondary schools, were randomly selected from the record of all schools. The research study area (the region) was selected based on the performance in the national examination whereas the region appeared among the top then regions in 2015, 2016, and 2017.

Qualitative and quantitative data collection methods were used, where interviews and questionnaires were used respectively for data collection. The interviews were conducted with teachers while the students were given some questionnaires to respond to. The study data was collected from the secondary schools where they were teaching science and mathematics subjects. Thematic analysis was used to analyze the data collected from research participants in the study area. The thematic analysis was done, and the research findings were obtained based on the research objectives and questions. Thematic analysis was done and the findings were presented in the tables, the frequencies of occurrence of the quantitative data were presented in pie charts, and the thematic networks in Chapter 4 of this dissertation.

The research study was conducted to investigate the factors which were causing the scarcity of science and mathematics teachers and the impacts on secondary schools in Tanzania. The research

study was conducted in Kibaha and Bagamoyo districts located in the Pwani region. The region and the districts were purposively selected, while the schools were randomly selected from the list of all schools which were teaching to advanced secondary school level in the districts. The schools were also teaching science and mathematics subjects. Mixed research approaches were used with interview and questionnaire tools to collect and analyze the data from the schools. The district education officers and the teachers who were teaching science and mathematics were involved in the research. Also, the students who were studying science and mathematics were involved in the research study.

The district education officers and the teachers were interviewed while the students were given some questionnaires to respond to. The data collected were compiled using Kobo Toolbox and Excel sheet and the thematic data analysis method was used to analyze the data according to Braun and Clarke 2006. The results were presented in tables and pie charts for easy understanding. The thematic data analysis method was used because it is a flexible and suitable method of analysis of qualitative data. The analysis was done according to the research question of the research study.

Based on the responses from the teachers and students on the extent of the scarcity of science and mathematics teachers in secondary schools, it was pointed out that there is a high scarcity of science teachers in secondary schools in Tanzania. More than 90% of the respondents reported that science and mathematics teachers are scarce in secondary schools. The findings revealed that there were factors that were causing the scarcity of science and mathematics teachers and their impacts on secondary schools in Tanzania. The main factors which were found to cause the scarcity of science and mathematics teachers include poor performance in science and mathematics subjects; students avoiding studying science and mathematics as they consider them hard subjects

to study; classrooms with high teacher-student ratio; unfinished syllabi; high teaching load; few student graduates in science and mathematics subjects; inadequate teaching and learning facilities; students joining other science and mathematics-related careers; no current employment of new teachers in the country but rather the replacement; and lastly, student graduates avoiding the teaching career.

The research study also found that there were some effects of the scarcity of science and mathematics teachers in secondary schools. The main impacts of the scarcity of science and mathematics teachers discovered in research include poor performance in science and mathematics subjects; low interest in studying science and mathematics among students; students looking for assistance from outside the school; students joining other science and mathematics-related careers; high teacher-student ratio; unfinished syllabi; and few student graduates in science and mathematics subjects.

However, in the process of doing the thematic analysis and interpretation of the data, it was realized some factors were causing the scarcity of science and mathematics teachers that also appeared to be the impacts of the scarcity the same. Poor performance in science and mathematics subjects, few graduates in science and mathematics subjects, students avoiding studying science and mathematics subjects due to the community stereotype that these two subjects are difficult to study, high teacher-student ratio, students avoiding teaching career as they consider it a low-paying job, students joining science and mathematics-related careers and that the performance is affected by the unfinished science and mathematics subjects syllabi. Moreover, the researchers discovered that the scarcity of science and mathematics teachers has resulted in students' low interest in studying science and mathematics subjects.

Based on the above discussion it can be observed that there is a cyclic relationship between the factors that are causing the scarcity of science and mathematics teachers and the impacts on secondary schools in Tanzania. This cyclic relationship is the main obstacle that hinders the efforts and interventions that were taken by the school management and the government to address this problem. Therefore, there is a need for taking serious measures to interfere with this cyclic relationship and break it. To be able to interfere and minimize or solve the problem, there is a need to involve all education stakeholders such as the students, teachers, school management, parents, and the government specifically the policymakers. Each individual has a role to break the cycle and minimize the scarcity of science and mathematics teachers and its impacts on secondary schools.

These results indicate that there is a need to put more effort into minimizing the scarcity of science and mathematics teachers and the impact on secondary schools in Tanzania. This can be done by involving all education stakeholders, including the school management, students, teachers, policymakers, education officers, and even parents. Since each education stakeholder has a role to play in ensuring that the scarcity of science and mathematics teachers is minimized, these research findings are useful to them. If individual education stakeholders perform their roles effectively in their respective positions, the problem of a scarcity of science and mathematics teachers may be reduced or eliminated. The research provided recommendations for application, which were presented in the previous section that the stakeholders can refer to. For instance, to minimize the scarcity of science and mathematics teachers, students have to change their perception of science and mathematics subjects, as well as build a tendency to like and join the teaching profession. This could be achieved through teamwork among all education stakeholders, including the government, school management, teachers, students, and sometimes parents.

Apart from the 5 chapters, the research presents the references cited by the researcher to support the findings and the dissertation write-up. The references are written in APA format version 7 which is the requirement of the University. The cited scholarly works which were used in this research study were less or equal to five years back published except where historical background information was needed to show the trend of the issue is been discussed. The research presents the appendices to support the work done during this research. The appendices include interview guide questions for teachers; a questionnaire for secondary school students and interview guide questions for education officers are presented in this research. Moreover, other appendices are presented in this research including the provisional approved UREC forms; approved final UREC forms; approved informed consent form by UREC; guardian informed consents form approved by UREC, the gatekeeper letter; and the research permit from RAS in Pwani Region in Tanzania.

Causes of the Scarcity of Teachers in Scientific and Mathematics Fields in Secondary Education

The current research study investigated the causes of the scarcity of teachers in science as well as mathematical classes, and findings showed that some factors were based on the students, teachers, school management, and government. The research study found that the students-based factors that were contributing to the shortages of teachers in science and mathematical fields in Tanzania's secondary schools included students' low interest in studying science and mathematics subjects, students' dislike of joining the teaching profession for the reason that it is a low-paying job, and students' avoidance of studying science and mathematics subjects as they consider them hard subjects to study.

Based on the above factors, students, in one way or another, contribute to the shortage of teachers in scientific and mathematical fields, especially when they avoid entering into teaching careers. Students need motivation and encouragement so that they could be able to cope with the situations and smoothly study and perform better in science and mathematics subjects. At some point, the parents should also be involved in encouraging the students to like the teaching profession. It should be noted that all other professional careers could not be able to flourish without the efforts of teachers or teaching careers.

Several variables that are responsible for the shortage of mathematical and science teachers should be reduced or eliminated to ensure that the shortage is as little as possible. The study suggested that secondary schools should continuously train and hire teachers who are qualified in science and mathematics. Secondary school students should be effectively trained from the ordinary secondary levels, particularly in sciences as well as mathematics subjects, so that they can continue studying in scientific and mathematical fields at tertiary levels.

To provide a more thorough knowledge of this research question, the current study aimed at filling the gap caused by the dearth of mathematical and science teachers. Teachers can help contribute to addressing the shortage of mathematical and scientific teachers in secondary education. As a result, the research identified several issues, most of which were teacher-based, that contributed to the shortage of science and math teachers. Due to these teacher-based factors, there were not enough science and math teachers including teachers' failure to finish up syllabi, the high teacher-student ratio, and the high classroom teaching workload among the teachers. However, no single factor was caused by only the teachers or students, but the factors were based on the teachers and students, the school management, the government, or all of them.

As for the students, teachers need to be motivated to be able to increase their productivity. The teachers need support from the school management, parent, and the government to be able to work effectively. The motivation here will be through in-service training, incentives, salary increments, and a suitable working environment. Moreover, teachers should be provided with teaching and learning facilities to enable them to work effectively. The facilities here mean laboratory equipment, chemicals, and specimens, just to mention a few, well-furnished libraries with both textbooks and eBooks, and housing facilities furnished with power, water, and other necessary needs.

The issues that are initiating a shortage of mathematical and scientific teachers in secondary educational institutions have been influenced by school management. The research found that some factors were school management-related, such as the issues of lack of adequate facilities such as libraries furnished with books, laboratories equipped with chemicals, apparatus, specimens, and a favorable teaching environment. The school management was responsible for furnishing the schools with enough facilities to be in a good position to support the science and mathematics teaching processes. If these facilities necessary for teaching science subjects were unavailable or inadequate, then the impacts would go on the student's performance and, in the long run, cause a shortage of science and mathematical teachers.

Other mentioned problems that were teacher-related and contributed to the shortage of science and math teachers were low salary increases that maintained earnings at low levels. Moreover, the research study revealed that there were poor incentives and motivation for teachers in most schools. The perception among the students that the teachers are paid low discourages the graduates from entering the teaching career. However, the research suggested that teachers could

always work as role models to show the students that teaching is like any other career. Though it should be taken into account that this work is complex, and major issues are not solved quickly or easily, thus the stakeholder should note that educational change can take time.

According to the current research study, the government must play a part in decreasing and perhaps even resolving the issue of the shortage of scientific and mathematics teachers. To address the shortage of scientific and math teachers, the Tanzanian government has implemented new policies and reforms through the Ministry of Science and Technology. One of the policies is to offer education loans to all university students majoring in mathematics and the sciences subjects. The primary issue is to increase the number since there is a need for more science and mathematical teachers in secondary education. Furthermore, free education policy that stipulated that education in Tanzania will be free from pre-primary school to ordinary secondary school levels was introduced, and that has resulted in increased secondary school enrolment, causing a high teacher-student ratio and also a high teaching workload for the teachers. In line with that policy, the impacts like high teacher-student ratio and high workload affect the students' overall performance, notably in both science and mathematics classes. The scarcity of mathematical and scientific expertise might get worse under this regime than where it is already.

Moreover, the government introduced education for all movements that had also increased the number of students enrolled in lower levels of education which later or soon increase the number of students in higher levels as these levels feed each other. This means that there is also a need to expand the higher levels in terms of the facilities and other resources such as the infrastructures and human resources.

However, in terms of human resources increase, the government, through its Higher Education Student Loan Board (HESLB), is providing loans to students pursuing higher degrees in science and mathematics. One of the greatest programs to address the issue of a lack of science and math instructors in secondary education is this one. However, it is not clear whether these students would like to pursue a teaching career after finishing their studies. Some of these students might have chosen to study science and mathematics due to the availability of the loan, which might be the only funding opportunity for them to pursue a university degree.

Since it was revealed in the current research findings that many of the teachers' graduates chose to enter other science-related careers, the government has to work on how to retain these graduate teachers in teaching careers. To be able to retain these science and mathematics teachers, the government has to ensure that teachers are supported in their training, and working environment, and also are employed. The study made some suggestions for further investigation into the effects of the free education policy as well as the Education for All movement campaign toward the shortage of teachers at the secondary education level in Tanzania. This could highlight more on what to do with the growing secondary school students' enrolments, which was caused by the free education policy from pre-primary to ordinary secondary education level and education for all movement.

The Effects of Teacher Shortages in Scientific and Mathematical Fields on Secondary Education

Students and the entire nation as a whole are affected to some extent by the shortage of teachers in education in science as well as mathematics. The results of the current research study show that the shortage of instructors in mathematics and science affects students' performance in secondary

education. The biggest worry of participants in this research study was poor performance in mathematics and science classes. Due to a shortage of instructors and students' lackluster enthusiasm for mathematics and science courses, many students score very poorly in these disciplines. Therefore, with few teachers in secondary schools, the teachers end up with a high teaching workload. The teachers' high workload reduces the teaching efficiency in the classwork because the teacher-student time of consultation is inadequate. Furthermore, due to poor performance in science and mathematics subjects, fewer students are advanced to higher levels of study, which leads to fewer graduates with degrees in mathematical and scientific fields. The shortage of teachers in science and mathematics fields is exacerbated by the fact that some of these few graduating students opt to pursue alternative occupations in those fields and not teach careers. Additionally, the study's findings showed that there are some effects of the lack of science and math teachers on society, where people think that these disciplines are difficult to learn and cause students to shy away from them.

The shortage of instructors in mathematics and science in secondary education also endures as a result of the assumption that these disciplines are difficult to study and that learners avoid them. The majority of students usually opt to pursue social sciences rather than science and mathematics.

Additionally, the study's findings revealed that a high teacher-to-student ratio is a result of the shortage of mathematical and science instructors, which might be higher with the introduction of the free education policy and the Education for All movement. The high teacher-to-student ratio hinders the teacher’s ability to manage the class, affects teaching efficiency, and causes poor teachers’ ability to contact individual students. This leads to subpar performance in secondary school mathematical and science classes and a low graduation rate for those two courses. This

trend becomes worse when it creates a cyclic relationship with the factors which are causing a lack of an adequate number of mathematical and science teachers in high secondary schools.

Furthermore, the research revealed that students avoid entering into teaching careers as they consider themselves to be underpaid, which has been exaggerated by the stereotype that exists in a society that teaching is a low-paying job. This situation affects students' decisions to enter the teaching career and, as a result, the scarcity of teachers in sciences and mathematical fields increases and exerts more impact on secondary schools in Tanzania. More efforts are needed from school administration, teachers, and the government to persuade students to pursue a career in education should be encouraged to like teaching careers. This can be done through their teachers, who have to be role models for them. These teachers have to inspire the students by teaching effectively and improving performance, notably in the sciences and mathematics classes.

This study found that students frequently seek help outside of school because there are not enough mathematical and science teachers, especially during school vacations. However, the quality of education obtained from the teachers outside the school is not known as it is not formal and the qualifications of such teachers are still a question. The current research study could not secure enough information about learning outside the school environment, which was an option for the students in response to the scarcity of teachers. Future research is required to investigate the impacts of learning outside the school on students who opt to join such programs.

Moreover, the research investigation found that an inadequate number of teachers contributed to the student's poor performance in science and mathematics classes. As a result, the secondary school curriculum's coverage was impacted because there were not enough science and math

instructors to complete the curriculum. This situation pushed the students to look for teachers outside the school, as discussed in the prior section.

Furthermore, the researchers found that students' motivation in pursuing sciences and mathematics in secondary school is poor due to the shortage of scientific and mathematics teachers in secondary educational institutions. Low students' interest in studying science and mathematics was intensified by other factors like poor performance, the student's perception of science and mathematics, and stereotypes that exist in a society that science and mathematics are hard subjects to study. The research findings showed that students like science and mathematics for some reason other than to become teachers. From the current research findings, students like science and mathematics because they want to become medical doctors, pilots, engineers, nurses, and other careers, but not teachers. Thus, the students prefer science and mathematics-related careers to teaching.

The study found a cyclical relationship between its impact on Tanzania's secondary schools and the shortage of mathematical and science teachers. The issues that were discovered to be the root causes of the shortage of science and mathematics teachers were also identified as having effects on secondary schools. There is a cyclical relationship between the issues that contribute to the shortage of science and mathematical teachers and the impacts delays all the efforts by the school management and the government in minimizing or eliminating the problem.

The Research Findings' Response to the Problem

The research findings describe the factors that contributed to the scarcity of science and mathematics teachers, as well as their effects on secondary schools in Tanzania. The findings

responded to the research problem as most of the factors can give the students, teachers, school management, and government a true picture of what is causing the problem so that they can know how to deal with it. Some of these factors are related to students, teachers, students and teachers, and school management, while others are related to government and education policies. This means that each education stakeholder has contributed to the problem in one way or another. Thus, finding a solution to this problem would also require each education stakeholder to act accordingly.

Many of the factors that were causing the scarcity of science and mathematics teachers were related to the teaching careers and the performance of the students. However, both the factors that were causing the scarcity of science and mathematics teachers and the impacts that were obtained were interrelated and connected, which made the problem persist. For instance, the scarcity of science and mathematics was causing high teaching workloads for teachers, and this resulted in unfinished science and mathematics subject syllabi, which later caused poor performance in those subjects.

The impacts of the scarcity of science and mathematics teachers, which were unveiled in this research study, were related to the factors which were causing the same. For instance, poor performance was the major cause of the scarcity of science and mathematics teachers, but it also had an impact on the scarcity of science and mathematics as a whole. Therefore, when we talk about the causing factors of the scarcity of science and mathematics teachers, we are also talking about the impacts of the same. The impacts of the scarcity of science and mathematics are similar to those caused by the same factors. One can conclude that the causing factors are similar to the results of the impacts. For instance, poor performance is the cause of the scarcity of science and mathematics teachers as well as the impact of the same. This means if we mitigate the impacts, we limit the causing factors and vice versa.

Specifically, the research study findings were able to respond to the research problem to some extent. The first research question Chapter 1 question stated “What is the scarcity level of Science and Mathematics teachers in secondary schools in Tanzania?” The students gave thoughtful responses to this issue, and the majority of them (96%) indicated that Tanzania's secondary schools have a severe shortage of scientific along with mathematics teachers. Only 4% of the students responded that there is no scarcity of science and mathematics teachers in secondary schools in Tanzania. On the other hand, the teacher’s response to this question was closer to the students’, whereas 98% of the teachers agree that there is a high scarcity of science and mathematics teachers in secondary schools in Tanzania, while only 2% said there is no high scarcity of science and mathematics teachers in secondary schools.

The second question as reflected in chapter section 1.5 research question 2 stated: “What are the factors causing the scarcity of Science and Mathematics teachers in secondary schools in Tanzania?” The main purpose of asking this question is to unveil the factors causing the scarcity of science and mathematics teachers in secondary schools in Tanzania. This question was answered by the students, the education officers, and the teachers who were involved in science and mathematics subjects.

The students revealed that the factors which contributed to the scarcity of science and mathematics teachers in secondary schools in Tanzania include: poor performance, students’ low interest in studying science and mathematics, unfinished syllabus, graduates joining other science and mathematics-related careers, high teacher-student ratio, and low interest in a teaching career among student graduates. At the same time, the teachers revealed that the factors causing the scarcity of science and mathematics teachers in secondary schools in Tanzania were poor performance, unfinished syllabus, high teacher student-ratio, high teaching load, unemployment

of the new teachers, few graduates in science and mathematics, low teacher salary / no salary increments, the situation of unemployment in the country, and low students' in studying science and mathematics subjects.

The third research question (Chapter 1, section 1.5 question 3) was indicated as, "What is the difference in the responses of the teachers and students on the factors causing the scarcity of Science and mathematics teachers in secondary schools in Tanzania?" This question was aimed at finding out if there were different responses between students and teachers regarding the factors causing the scarcity of science and mathematics teachers in secondary schools in Tanzania. The responses from the students and teachers were not so much different except if some answers were related to teaching for teachers and some answers were related to learning for students therefore, the answers came from only the students.

The fourth question in section 1.5 research question 4 stated 'What are the impacts of the scarcity of Science and Mathematics teachers on secondary schools in Tanzania?' This question was asked to unveil the impacts of the scarcity of science and mathematics teachers in secondary school teachers in Tanzania. The responses to this question from the students differ slightly from the responses from the teachers. While students responded as learners, the teachers responded as employees. The students did not consider issues related to employment and working conditions while the teachers did.

However, since they all share the situation of teaching and learning environment some responses were similar to each other. The responses from the students on the impacts of the scarcity of science and mathematics were: poor performance in science and mathematics subjects, few graduates in science and mathematics, low students' interest in studying science and mathematics subjects,

unfinished syllabus, students looking for alternative teachers outside the school. Teachers' responses to similar questions were: poor performance in science and mathematics subjects; high teacher-student ratio; unfinished syllabus; high teachers' workload; few graduates in science and mathematics; and students lack of interest in studying science and mathematics.

The fifth question of this dissertation (research question 5) asked was: 'What are the differences in the responses of teachers and students on the impacts of the scarcity of sciences and mathematics in secondary schools in Tanzania?' The major goal of raising this inquiry was to learn how both teachers and students' perspectives on the effects of the teacher shortage in science and mathematics differed. The research findings revealed in this research showed that the question is answered. The responses from students and the teachers are more or less similar to each other except for a few. They all revealed that the scarcity of science has an impact on the teaching and learning process in secondary schools in Tanzania. On behalf of the students, the impacts of the scarcity of science and mathematics teachers include poor performance in science and mathematics subjects, low students' interest in studying science and mathematics subjects, unfinished syllabi, few graduates in science and mathematics, students avoiding studying science and mathematics and lastly students look for help from outside the school.

The sixth research question of this study asked was phrased: 'What strategies could be used to minimize the scarcity of science and mathematics teaching in secondary schools in Tanzania?' The aim of setting this question was to get information on how the students and the teachers think about resolving the problem of the scarcity of science and mathematics teachers in secondary schools in Tanzania. The main strategies revealed were: The efforts to encourage students to like science and mathematics subjects; the efforts to inspire students who are studying science and mathematics to like teaching careers; appreciate and motivate science and mathematics teachers through paying

more and providing incentives; provision of short causes for science and mathematics teachers to improve their knowledge and skills in those subjects, and employ qualified teachers to raise the students' performance in science and mathematics in secondary schools.

Through this research study, different education stakeholders such as school management, teachers, students, and other education officers could be able to access different strategies highlighted here and apply them in their respective schools. The school management teams could be able to improve their school environment to suit their teaching and learning processes. Teachers' decisions on where they teach and whether or not to remain are strongly influenced by the teaching-learning environments for both teachers as well as students. School leadership and administrative support are frequently cited as the primary reasons for teachers leaving or remaining in the profession, or a specific school, outweighing even salary considerations for some teachers. From the literature, opportunities for professional collaboration and shared decision-making with teachers about their career choices are shaped by their affiliation with a team working toward a common goal. Key factors include opportunities for teachers, collaboration, and input in a particular institution. The teachers have to be allowed to contribute to curriculum development, policymaking, and decision-making on educational issues.

Moreover, there is a need for the school management and the government to ensure that teachers are getting in-service training to frequently improve their knowledge and skill so that they can adapt to the world's changes in science and technology. In this way, the teachers would become up to date and they would also like their careers. Through in-service programs which will improve teachers' ability to teach, the student's performance would as well change positively. On the other hand, this could increase the student's interest in studying scientific and mathematics subjects and they would even like the teaching careers.

The seventh research question of this study asked was phrased: 'How effectively do the approaches used by the school management manage the scarcity of science and mathematics teaching in secondary schools in Tanzania?' As with other research questions, this question was answered. While some of these strategies were effectively improving teaching and learning others were not useful to schools. Starting with the useful strategies the school management introduced remedial classes which seemed to improve the performance of the students in science and mathematics subjects. The efforts to encourage students to like science and mathematics subjects was a very useful strategy that needs to be emphasized in all secondary schools.

Moreover, the teachers suggested that there is a need to inspire students who are studying science and mathematics to like teaching careers. To fulfill this strategy, the teachers have to work effectively and be role models to their students so that they may be attracted and become motivated to become teachers in the future. Other education responsible authorities should value and consider the teaching career like any others and improve teachers' salaries and incentives, provide in-service training, seminars, and other programs. School management should be more serious when it comes to the employment of teachers. They should consider hiring those with a qualification in science and mathematics. This is the powerful / strongest strategy that may change the whole problem of the scarcity of science and mathematics teachers and the impacts on secondary schools. If qualified teachers are employed to teach science and mathematics subjects, they could be able to handle classes positively since they have the knowledge and skills to deliver the subject matter and be able to use the available resources to teach.

The research study revealed that there is a need to appreciate and motivate science and mathematics teachers by paying more and providing incentives. In this way, the teachers and

students will work effectively and, in the end, the performance of the students will become high. Provision of short causes for science and mathematics teachers to improve their knowledge and skills in those subjects. The provision of the in-service short courses for the students there could improve the teacher's knowledge and skill and this makes the teaching much better. On the other hand, according to the findings of this study, there could be a significant effect on performance in science and mathematics subjects. The improvement of the teaching and learning resources specifically well-furnished laboratories and libraries could also help in the improvement of students' performance. Science and mathematics performance in Tanzanian secondary schools can be improved if students participate in practical lessons led by well-trained and qualified teachers. This increases their motivation and, as a result, changes their attitude toward science and subjects, resulting in improved performance.

The Research Findings' Contribution to Existing Literature and Practice

The research study has investigated and unveiled the main factors that are causing the scarcity of teachers in science as well as mathematics and its impacts on Tanzanian secondary education. From the current research problem, it was revealed in the research study that, science and mathematics teachers were scarce, and this has caused some impacts on secondary schools in Tanzania. The current research has contributed to the existing literature and practice as the knowledge about the problem is now available to be used by different education stakeholders to minimize or eliminate it as discussed below. Such education stakeholders include students, teachers, the school management team, other education officers, policy-makers, and even government education planners.

With the unveiled factors which are causing the scarcity of science and mathematics teachers, these findings are useful to government education officers, school education management teams, teachers, students, policy-makers, and decision-makers to understand the existing problem more clearly so that they could take proper and effective actions. Moreover, the research findings are useful to all of the education stakeholders to be able to comprehend thoroughly the impacts of the factors that contribute to a shortage of mathematical and scientific teachers in Tanzania's secondary schools. The findings would also assist the Ministry of Science and Technology, which is accountable for teacher training education, to find the proper ways of training, attracting, and retaining science and mathematics teachers in the teaching career to reduce the scarcity and its impacts.

Furthermore, the current research findings serve as a reference to the educational planners and decision-makers who need to invest more in training science and mathematical teachers, employ enough qualified teachers, as well as be able to mitigate the problem of the scarcity of teachers in secondary schools to promote the provision of quality science and mathematics subjects. Also, it can serve as a base to motivate and encourage teachers to work more effectively as well as inspire students to like and take up teaching careers in Tanzania.

The research study recommends that to solve the problem there is a need to intervene in the cyclic relationship between the causes and the impacts of the shortage of teachers in science and mathematics fields that is shown on the cyclic relationship model. The government should motivate the teachers economically and professionally to the highest level possible to help students to like and perform better in scientific as well as mathematics fields. This is in line with findings and recommendations by Dee and Goldhaber in 2017, who reported that conceptually, paying

teachers at hard-to-staff rural schools and in subjects with high demand makes sense. It is clear from the studies that financial incentives have an impact on retention, therefore policymakers would be wise to start here to address the skills gap as well as the personnel shortage in schools. There is a need to prioritize certain subjects and raise pay to reduce the teacher shortage. Financial incentives might be used to address staffing concerns. Although these recommendations have strong logic and are supported by empirical data, we must be careful to emphasize that the fundamental evidence is not flawless. Both intrinsic and extrinsic motivations are necessary to ensure that by any means the teachers deliver what is required in the curriculum. If this is done thoroughly the students' performance will be high and finally motivate more graduates to join science and mathematics teaching careers.

Many strategies have been employed over the decades to lessen teacher shortages, and new programs are developed every year. This problem can only be solved when all the education stakeholders, leaders, and vested interests come together to collaborate on a plan. The government should come up with plans to make teaching an appealing profession, the report in question advises. Education stakeholders should upraise the teaching profession and make it a rewarding, valued, and appreciated position in our communities to motivate and attract more students to like studying science and mathematics and join teaching careers.

The study's findings continue to serve as the foundation for additional investigation into the problems associated with a shortage of scientific and mathematical teachers in Tanzania's secondary schools. Several recommendations for further research which are presented in this research have created a great avenue for the researchers who are interested to conduct research related shortage of teachers and any other related to science and mathematics teaching careers.

Moreover, the research findings help the school management evaluate the approaches or strategies they have been using to minimize or eliminate shortages of scientific and mathematical teachers, and the impacts on Tanzania's secondary schools. For the students, the research findings are useful to those whose interest is in science and mathematics-related careers, including teaching in the future. Moreover, the research is expected to inspire more students to join science and mathematics courses and especially those related to teaching careers. For parents whose priority for their children is to pursue science and mathematics careers, the research findings are useful because they are in a good position to advise their children on this. Parents have a big role to inspire their children to study preferable courses. Thus, through this research, the parents and the students would be able to see the importance of teaching careers in society.

The success of future generations, especially those living in marginalized cultures in rural areas, depends on the employment and retention of highly trained trainers, especially in the fields of mathematical and scientific studies. The causes contributing to a shortage of educators who teach science and mathematics have fortunately been identified by the current research investigation and revealed an interaction with the impacts which forms a cyclic trend. The trend inhibits all the intervention efforts that have been put forward by the school management and the government through its Ministry of Education, Science, and Technology. Through the research findings, the decision-makers could be able to come up with education policies and strategies that could be used to improve the school environment that would help in attracting and retaining teachers in teaching careers. Local conditions which are specific to an area will determine which set of research-based policies are most appropriate for a particular school to ensure that their teachers are paid and retained rather than letting them quit their careers. A wide-ranging set of goals is needed to address

our scarcity of emerging science and mathematics teachers and to ensure that every child is taught by a competent and dedicated teacher.

The research findings contributed to the existing knowledge in that it was able to identify the causes of the shortage of science and mathematical trainers and the impacts which have shown that the trend is cyclic as explained earlier in the current research. To resolve or lessen the issue of the shortage of scientific and mathematical educators, serious actions are required to intervene in the trend of the cyclic relationship between the factors causing the scarcity of science and mathematics and its impacts. This intervention requires each education stakeholder to take action at the levels they belong to, whether a student, teacher, school management, parents, or the government. Since the impacts of the scarcity of science and mathematics teachers are then caused by the scarcity of teachers, all education stakeholders are accountable and responsible for intervening in this trend to minimize the problem. Students, teachers, school management, and the government all together have to intervene in the causes of Tanzania's secondary education' shortage of mathematical and scientific teachers.

To be able to intervene teachers have to teach effectively to ensure that the student's performance which is the primary reason for the dearth of scientific and mathematical teachers is greatly improving. To enhance their academic achievement in subjects such as science and mathematical subjects, learners should work hard in the classroom. However, to enhance the performance of teachers who teach science and mathematics and students need adequate teaching and learning facilities. These facilities include libraries with enough textbooks, laboratories equipped with necessary chemicals and equipment, and off cause sufficient science and mathematics teachers. To be able to have all those facilities the school management and the government have to make

sure they are available in every school where science and mathematics are been taught. Teachers are responsible to work as role models to inspire and build students' interest in studying and liking science and mathematics as well as becoming interested in teaching careers. For the teachers to work as role models they need to be motivated and encouraged through proper payment and incentives as well as be provided with professional development programs including in-service programs and short courses as well as online programs.

For the school management, they should avoid hiring temporary or part-time teachers for science and mathematics teachers as some of them lack enough knowledge and skills in teaching methods. On another hand, the school management has hired or employed well-qualified teachers who are competent and have teaching methodology knowledge and skills in their teaching career. By hiring an adequate number of qualified teachers, the student would stop looking for alternative teachers outside the school. These students would not behave negatively attitude toward science and mathematics subjects that they perceived are hard to study but rather they would as well like to study these subjects.

With enough qualified teachers, the syllabi coverage would not lag behind the schedule and the students' performance would improve to a large extent. The students would not find substitute teachers outside the school during the school holiday. Moreover, with enough qualified science and mathematics teachers would be lower and the teaching becomes effective. The supply of sufficient qualified science and mathematics teachers would also minimize the teacher-student ratio in secondary schools. Teachers will be able to have contact with each student in the classroom during the teaching-learning process. Teachers would thus be able to comprehend each student's issues and offer appropriate assistance.

REFERENCES

Abdi, A. A., & Kharbirymbai, A. A. (2019). Teacher shortage in Kenya: Trends and policy implications. *Online International Interdisciplinary Research Journal, 9*(5), 128-137. https://www.researchgate.net/publication/344304225_Teacher_Shortage_in_Kenya_Trends_and_Policy_Implications

Adom, D., Hussein E. K., & Agyem, J. A. (2018). Theoretical and conceptual framework: Mandatory ingredients of quality research. *International Journal of Scientific Research*, 7 (1), 438-441. https://www.researchgate.net/publication/322204158_theoretical_and_conceptual_framework_mandatory_ingredients_of_a_quality_research/link/5a4b67d00f7e9ba868b0aaa2/download

Adnot, M., Dee, T., Katz., V. & Wyckoff., J. (2016). Teacher turnover, teacher quality, and student achievement in DCPS. *Educational Evaluation and Policy Analysis*, *39*(1), 54–76. https://files.eric.ed.gov/fulltext/ED577321.pdf

Aguilar-Solana, M. (2020). Triangulation and trustworthiness advancing research on public service interpreting through qualitative case study methodologies. *Fitispos International Journal*, *7*(1), 31-52. http://dx.doi.org/10.37536/FITISPos-IJ.2020.7.1.249

Akaranga, S. I., & Makau, B. K. (2016). Ethical Considerations and their Applications to Research: A Case of the University of Nairobi. *Journal of Educational Policy and Entrepreneurial Research*, *3*(12), 1-9. https://profiles.uonbi.ac.ke/kuria_paul/files/429-825-2-pb.pdf

Akinyode, B. F., & Khan, T. H. (2018). Step-by-step approach for qualitative data analysis. *International Journal of Built Environment and Sustainability - IJBES,* 5(3), 163-174. DOI: https://10.11113/ijbes.v5.n3.267

Allo, M. D. G. (2020). Is online learning good in the midst of Covid-19 Pandemic? The case of EFL learners. *Jurnal Sinestesia, 10*(1), 1-10. https://sinestesia.pustaka.my.id/journal/article/view/24

American Psychological Association. (2002). *Ethical principles of psychologists and code of conduct*. With the 2016 Amendment to Standard 3.04 Adopted August 3, 2016 Effective January 1, 2017. https://www.apa.org/ethics/code/ethics-code-2017.pdf

Anaeto, F. C., Asiabaka, C. C., Ani, A. O., Nnadi, F. N., Ugwoke F. O., Asiabaka I. P., Anaeto, C. A., & Ihekeronye, N. (2016). The roles of science and technology in national development. *International Standard Journal Number (ISJN),* 3 (3), 38-43. https://directresearchpublisher.org/drjsses/files/2016/12/Anaeto-et-al1.pdf

Attride-Stirling, J. (2001). Thematic networks: An analytic tool for qualitative research. *Qualitative research, 1*(3), 385-405. DOI: http://dx.doi.org/10.1177/146879410100100307

Babbie, E. (1983). *Practice of Social Research.* Wadsworth Publishing Company, Belmont. California.

Barrett, A. M., Gardner, V., Joubert, M., & Tikly, L. (2019). *Approaches to strengthening secondary STEM & ICT education in Sub-Saharan Africa.* MasterCard Foundation. https://mastercardfdn.org/wp-content/uploads/2019/07/Strengthening-STEM-ICT-in-Sub-Saharan-Africa-v.F.pdf

Boren, M. (2022). *A Blueprint to solve teacher shortages*. Southern Regional Education Board (SREB) April Report 2022. https://www.sreb.org/sites/main/files/file-attachments/blueprint_2022_links.pdf?1651168612

Bourdon, J., Frölich, M., & Michaelowa, K. (2007). *Teacher shortages, teacher contracts and their impact on education in Africa.* IZA - Discussion Paper No. 2844 . https://repec.iza.org/dp2844.pdf

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101.

https://www.researchgate.net/publication/235356393_Using_thematic_analysis_in_psychology

British Psychological Society. (2010). Code of Human Research Ethics. BPS. https://www.bps.org.uk/

Caracelli, V. J., & Greene, J. C. (1993). Data analysis strategies for mixed method designs. *Educational Evaluation and Policy Analysis, (15)*2, 195-207. https://vt.instructure.com/files/321861/download?download_frd=1

Carver-Thomas, D., & Darling-Hammond, L. (2019). The trouble with teacher turnover: How teacher attrition affects students and schools. *Education Policy Analysis Archives*, 27(36). http://dx.doi.org/10.14507/epaa.27.3699

Cheung, D. (2018). The key factors affecting students' interest in school science lessons. *International Journal of Science Education*, *40*(1), 1-23. https://dx.doi:10.1080/09500693.2017.1362711

Clarke, V., & Braun, V. (2013). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The Psychologist, 26*(2), 120-123. https://www.researchgate.net/publication/269928387_Teaching_thematic_analysis_Overcoming_challenges_and_developing_strategies_for_effective_learning

Cobbold, C. (2015). Solving the teacher shortage problem in Ghana: Critical perspectives for understanding the issues. *Journal of Education and Practice, 6*(9), 71-80. https://files.eric.ed.gov/fulltext/EJ1082464.pdf

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39*(3), 124-130. https://people.ucsc.edu/~ktellez/Creswell_validity2000.pdf

Croft, M., Guffy, G., & Vitale, D. (2018). Encouraging More High School Students to Consider Teaching. *Act Research and Policy.* Brief Issue. https://www.luminafoundation.org/wp-content/uploads/2018/09/encouraging-more-hs-students-to-consider-teaching.pdf

Dee, T. S., & Goldhaber, D. (2017). *Understanding and addressing teacher shortages in the united states*. The Hamilton Project. https://www.brookings.ed/wp-content/uploads/2017/04/es_20170426_understanding_and_addressing_teacher_shortages_in_us_pp_dee_goldhaber.pdf

Dlamini, Z. T. (2014). *Factors associated with the shortage of physics teachers in senior secondary schools in Swaziland*. A dissertation submitted for the fulfillment of Master of Education - with specialization in curriculum studies. The University of South Africa. https://pdfs.semanticscholar.org/ed7d/a554b9c977dbed8926c3ea1f5a0f2607e965.pdf

Dolenc, K., Šorgo, A., & Virtičs, P.M. (2021). Signs of a catastrophe: a predicted shortage of teachers of lower secondary science and technics and technology in Slovenia. *Journal of Elementary Education*, *14*(2), 239-256. https://www.researchgate.net/publication/352998649_Signs_of_a_Catastrophe_Predicted_Shortage_of_Teachers_of_Lower_Secondary_Science_and_Technics_and_Technology_in_Slovenia

Elliniadou, E., & Safianopoulou, C. (2022). "*A STEM intervention on students' attitudes towards science*," 2022 IEEE Global Engineering Education Conference (EDUCON), 386-393. https://ieeexplore.ieee.org/document/9766715

Estome, S. E., & Lyonga F. I. N. (2020). Student-teacher ratio and students' academic performance in public universities: The case of the University of Buea, Cameroon. *European Journal of Education Studies* 7(6). https://oapub.org/edu/index.php/ejes/article/view/3110/5747

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics. 5*(1), 1-4. https://www.researchgate.net/publication/304339244_Comparison_of_Convenience_Sampling_and_Purposive_Sampling

Evarist, A. (2019). Teacher – Student ratio on classroom practices in universal secondary schools in Wakiso District – Uganda. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS) 9*(4), 167-177. https://www.researchgate.net/publication/333774652_Teacher-Student_Ratio_on_Classroom_Practices_in_Universal_Secondary_Schools_in_Wakiso_District-Uganda

Flannery, M. E. (2020). *The teacher shortage can be addressed - With key changes*. NEA News. https://www.nea.org/advocating-for-change/new-from-nea/teacher-shortage-can-be-addressed-key-changes

Fomichova, K., & Misonou, T. (2018). parents' perception of previous and current science education system in Japan. *Indonesia Journal of Biology Education.* 4(2), 113-122. https://www.researchgate.net/publication/326283737_Parents'_perceptions_on_previous_and_current_science_education_system_in_Japan

Garcia, E., & Weiss, E. (2019). *The teacher shortage is real, large and growing, and worse than we thought.* The first report in 'The perfect storm in the teacher labor market' series. https://www.epi.org/publication/the-teacher-shortage-is-real-large-and-growing-and-worse-than-we-thought-the-first-report-in-the-perfect-storm-in-the-teacher-labor-market-series/

Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups *BDJ* 204, 291-295. https://www.nature.com/articles/bdj.2008.192

Government of the United Republic of Tanzania. (2020). *Basic Education Statistics in Tanzania: National Data.* Ministry of Education, Science and Technology.

Handal B., Watson, Petocs, P., & Maher, M. (2018). Choosing to teach in rural and remote schools: the zone of free movement. education research perspective: *An International Journal, 45*, 1-32. https://www.erpjournal.net/wp-content/uploads/2020/02/01_ERPV45_Handal.pdf.pdf

Hellsten, L. M., & Prytula, M. P. (2009). Why teaching? Motivations influence beginning teachers' choice of profession and teaching practice. *Research in Higher Education Journal*, 1-19. http://www.aabri.com/manuscripts/11882.pdf

HAKIELIMU. (2011). *Are our teachers qualified and motivated to teach?* a research report on teachers' qualifications, motivation, and commitment to teaching and their implications on quality education. http://hakielimu.org/files/publications/Are%20Our%20Teacher%20Motivated%20and%20Qualified%20to%20Teach.pdf

Hamilton, M., Mahera, W. C., Mateng'e, F. J., & Machumu, M. M. (2010). *A need assessment study of Tanzania science education.* A consultancy report by The Economic and Social Research Foundation (ESRF). http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_A_Needs_Assessment_Study_of_Tanzania_Science_Education.pdf

Ieren, T. G., & Innocent, E. (2017). Teachers' and students' perception of factors influencing interest in mathematics in Makurdi Municipality. *African Journal of Studies in Education*, *12*(1), 40-55. https://www.researchgate.net/publication/331386233_Teachers'_and_Students'_Perception_of_factors_influencing_interest_in_Mathematics_in_Makurdi_municipality

Ingersoll, R. (2003). *Is there a teacher shortage*? https://repository.upenn.edu/gse_pubs/133

Ingersoll, R. (2006). *Understanding supply and demand among mathematics and science teachers.* https://repository.upenn.edu/gse_pubs/136

Ingersoll, R., & Perda, D. (2009). The mathematics and science teacher shortage: fact and myth. *CPRE Research Reports*. https://repository.upenn.edu/cgi/viewcontent.cgi?article=1027&context=cpre_researchreports

International Labour Organization. (2008). *Income inequalities in the age of financial globalization / International Labor Office, International Institute for Labour Studies*. World of work report 2008 – Geneva: 180. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_100354.pdfJol

Kalufya, N., Michael, F., & Chalu, H. (2015). Assessing the Relationship between Human Resource Strategies and Local Content in Tanzania Oil and Gas Industry. *Asian Journal of Business and management, 7*, 55-62. https://www.semanticscholar.org/paper/Assessing-the-Relationship-between-Human-Resource-Kalufya-Michael/192d5a7f8920f520b66db5588d6894b49efb4509

Kamagi, D. (2017 April n.d.). *Tanzania needs over 24,000 science and mathematics teachers parliament told.* The Citizen Newspaper article. https://www.ippmedia.com/.../we-need-over-24000-science-and maths-teachers-parliament-told.html

Kapur, R. (2018). *Shortage of teachers in schools*. https://www.researchgate.net/publication/323725749_Shortage_of_Teachers_in_Schools

Kaur, S. (2021). Sample size determination. *International Journal of current research*, 9(03), 48365-48367. https://www.researchgate.net/publication/349862047_SAMPLE_SIZE_DETERMINATION

Kihwele, J. (2014). Students' perception of science subjects and their attitude in Tanzanian secondary schools. *World Journal of Educational Research,* 1(1), 1-7. https://www.researchgate.net/publication/340136798_STUDENTS'_PERCEPTION_OF_SCIENCE_SUBJECTS_AND_THEIR_ATTITUDE_IN_TANZANIAN_SECONDARY_SCHOOLS

Kimberlin, C. L., & Winterstein, A. G. (2008). Validity and reliability of measurements used in research. *American Journal of Health-System Pharmacists*, *65*(1), 2276-2284. https://www.ajhepworth.yolasite.com/resource/9817-reliability%20and%validity.pdf

King'aru, J. M. (2014). *Factors contributing to the poor performance of science subjects: A case of secondary schools in Kawe Division Kinondoni Municipality*. A Dissertation in partial fulfillment of the requirement for the Degree of Master Project Management of the Open University of Tanzania. http://repository.out.ac.tz/598/1/JAMES_MUCHWE_KING%E2%80%9DARU_Final_Thesis.pdf

Koc, N., & Celik, B. (2015). The impact of number of students per teacher on student achievement. *Procedia - Social and Behavioral Sciences 177 (2015)* 65-70. https://www.researchgate.net/publication/275670865_The_Impact_of_Number_of_Students_per_Teacher_on_Student_Achievement

Kothari, C. R. (2004). *Research methodology: Methods and techniques* New Age International (P) Limited Publishers. 2nd Multi Colour Edition. New Delhi, India. https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf

Kothari, C. R., & Garg, G. (2009). *Research methodology: Methods and techniques* New Age International (P) Limited Publishers. 4th Edition. New Delhi, India. https://www.newagepublishers.com/samplechapter/000896.pdf

Laming, M. M. (2008). *The shortage of teachers and its impact on sustainability education*. Conference Paper. https://www.researchgate.net/publication/235968875_The_shortage_of_teachers_and_its_impact_on_sustainability_education

Latifoglu, A. (2016). I quit: Why do so many young teachers abandon the profession? http://www.smh.com.au/comment/i-quit-why-do-so-many-young-teachers-abandon-the-profession-20160126-gmebbu.html

Lyimo, N. S., Too, J. K., & Kipng'etich, K. J. (2017). Assessment of teaching staff adequacy in Tanzanian community secondary schools: A case of Arusha District. *International Journal of Educational Policy Research and Review*, *4*(5), 81-89. https://journalissues.org/wp-content/uploads/2017/05/Lyimo-et-al.pdf

Magano, F. L. (2014). *A review of strategies to address the shortage of science and mathematics educators in grades 10-12.* Submitted in partial fulfillment of the requirements for the degree of Ph.D. in Education in the Department of Education management Law and Policy at the University of Pretoria Faculty of Education. https://repository.up.ac.za/bitstream/handle/2263/43155/Magano_Review_2014.pdf?sequence=1&isAllowed=y

Maguire, M., & Delahunt, B. (2017). Doing a Thematic Analysis: A Practical, Step-by-Step Guide for Learning and Teaching Scholars. *All Ireland Journal of Higher Education (AISHE-J), 8*(3), 3351-33514. https://ojs.aishe.org/index.php/aishe-j/article/view/335/553

Malanga, A. (2019 May 8). "*Tanzanian Schools Face Shortage of 80,000 Teachers*." The Citizen, 2019. https://allafrica.com/stories/201905080873.html

Mamlok-Naaman, R. (2015). Reform in science education in Tanzania. *Weizmann Institute of Sciences,* Rehovot 76100, Israel. https://www.researchgate.net/publication/271418466_A_Reform_in_Science_Education_in_Tanzania

Mangrubang, F. R. (2005). Issues and trends in science education: The shortage of qualified science teachers. *Spring, 150*(1), 42-46. https://pubmed.ncbi.nlm.nih.gov/15969222/

Manyengo, P. R. (2021). *Digitalization in teaching and education in the United Republic of Tanzania Digitalization, the future of work and the teaching profession project*. Report to International Labour Office, Geneva, Switzerland. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_783673.pdf

Mazana, M. Y., Montero, C. S., & Casmir, R. O. (2019). Investigating Students' Attitude towards Learning Mathematics. *International Electronic Journal of Mathematics Education, 14*(1), 207-231. https://doi.org/10.29333/iejme/3997

Mazana, M. Y., Montero, C. S., & Casmir, R. O. (2020). Assessing students' performance in mathematics in Tanzania: The teacher's perspective. *International Electronic Journal of Mathematics Education*, 15(3), 1-28. https://www.iejme.com/download/assessing-students-performance-in-mathematics-in-tanzania-the-teachers-perspective-7994.pdf

McKenna, B. (2018). US *Teacher shortages - causes and impacts*. Memo August 2018. Learning Policy Institute. https://learningpolicyinstitute.org/sites/default/files/body/Teacher_Shortages_Causes_Impacts_2018_MEMO.pdf

Mlay, N. (2010). *Influence of the language of instruction on students' academic performance in secondary schools: A comparative study of urban and rural schools in Arusha- Tanzania.* A thesis submitted in partial fulfillment of the requirement for the degree of Master of Philosophy in Comparative and international education. Institute of Educational Research University of Oslo. https://www.academia.edu/32697947/the_influence_of_the_language_of_instruction_on_students_academic_performance_in_secondary_schools_in_Arusha_tanzania?email_work_card_=view-paper

Michael, I. (2015). *Factors leading to poor performance in mathematics subjects in Kibaha secondary schools*. A Dissertation submitted in partial fulfillment of the requirement for the degree of master of education in administration, planning and policy studies (med. Apps) of the Open University of Tanzania. http://repository.out.ac.tz/1293/1/Dissertation_-_Isack%27s_Final.pdf

Moshi, H.P.B. (2014). Opportunities and challenges for the extraction of natural gas in Tanzania: The imperative of adequate preparedness. *African Journal of Economic Review, 1*(1), 25-37. https://www.ajol.info/index.php/ajer/article/view/116288/151739

Munna, A. S., & Kalam, M. A. (2021). Teaching and learning process to enhance teaching effectiveness: a literature review. *International Journal of Humanities and Innovation (IJHI) 4*(1), 1-4. https://files.eric.ed.gov/fulltext/ED610428.pdf

Ndalichako, J. L., & Komba, A. A. (2014). Students' subject choice in secondary schools in Tanzania: A matter of students' Ability and interests or forced circumstances? *Open Journal of Social Sciences,* 2, 49-56. *http://dx.doi.org/10.4236/iss.2014.28008*

Neale, J., Miller. P., & West, R. (2014). Reporting quantitative information in qualitative research: guidance for authors and reviewers. *Addiction, 109,* 175-175. https://pubmed.ncbi.nlm.nih.gov/24422609/

Nedev, R. (2014). The importance of teaching science and technology in early education levels in an emerging economy. *Bulletin of Science, Technology & Society.* 1-7. https://www.academia.edu/22368970/The_Importance_of_Teaching_Science_and_Technology_in_Early_Education_Levels_in_an_Emerging_Economy

New York Educational Conference Board. (2020). *Shortage of substitute teachers and lack of educator diversity add to the challenges.* Sayaans' News. https://saanys.org/news/teacher-shortages-impede-educational-opportunities-for-students/

Nghambi, G. H. (2014). *Factors contributing to poor academic performance in certificate of secondary education examination for community secondary schools in Urambo District, Tabora, Tanzania*. Dissertation submitted in fulfillment of the requirements for the Degree of Master of Education in Administration, Planning and Policy Studies of the Open University of Tanzania. https://core.ac.uk/download/pdf/44684818.pdf

Ngema, M. H. (2016). Factors that cause poor performance in science subjects at Ingwavuma Circuit. Submitted by the requirement for the Degree of Master of Education the subject of natural science education at the University of South Africa. http://uir.unisa.ac.za/bitstream/handle/10500/23003/dissertation_ngema_mh.pdf?sequence=1

Noble, H., & Heale, R. (2019). Triangulation in research, with examples. *Evid Based Nurs, 22*(3), 67-68. https://www.researchgate.net/publication/333794057_Triangulation_in_research_with_examples/link/5dcf19fe4585156b351642e1/download

Nuffic. (2015). *Education system Tanzania*. Nuffic 1st Ed, Version 1. https://www.nuffic.nl/sites/default/files/2020-08/education-system-tanzania.pdf

Olanrewaju, M. K., & Mremi, J. D. (2021). Tanzania online education challenges during coronavirus pandemic. In Verma, K., Mullemwar., S. Y., Sigh, G. Malik, L., & Tara, K. (2021). (Eds.), *Interdisciplinary Research and Innovation. (*pp19-22). First Edition. JPS Scientific Publications, India. www.jpsscientificpublications.com

Osaki, K. M. (2007). *Towards a relevant education for science and mathematics, language, and skills development about existing market demands*. Annual Education Sector Review Ministry of Education and Vocational Training. http://www.tzdpg.or/tz>education>JESR09Kalafunjarelevanceofeducation

Osaki, K. M. (2007). Science and mathematics teacher preparation in Tanzania: Lessons from teacher improvement projects in Tanzania 1965-2006. *NUE Journal of International Education Cooperation*, *2*(1), 51-64. https://www.researchgate.net/publication/313045389_Science_and_mathematics_teacher_preparation_in_Tanzania_Lessons_from_teacher_improvement_projects_in_Tanzania_1965-2006

Padhi, G. (2021). Factors affecting teaching-learning process. *International Journal of Creative Research Thoughts (IJCRT), 9*(4), 2418-2423. https://ijcrt.org/download.php?file=IJCRT2104308.pdf

Pister, K. S. (2007). The shortage of science teachers. *Science, 317*(5837), 451-452. https://www.science.org/doi/full/10.1126/science.317.5837.450c

Podolsky, A., Kini, T., Bishop, J., & Darling-Hammond, L. (2016). *Solving the teacher shortage: how to attract and retain excellent educators* (research brief). Palo Alto, CA: Learning Policy Institute. https://learningpolicyinstitute.org/product/solving-teacher-shortage-brief

Projest, G. (2013). *The effects of shortage of teachers on curriculum implementation in community secondary schools in Tanzania, the case of Bukoba Municipality*. MA Dissertation. http://repository.out.ac.tz/911/1/Godfrey_Projest_final.pdf

Saga, W. M. (2014). *Access and quality challenge facing community secondary schools: A case of Kilolo District Iringa, Tanzania*. Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Education in administration, Planning and Policy Studies of the Open University of Tanzania. https://core.ac.uk/download/33424927.pdf

Sijaona, R.J., & Kitula, P. R. (2022). Assessment of the shortage of science and mathematics teachers and its effects on secondary education in Karatu District. *Journal of Research Innovation and Implications in Education, 6*(3), 538-548. https://jriiejournal.com/wp-content/uploads/2022/10/JRIIE-6-3-047.pdf

South Africa Council of Educators. (2011). Redefining Role and Functions of the South African Council for Educators(SACE). https://sace.org.za/assets/documents/uploads/sace_61547-2016-08-31-The%20Role%20of%20the%20South%20African%20Council%20for%20Educators.pdf

Saks, K., Soosaar, R., & Ilves, H. (2016). The students' perceptions and attitudes to teaching profession, the Case of Estonia. *The European Proceedings of Social and Behavioural Science (EpSBS).* A conference Paper. https://www.researchgate.net/publication/310739162_The_Students'_Perceptions_and_Attitudes_to_Teaching_Profession_the_Case_of_Estonia

Saavedra, J. (2020). *Educational challenges and opportunities of the coronavirus (COVID-19) Pandemic*. World Bank Blogs. https://blogs.worldbank.org/education/educational-challenges-and-opprtunities-covid-19-pandemic

Silverman, D. (2017). *Doing qualitative research.* 5th Edition. London, Sage. https://www.researchgate.net/publication/279187479_Qualitative_Research

Sterling, D. R. (2020). The teacher's shortage: National trend for science and mathematics teachers. *The Journal of Mathematics and Science: Collaborative Explorations 7,(2004)* 85-96. https://www.scholarscompass.vcu.edu/cgi/viewcontent.cg?article=1225&context=jmsce_vansc

Sumra, S., & Rajani, R. (2006). *Secondary education in Tanzania: Key policy challenges*. Working paper on the Norwegian Post- Primary Education Fund for East Africa (NPEF), Oslo, 13-14. September 2006. *In* Jidamva, G. (2012). Understanding and improving the quality of secondary school education: Conceptions among teachers in Tanzania. Åbo Akademi University Press Åbo, Finland. http://bibbild.abo.fi/ediss/2012/jidamva_george.pdf

Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2016). *A coming crisis in teaching? teacher supply, demand, and shortages in the U.S.* Palo Alto, CA: Learning Policy Institute. https://learningpolicyinstitute.org/product/coming-crisis-teaching

Taasisi ya Maendeleo Shirikishi ya Vijana Arusha (TAMASHA). (2010). *Education schooling or fooling?* TAMASHA Report. https://www.twaweza.org/uploads/files/Education%20Tamasha.pdf

Taherdoost, H. (2016). Validity and reliability of the research instrument: How to test the validation of a questionnaire/survey in a research. *International Journal of Academic Research in Management (IJARM)*, 5. https://hal.archives-ouvertes.fr/hal-02546799/document

The Citizen. (2018 February 05). *Why students continue to perform poorly in Maths.* https://www.thecitizen.co.tz/tanzania/magazines/success/-why-students-continue-to-perform-poorly-in-maths-2669752

The Citizen. (2022 February 22). Solve teacher shortage to avoid further agony. *The Citizen Editorial note*. https://www.thecitizen.co.tz/tanzania/oped/editorial-solve-teacher-shortage-to-avoid-further-agony-3725408

Turner, P., & Turner, S. (2009). Triangulation in Practice. *Virtual Reality* *13*(3):171-181. DOI:10.1007/s10055-009-0117-2

Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment strategies for enhancing students' mathematical problem-solving skills: A review of literature *Eurasian Journal of mathematics, science and technology education, 17*(3). DOI:10.29333/ejmste/9728

UNESCO. (2006). Teachers and Educational Quality: Monitoring Global Needs for 2015. Montreal: UNESCO Institute for Statistics. www.unesco.org

UNESCO. (2013). *A teacher for every child: Projecting Global Teacher Needs from 2015 to 2030*. UIS Fact Sheet. http://uis.unesco.org/sites/default/files/documents/fs27-a-teacher-for-every-child-projecting-global-teacher-needs-from-2015-to-2030-en.pdf

UNESCO. (2020). *Policy Brief: Education during COVID-19 and beyond*. August 2020 report. 1-26. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/08/sg_policy_brief_covid-19_and_education_august_2020.pdf

United Nations International Children's Emergency Fund – UNICEF. (2018). *Education budget brief - 2018* Tanzania Report. https://www.unicef.org/tanzania/media/1236/file/UNICEF-Tanzania-2018-Education-Budget-Brief.pdf

URT-MOEVT. (2010). *The United Republic of Tanzania, Ministry of Education and Vocational Training: Basic Mathematics Syllabus for Secondary Schools – from I to IV*, (2nd Edition). Tanzania Institute of Education (TIE): Dar es Salaam.

Uwineza, I. Rubagiza, J., Hakizimana, T., & Uwamahoro, J. (2018). Gender attitudes and perceptions towards mathematics performance and enrolment in Rwandan secondary schools. *Rwandan Journal of Education, 4*(2), 44-56. https://www.ajol.info/index.php/rje/article/view/175131/164518

Wedgwood, R. (2007). Education and poverty reduction in Tanzania. *International Journal of Educational Development, 27,* 383-396. https://assets.publishing.service.gov.uk/media/57a08c76ed915d3cfd0013e0/OXCON_Wedgwood_final.pdf

Weiner, B. (1986). An attributional theory of motivation and emotion. New York: Springer-Verlag. https://link.springer.com/book/10.1007/978-1-4612-4948-1

Wong, L. P. (2008). Data Analysis in Qualitative Research: A Brief Guide to Using NVivo. *Malays Fam Physician, 3*(1), 14-40. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4267019/

White, B. (2019). *The impacts of the teachers' shortage.* The Educators Room. https://theeducatorsroom.com/the-impacts-of-the-teacher-shortage/

Wojatzki, M., Mohammad, S., Zesch, T., & Kiritchenko, S. (2018). *Quantifying qualitative data for understanding controversial issues. In* Proceedings of the 11th edition of the Language Resources and Evaluation Conference, Miyazaki, Japan, May 2018. https://aclanthology.org/L18-1224.pdf

APPENDICES

Appendix A: Formatting Appendices

Interview Guide Questions for the Teachers

Background Information

1. Gender: Male .....

Female ……

2. Name of school .....

3. District …….

4. Date .....

Questions:

5. For how long have you been working at this school?

6. Which subjects are you teaching in this School?

7. How many classes do you teach at this school? (a) One (b) Two (c) More than two.

8. a). Have you experienced any scarcity of science and mathematics teachers at your school? YES/NO. (Put a tick where appropriate)

(b) If YES, explain why?

i. …….. ii.

…….……. iii.

…….…….

9. (a) How do you compare the shortage of science and mathematics teachers with other subject teachers in this school?

……..

……..

(b) Does the scarcity of science and mathematics affect your teaching loads in the teaching profession? YES/NO. (Put a Tick (v) where appropriate)

(c)) c) If YES, describe how it impacts you

…….

10. a). What are the causes of the scarcity of science and mathematics teachers in your school?

i.) ……..

ii.) ……..……

iii.) ……..……

iv.) ……..…….

v.) ……..

11. Are you concerned with the scarcity of science and mathematics teachers in your school? YES/NO. (Tick (v) where Appropriate) (b) If YES, explain

i). ……..……...……

ii). ……

iii) ……

iv) ……..……

12. a) Does the scarcity of science and mathematics teachers affect students' performance YES/NO (Tick (v) where Appropriate) (b) If YES, explain how?

……..…

……..

…….…….

13. What strategies do you have to improve the performance of your science and mathematics classes in this school?

i). …….

ii). ……..

iii)……..

iv)……..

14. (a) Does the scarcity of science and mathematics teachers have any impact on student choice of subjects? (b) If YES, explain how it affects you

i). ……

ii). ……...

iii)……

iv)……

(c) If YES, what are those impacts?

i) ……. ii)

…… iii)

……..

iv) ……...

v) ……...

(d) What measures do you take to reduce the impacts?

i. ……...… ii.

……...…… iii.

……...

iv. ……..……

15. Are the impact of the shortage of science and mathematics teachers have any problems in the educational system? If YES, explain how it affects the educational system.

i. …… ii.

…… iii.

……...…… iv.

…… v.

……..……

17 (a) Does the School Management have some strategies to minimize the scarcity of science and mathematics teachers? YES/NO (Tick (V) where appropriate)

(b) If YES/What are those strategies?

i. …….

ii. ……. iii.

……. iv.

……. v.

…….

18 (a) Are those school management strategies reducing the problem, YES/NO put a (Teck (V) where appropriate)

(b) If NO, what strategies would you advise the school Management to adopt?

i) …….

ii) …….

iii) ……

iv)……...……..

19. Provide your opinion on how to reduce the scarcity of science and mathematics teachers in your secondary school.

i) ……

ii) ……

iii) ……..

iv) ……

Questionnaire for Secondary Students

Background Information

1. Gender: Male .....Female ……

2. Name of school .....

3. Class/Form ……..

4. District …….

5. Date .....

Questions

6. (a) Do you have enough science and mathematics teachers in your school? YES/NO put a (Tick (V) where appropriate)

(b). Explain why?.....

7. Which combination of science subjects are you studying? (Tick (V) the appropriate)

i. CBG – Chemistry, Biology, and Geography

ii. PCM – Physics, Chemistry, and Mathematics

iii. EGM – Economics, Geography, and Mathematics

iv. PGM – Physics, Geography, and Mathematics

v. PCB – Physics, Chemistry, and Biology

vi. CBN – Chemistry, Biology, and Nutrition

vii. CBA – Chemistry, Biology, and Agriculture

8. Why did you choose those subjects and not others?

i. ……. ii.

…… iii.

……

9. a). What are the causes of the scarcity of science and mathematics teachers in your school?

i). ……..

ii). …...……..……

iii). ..…….……

iv). ……...

v). ..……..

10. What are the effects of the shortage of science and mathematics teachers in your school?

(ii) …….……

(iii) …….

(iv) …….

(v) …….

11. a). Is this shortage of science and mathematics teachers have effects on your academic performance? YES/NO put a (Tick (V) where appropriate).

b). If YES, what are the effects?

(i) ……

(ii) …….

(iii) …….

(iv) …….

12. (a) What are the measures taken by the school management against this shortage to make sure that you are not affected in academic performance?

(i) ……..…

(ii) …….

(iii) …….

(iv) ……

(v) ……..……...

b) Do you think the measure mentioned above will solve the problem of the shortage of science and mathematics teachers? YES/NO put a (Tick (V) where appropriate).

c). If NO, what do you think can be done to solve this problem forever?

(i) ……

(ii) …….

(iii) …….

(iv) …….

(v) ……....

13. (a) Does the shortage of science and mathematics teachers them discourage from joining science combination at an advanced level? YES/NO put a (Tick (V) where appropriate). If YES, explain.

(i) …….

(ii) …….

(iii) …….

(iv) …….

14. a) Does the shortage of science and mathematics teachers hinder you from covering the science and mathematics syllabus? YES/NO put a (Tick (V) where appropriate).

b) If YES, which specific subject is affected the most?

……

c) What other efforts do you take to finish up the science and mathematics syllabi?

15. (a) Do you think the scarcity of science and mathematics teachers will affect your future career? YES/NO put a (Tick (V) where appropriate).

b). If Yes, explain how and why?

(i) …….

(ii) …….

(iii) …….

(iv) …….

16. a). Is the scarcity of science and mathematics teachers affecting your future life? YES/NO (Tick (V) where appropriate).

(b) If YES explain how.

(i) …….

(ii) ……

(iii) ……...

(iv)……

17. c). Are your parents have any concerns about this scarcity of science and mathematics teachers? YES/NO (Tick (V) where appropriate).

(b) If YES explain why.

(i) …….

(ii) ……

(iii) ……..

(iv) ……..

18. a). Are there any measures taken by your parents to solve the issue of the scarcity of science and mathematics teachers in your school? YES/NO (Tick (V) where appropriate).

b) If NO what do you think could be done to solve this problem?

(i) ……..……..

(ii) ……..

(iii) …….

(v) ……..…….

c). If YES, what are the measures?

i). …….

ii). ……

iii)…….

iv)…….

19. Provide your opinion on how to reduce the scarcity of science and mathematics teachers in your secondary school.

i) …… ii)

……..... iii)

……

Interview Guide Questions for the Education Officers (District Levels)

Background Information

1. Gender: Male …….

2. Female …….

3. Name of school ……

4. District …….

5. Date .....

Questions:

6. For how long have you been working in this office? ……..

7. (a) How many secondary schools have ordinary level to advanced level in your district/region? …….

(b) How many schools are teaching science and mathematics subjects at A-Level? ……

c) How many are teaching mathematics subjects? ……..

8. a). Do you have any information on the shortage of science and mathematics teachers in secondary schools in your district? YES/NO. (Tick (V) where appropriate). If YES, how many schools are facing this problem? ……

b). How do you get information on the shortage of teachers in secondary schools in your district?

i. ……..……

ii. ……..……

iii. ……..

9. Which among the following subjects is facing a great shortage of teachers in secondary schools in your District? (Tick (V) where appropriate)

(i) Science and mathematics.

(ii) Arts.

(iii) Business.

(iv) other subjects

10. What do you think are the causes of the shortage of science and mathematics teachers in secondary schools in your District?

i) ……..… ii)

. ….…….…….. vi)i)

…….. vii)ii)

……..

viii)iii) ……..

11. (a) Are there any strategies that your office has to assist secondary schools to reduce the scarcity of science and mathematics teachers in your districts? YES/NO. (Tick (V) where appropriate).

(b) If YES, what are those strategies?

i). ……..……

ii). ……..……

iii). ……

iv). …….

v). ……..

vi). …….

12. To what extent are your office assisted secondary schools in solving the problem of the scarcity of science and mathematics teachers in the District?

a). ……..

b). ……..

c). ……..

13. a). Do you think the strategies to solve the problem of scarcity of science and mathematics teachers in secondary schools have minimized the problem? YES/NO ((Tick (V) where appropriate).

(b) If YES, to what extent? …….

c). If NO, why? ……

14. Are the schools in your District have some strategies to manage the problem of the scarcity of science and mathematics in secondary schools? YES/NO (Tick (V) where appropriate).

(b) If YES, what are the strategies?

i. ……..... ii.

…… iii.

…….

15. a) Are you satisfied with the examination results from the schools in your District? YES/NO. (Tick (V) where appropriate).

(b) If NO, Why?

……

……

……

16. a) What do you suggest to be done to minimize the problem of the scarcity of science and mathematics teachers in secondary schools in your District?

i). ……..…

ii). ……..……

iii). ……

iv). ……

Appendix B: Useful Resources

Provisional Approved UREC Forms

UNICAF UNIVERSITY

REAF_DSPA - Version 1.0

UNICAF UNIVERSITY
RESEARCH ETHICS APPLICATION FORM
DOCTORAL STUDIES PROVISIONAL APPROVAL

The Provisional Approval - Research Ethics Application Form (REAF) should be completed by Doctoral level candidates enrolled on Dissertation stage 1.

This form is a **provisional approval** which means that the UREC committee has accepted the initial description of the project but this is conditional as changes may have to be implemented following Dissertation Stage 2 and piloting in Dissertation Stage 3.

This is a conditional offer and acceptance of the project needs to be verified and confirmed upon completion of the Research Ethics Application Form in Dissertation Stage 3.

Important Notes:

- An electronic version of the completed form should be uploaded by the student to the relevant submission link in the VLE. Student's supervisor will then review the form and provide feedback commentary. Once supervisor's initial approval is given then the supervisor will forward this to doctoral.studies-aa@unicaf.org for provisional approval by the Unicaf University Research Ethics Committee (UREC).
- Please type your answers and **do not** submit paper copy scans. Only *PDF* format documents should be submitted to the committee.
- If you need to supply any supplementary material, not specifically requested by the application form, please do so in a separate file. Any additional document(s) should be clearly labelled and uploaded in the relevant VLE link.
- If you have any queries about the form, please address them to your dissertation or project supervisor.

Josephine Donald Mwemi K1704020601335 1

UNICAF UNIVERSITY

REAF_DSPA - Version 1.0

UNICAF UNIVERSITY RESEARCH ETHICS APPLICATION FORM DOCTORAL STUDIES PROVISIONAL APPROVAL	UREC USE ONLY: Application No: Date Received:

Student's Name: Josephine Donald Mremi

Student's E-mail Address: josengalas@gmail.com

Student's ID #: R1704D2601935

Supervisor's Name: Dr. Muraina Kamilu Olanrewaju

University Campus: Unicaf University Malawi (UUM)

Program of Study: UUM: PhD Doctorate of Philosophy - Education

Research Project Title: Factors Causing the Scarcity of Science and Mathematics Teachers and the Imparts on Secondary Schools in Tanzania

1. **Please state the timelines involved in the proposed research project:**

Estimated Start Date: 25-Nov-2019 Estimated End Date: 31-Dec-2020

2. **The research project**

a. **Project Summary:**

In this section please fully describe the purpose and underlying rationale for the proposed research project. Ensure that you pose the research questions to be examined, state the hypotheses, and discuss the expected results of your research and their potential.

It is important in your description to use plain language so it can be understood by all members of the UREC, especially those who are not necessarily experts in the particular discipline. To that effect please ensure that you fully explain / define any technical terms or discipline-specific terminology (maximum 300 words +/- 10%).

The purpose of this research is to determine the factors that are causing the scarcity of of science and mathematics teachers and assess the impacts on secondary schools in Tanzania. The scarcity has prevailed for a long time despite of several efforts taken and some reforms in education system. From the literature it has been confirmed that there is this scarcity of science and mathematics teachers in secondary schools in the country (Ndalichako & Komba 2014; Osaki, 2007; Kamagi, 2007; UNESCO, 2008; TAMASHA, 2010; Project, 2018; Wedgwood, 2007).

From literature there is also limited information on the factors that are causing this scarcity and maintain the problem for many years. The current study is working to find out the factors contributing to the scarcity of secondary school science and mathematics teachers and make assessment of the impacts caused by this scarcity problem on the secondary schools in the country. The study will examine the participants' interest on science and mathematics teaching in secondary schools in Tanzania. Also the study will evaluate the efficiency of the approaches used by the school management to reduce the impacts of science and mathematics teacher's scarcity in secondary schools in Tanzania. Moreover the study will determine the ways to minimize the scarcity and the impacts of the scarcity of the these important science and mathematics teachers subjects.

b. Significance of the Proposed Research Study and Potential Benefits:

Outline the potential significance and/or benefits of the research (maximum 200 words).

From the literature there is limited information available on the factors causing the scarcity of science and mathematics teachers and also the impacts on the secondary schools in Tanzania. However, the literature confirms the existence of the problem in the country. Therefore, the current research will contribute a potential benefits to the government and other educational stakeholders.

The expected research study results for the causes of the scarcity science and mathematics and the impacts on secondary schools will be of benefit to the different education stakeholders who will used them to resolve the problem. The findings will be useful to address the issues hindering the rapid growth of the science and mathematics in secondary schools in the country. The study will provide the ways to minimize the impacts of the scarcity on secondary schools.

3. **Project execution:**

a. Type of project. The following study is an:

- [x] experimental study (primary research)
- [ ] desktop study (secondary research)
- [ ] desktop study using existing databases involving information of human/animal subjects
- [ ] Other

If you have chosen 'Other' please Explain:

b. **Methods. The following study will involve the use of:**

Method	Materials / Tools
☑ Qualitative	☐ Face to Face Interviews Phone
	☑ Interviews
	☑ Face to Face Focus Groups
	☐ Online Focus Groups
	☐ Asynchronous Focus Groups
	☐ Other*
☐ Quantitative	☐ Face to Face Questionnaires
	☐ Online Questionnaires
	☐ Experiments
	☐ Tests
	☐ Other *

*If you have chosen 'Other' please Explain:

4. **Participants**

a. **Does the Project involve the recruitment of participants?**

☑ YES **If YES, please complete all following sections.**

☐ NO **If NO, please directly proceed to Question 5.**

Note: The definition of "participation" includes active participation, such as when participants knowingly take part in an interview or complete a questionnaire.

b. Relevant Participant Details of the Proposed Research

Please state the number of participants you plan to recruit, and describe important characteristics such as: demographics (e.g. age, gender, location, affiliation, level of fitness, intellectual ability etc). It is also important that you specify any inclusion and exclusion criteria that will be applied (e.g. eligibility criteria for participants).

Number of participants: 96

Age range: From 15 To 60

Gender: ☑ Female ☑ Male

Eligibility Criteria:

- Inclusion criteria: At the Regional and District levels only Education officers will be involved in the research study. At school level, the teachers who are teaching science and mathematics subjects will be involved in the research and the students who are studying those science and mathematics subjects will be participate in the study. Both public and government schools will be purposive selected and be involved in this research study.

- Exclusion criteria: Teachers who are not teaching Science and Mathematics in secondary schools will not participate in the research study. Also the students who are not studying science and mathematics will not be involve in this research study.

Disabilities:

Other relevant information (maximum 100 words):

c. Recruitment Process for Human Research Participants:

Please clearly describe how the potential participants will be identified, approached and recruited (maximum 200 words).

This research will be conducted in Tanzania's Education Sector. It will involve participants from the Regional, District and Secondary Schools in two Districts in the Region. The principal researcher will visit the office of Regional Administration Secretary (RAS) to obtain an informed consent and introduction letter that will inform the District Education Office (DEO) to accept the researcher to conduct the research study in secondary schools in two Districts. This permission will be obtained following the submission of an introduction letter from the UNICAF University.
On acceptance of the letter, the DEO office will allow the researcher visit the secondary schools in the district and collect the research information using both structured and non-structured interviews guide questions and focus group discussion. The researcher will proceed to secondary schools where the school management will allow the researcher to purposively select participants from the school as per proposed research study. The selection will consider the science and mathematics teachers and the students who are studying science and mathematics subjects in the school. Before selecting the participants, the researcher will explain about the research purpose to teachers and students in the particular school. Then the selection will follow as planned in the research proposal. When selected the participants will be informed on their right to agree or refuse to join the research and that they allowed to withdraw from the research at any time as they wish.

d. Relationship between the principal investigator and participants:

Is there any relationship between the principal investigator (student), co-investigators(s), (supervisor) and participant(s)? For example, if you are conducting research in a school environment on students in your classroom (e.g. instructor-student).

☐ YES ☑ NO

If YES, please specify (maximum 100 words).

5. Further Approvals

Are there any other approvals required (in addition to ethics clearance from UREC) in order to carry out the proposed research study?

☑ YES ☐ NO

If YES, please specify (maximum 100 words).

To carry out the research study in area the UNICAF University has to introduce the researcher to the Regional Administration Secretary (RAS) as the student who want to conduct a research in the region. On the acceptance the office of RAS will introduce the researcher to the Districts Education Offices (DEO) in the study area. The DEO will permit and introduce the researcher to secondary school heads and allow the researcher conduct the research in Secondary Schools in the District.

6. **Potential Risks of the Proposed Research Study**

Are there any potential risks, psychological harm and/or ethical issues associated with the proposed research study, other than risks pertaining to everyday life events (such as the risk of an accident when travelling to a remote location for data collection)?

☐ YES ☑ NO

If YES, please specify (maximum 150 words):

7. **Application Checklist**

Please mark √ if the study involves any of the following:

☑ Children and young people under 18 years of age, vulnerable population such as children with special educational needs (SEN), racial or ethnic minorities, socioeconomically disadvantaged, pregnant women, elderly, malnourished people, and ill people.

☐ Research that foresees risks and disadvantages that would affect any participant of the study such as anxiety, stress, pain or physical discomfort, harm risk (which is more than is expected from everyday life) or any other act that participants might believe is detrimental to their wellbeing and / or has the potential to / will infringe on their human rights / fundamental rights.

☐ Risk to the well-being and personal safety of the researcher.

☐ Administration of any substance (food / drink / chemicals / pharmaceuticals / supplements / chemical agent or vaccines or other substances (including vitamins or food substances) to human participants.

☐ Results that may have an adverse impact on the natural or built environment.

8. **Final Declaration by Applicants:**

(a) I declare that this application is submitted on the basis that the information it contains is confidential and will only be used by Unicaf University and Unicaf University Research Ethics Committee (UREC) for the explicit purpose of ethical review and monitoring of the conduct of the research proposed project as described in the preceding pages.

(b) I understand that this information will not be used for any other purpose without my prior consent, excluding use intended to satisfy reporting requirements to relevant regulatory bodies.

(c) The information in this form, together with any accompanying information, is complete and correct to the best of my knowledge and belief and I take full responsibility for it.

(d) I undertake to abide by the highest possible international ethical standards governing the Code of Practice for Research Involving Human Participants, as published by the UN WHO Research Ethics Review Committee (ERC) on http://www.who.int/ethics/research/en/ and to which Unicaf University aspires to.

(e) In addition to respect any and all relevant professional bodies' codes of conduct and/or ethical guidelines, where applicable, while in pursuit of this research project.

(f) I understand it is my responsibility to submit a full REAF application during Dissertation Stage 3 to UREC. If a REAF application is not submitted my project is not approved by UREC.

(g) I fully acknowledge that this form does not constitute approval of the proposed project but it is only a provisional approval.

☑ **I agree with all points listed under Question 8**

Student's Name: Josephine Donald Mremi

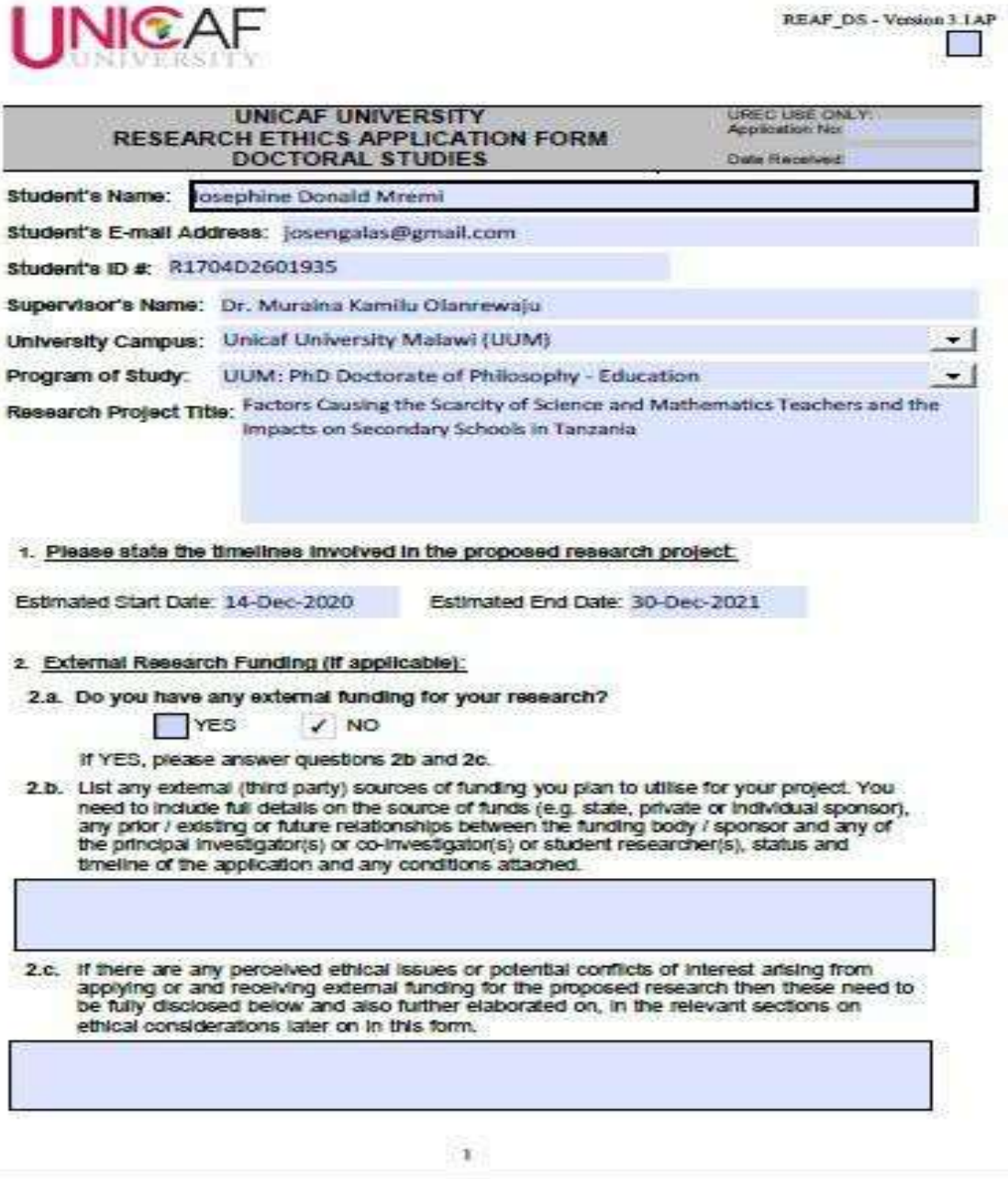
Supervisor's Name: Dr. Muraina Kamilu Olanrewaju

Date of Application: 08-Dec-2019

Important Note
Please now save your completed form (we suggest you also print a copy for your records) and then submit it to your UU Dissertation/project supervisor (tutor). **In the case of student projects, the responsibility lies with the Faculty Dissertation/Project Supervisor.** If this is a student application, then it should be submitted via the relevant link in the VLE. Please submit only electronically filled in copies; **do not** hand fill and submit scanned paper copies of this application.

☑ **Before submitting your application, please tick this box to confirm that all relevant sections have been filled in and the information contained is accurate to the best of your knowledge.**

Approved UREC Forms



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REAF_DS - Version 3.1.AP

UNICAF UNIVERSITY
RESEARCH ETHICS APPLICATION FORM
DOCTORAL STUDIES

UREC USE ONLY:
Application No:
Date Received:

Student's Name: Josephine Donald Mremi

Student's E-mail Address: josengalas@gmail.com

Student's ID #: R1704D2601935

Supervisor's Name: Dr. Muraina Kamilu Olanrewaju

University Campus: Unicaf University Malawi (UUM)

Program of Study: UUM: PhD Doctorate of Philosophy - Education

Research Project Title: Factors Causing the Scarcity of Science and Mathematics Teachers and the Impacts on Secondary Schools in Tanzania

1. **Please state the timelines involved in the proposed research project:**

Estimated Start Date: 14-Dec-2020 Estimated End Date: 30-Dec-2021

2. **External Research Funding (if applicable):**

2.a. **Do you have any external funding for your research?**

☐ YES ✓ NO

If YES, please answer questions 2b and 2c.

2.b. List any external (third party) sources of funding you plan to utilise for your project. You need to include full details on the source of funds (e.g. state, private or individual sponsor), any prior / existing or future relationships between the funding body / sponsor and any of the principal investigator(s) or co-investigator(s) or student researcher(s), status and timeline of the application and any conditions attached.

2.c. If there are any perceived ethical issues or potential conflicts of interest arising from applying or and receiving external funding for the proposed research then these need to be fully disclosed below and also further elaborated on, in the relevant sections on ethical considerations later on in this form.

1

3. The research project

3.a. Project Summary:

In this section fully describe the purpose and underlying rationale for the proposed research project. Ensure that you pose the research questions to be examined, state the hypotheses, and discuss the expected results of your research and their potential.

It is important in your description to use plain language so it can be understood by all members of the UREC, especially those who are not necessarily experts in the particular discipline. To that effect ensure that you fully explain / define any technical terms or discipline-specific terminology (use the space provided in the box).

The main purpose of this qualitative research study is to unveil the factors causing the scarcity of science and mathematics teachers and to assess the impacts on secondary schools in Tanzania. The study will examine the factors causing current scarcity of science and mathematics teachers as well as impacts on secondary schools in Tanzania. Moreover, the study will assess the strategies that are been used in schools to minimize the scarcity of science and mathematics teachers on secondary schools in Tanzania.

The scarcity of science and mathematics teachers and the impacts on secondary schools has prevailed for a long time in Tanzania despite of several efforts taken as well as some reforms in educational system. From the literature review done, it has been confirmed that there is this scarcity of science and mathematics teachers and the impacts on secondary schools in the country (Ndalichako & Komba, 2014; Osaki, 2007; Kamagi, 2007; UNESCO, 2006; TAMASHA, 2010; Project, 2018; Wedgwood, 2007).

From literature there is also limited information on the factors that are causing this scarcity and maintain the problem for many years. The current study is working to find out the factors contributing to the scarcity of secondary school science and mathematics teachers and make assessment of the impacts caused by this scarcity problem on the secondary schools in the country. The study will also investigate also the extent of the scarcity of science and mathematics teachers and the impacts on secondry schools. Moreover, the study intends to assess the strategies used by the school management team to minimize the scarcity of science and mathematics teachers and the impacts on secondary schools in Tanzania. Furthermore, the study will evaluate the effectiveness of those strategies used by the school management team to manage the scarcity of science and mathematics tearchers on secondary schools in Tanzania.

The research findings will be a motivative base for the students whose interest is to join science careers and the parents as well as theachers whose priority and perception for their children is to study science and mathematics for their future career endeavours.

3.b. Significance of the Proposed Research Study and Potential Benefits:

Outline the potential significance and/or benefits of the research (use the space provided in the box).

i. The study will be useful to the government education officers, policy and decision makers, school education managers, teachers, parents, students and other stakeholders to understand the in-depth of the factors causing the scarcity of science and mathematics teachers in secondary schools in Tanzania. ii. The study will help the government education officers, school education managers, and other stakeholders to comprehend thoroughly the impacts of factors causing the scarcity of science and mathematics teachers secondary schools in Tanzania. iii. The findings will serve as a reference to the educational planners and decision makers to invest more on science and mathematics teachers training and allocation of enough of them in secondary schools so as to promote the provision of quality science and mathematics subjects in Tanzania. iv. The findings will assist appropriate authorities responsible in the training of teachers in finding the best ways of training, retaining, and attracting science and mathematics teachers in the teaching profession so as to reduce the scarcity. v. The findings will help the school management to review the approaches they have been using to minimize the scarcity of science and mathematics teachers and its impacts on the secondary schools in Tanzania. vi. The research findings will be useful to students whose interest is to join science careers in their future endeavours. vii. The research findings will be useful to parents whose priority and perception for their children is to join science for their future careers.

4. **Project execution:**

4.a. The following study is an:

- [x] experimental study (primary research)
- [ ] desktop study (secondary research)
- [ ] desktop study using existing databases involving information of human/animal subjects
- [ ] Other

If you have chosen 'Other' please Explain:

4.b. Methods. The following study will involve the use of:

Method	Materials / Tools
Qualitative:	☑ Face to Face Interviews
	☑ Phone Interviews
	☐ Face to Face Focus Groups
	☐ Online Focus Groups
	☑ Other *
Quantitative:	☐ Face to Face Questionnaires
	☐ Online Questionnaires
	☐ Experiments
	☐ Tests
	☐ Other *

*If you have chosen 'Other' please Explain:

The students who will participate in this research will be given questionnaires instead of interview or focus group discussion. The researcher will briefly explain about the main purposes of the research to the participants (selected students) before providing questionnaires to them. These selected students will be given some time to go through the questionnaires and response in writing accordingly.
The researcher will guide the students in filling the questionnaires and respond to any question that might arise during the process. For the students who will feel that they want to withdraw themselves from participating in the research will be allowed to go at any time.

5. Participants:

5 a. Does the Project involve the recruitment and participation of additional persons other than the researcher(s) themselves?

☑ YES **If YES, please complete all following sections.**

☐ NO **If NO, please directly proceed to Question 7.**

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5 b. Relevant Details of the Participants of the Proposed Research

State the number of participants you plan to recruit, and explain in the box below how the total number was calculated.

Number of participants: 152

The study will recruit different participants include four (4) education officers from each of the two districts. This study will recruit six (6) science and mathematics teachers from eight (8) secondary schools making a total of 48 of them from the two districts. Moreover, the study will recruit a total of 96 science and mathematics students, whereby twelve (12) students will be selected from each of eight (8) secondary schools. Thus, the grand total participants to be recruited in this research is 152.

Describe important characteristics such as: demographics (e.g. age, gender, location, affiliation, level of fitness, intellectual ability etc). It is also important that you specify any inclusion and exclusion criteria that will be applied (e.g. eligibility criteria for participants).

Age range: From 15 To 60

Gender: ☑ Female ☑ Male

Eligibility Criteria:

- Inclusion criteria: At the Regional and District levels only education officers will be involved; at school level science and mathematics teachers and students will be involved in the research; and government and pulic schools will be purposive selected to be involved.
- Exclusion criteria: Teachers who are not teaching Science and Mathematics in secondary schools will not participate in this research study. Also the students who are not studying science and mathematics will not be involve in this research study.

Disabilities: Participants with disabilities will be involved this research except those with mental disabilities and only if they can provide the informed consent by themselves.

Other relevant information (use the space provided in the box):

Moreover, where necessary the national language, in this case Kiswahili will be used during the interviews and focus group discussion to essure that the participants are free to speak and that they have confidence to fully participate in the reaserch. In schools all students who are studying science and mathematics have equal chance to be selected to parcipated in the research provided that they can provide the infromed consent by themselves.

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5 c. Participation & Research setting:

Clearly describe which group of participants is completing/participating in the material(s)/ tool(s) described in 5b above (use the space provided in the box).

The research will involve the education officers at the District levels; science and mathematics teachers; students studying science and mathematics subjects from the selected secondary schools in the study area.
Face to face interviews will be conducted with eight (8) education officers at the District levels (including academics offers, quality assurance officers and District Education officers) as well as 48 teachers who are teaching science and mathematics in selected secondary schools in the study area.
Moreover, some study questionnaires will be administered to students who are studying science and mathematics subjects, and a total of 96 students, whereby at least twelve (12) students will be selected from each of eight (8) secondary schools in the study area.

5 d. Recruitment Process for Human Research Participants:

Clearly describe how the potential participants will be identified, approached and recruited (use the space provided in the box).

The principal researcher will visit the office of the Regional Administrative Secretary (RAS) with the dull filled informed consent form. The obtained informed consent forms signed by RAS, REO and DEO will be sent to the secondary schools by the researcher for data collection. The participants will be identified from purposively selected secondary schools and depending on the number of available individuals then the participants will be randomly selected from the group. Heads of schools will assist to sign the guardian informed consent forms for their students. Verbal informed consent will be obtained from teachers before the interviews started. The researcher will briefly explain about the purpose of the research to the participants before start. The participants will be allowed to withdraw themselves and their information from the interview or the research at any time as they wish to.

5 e. Research Participants Informed Consent.

Select below which categories of participants will participate in the study. Complete the relevant Informed Consent form and submit it along with the REAF form.

Yes	No	Categories of participants	Form to be completed
☑	☐	Typically Developing population(s) above the maturity age *	Informed Consent Form
☑	☐	Typically Developing population(s) under the maturity age *	Guardian Informed Consent Form

* Maturity age is defined by national regulations in laws of the country in which the research is being conducted.

5 f. Relationship between the principal investigator and participants.

Is there any relationship between the principal investigator (student), co-investigators(s), (supervisor) and participant(s)? For example, if you are conducting research in a school environment on students in your classroom (e.g. instructor-student).

☐ YES ☑ NO

If YES, specify (use the space provided in the box).

6. Potential Risks of the Proposed Research Study.

6 a. i. Are there any potential risks, psychological harm and/or ethical issues associated with the proposed research study, other than risks pertaining to everyday life events (such as the risk of an accident when travelling to a remote location for data collection)?

☐ YES ☑ NO

If YES, specify below and answer the question 6 a.ii.

6 a.ii Provide information on what measures will be taken in order to exclude or minimise risks described in 6.a.i.

6 b. Choose the appropriate option

		Yes	No
i.	Will you obtain written informed consent form from all participants?	☑	☐
ii.	Does the research involve as participants, people whose ability to give free and informed consent is in question?	☑	☐
iii.	Does this research involve participants who are children under maturity age? **If you answered YES to question iii, complete all following questions.** **If you answered NO to question iii, do not answer Questions iv, v, vi and proceed to Questions vii, viii, ix and x.**	☑	☐
iv.	Will the research tools be implemented in a professional educational setting in the presence of other adults (i.e. classroom in the presence of a teacher)?	☑	☐
v.	Will informed consent be obtained from the legal guardians (i.e. parents) of children?	☑	☐
vi.	Will verbal assent be obtained from children?	☑	☐
vii.	Will all data be treated as confidential? If NO, explain why confidentiality of the collected data is not appropriate for this proposed research project, providing details of how all participants will be informed of the fact that any data which they will provide will not be confidential.	☑	☐
viii.	Will all participants /data collected be anonymous? If NO, explain why and describe the procedures to be used to ensure the anonymity of participants and/or confidentiality of the collected data both during the conduct of the research and in the subsequent release of its findings.	☑	☐

		Yes	No
ix.	Have you ensured that personal data and research data collected from participants will be securely stored for five years?	☑	☐
x.	Does this research involve the deception of participants? If YES, describe the nature and extent of the deception involved. Explain how and when the deception will be revealed, and who will administer this debrief to the participants:	☐	☑

6 c. i. Are there any other ethical issues associated with the proposed research study that are not already adequately covered in the preceding sections?

☐ Yes ☑ No

If YES, specify (maximum 150 words).

6.c.ii Provide information on what measures will be taken in order to exclude or minimise ethical issues described in 6.c.i.

6 d. Indicate the Risk Rating.

☐ High ☑ Low

7. **Further Approvals**

Are there any other approvals required (in addition to ethics clearance from UREC) in order to carry out the proposed research study?

☑ YES ☐ NO

If YES, specify (maximum 100 words):

The UNICAF University has to introduce the researcher to the Regional Administration Secretary (RAS) as the student who want to conduct a research in the region. The RAS will introduce the researcher to the Regional Education Officer (REO) & Districts Education Offices (DEO) to allow her to conduct the research. (Informed Consent suffice).

8. **Application Checklist**

Mark √ if the study involves any of the following:

☑ Children and young people under 18 years of age, vulnerable population such as children with special educational needs (SEN), racial or ethnic minorities, socioeconomically disadvantaged, pregnant women, elderly, malnourished people, and ill people.

☐ Research that foresees risks and disadvantages that would affect any participant of the study such as anxiety, stress, pain or physical discomfort, harm risk (which is more than is expected from everyday life) or any other act that participants might believe is detrimental to their wellbeing and / or has the potential to / will infringe on their human rights / fundamental rights.

☐ Risk to the well-being and personal safety of the researcher.

☐ Administration of any substance (food / drink / chemicals / pharmaceuticals / supplements / chemical agent or vaccines or other substances (including vitamins or food substances) to human participants.

☐ Results that may have an adverse impact on the natural or built environment.

9. **Further documents**

Check that the following documents are attached to your application:

		ATTACHED	NOT APPLICABLE
1	Recruitment advertisement (if any)	☐	☑
2	Informed Consent Form / Guardian Informed Consent Form	☑	☐
3	Research Tool(s)	☑	☐
4	Gatekeeper Letter	☑	☐
5	Any other approvals required in order to carry out the proposed research study, e.g., institutional permission (e.g. school principal or company director) or approval from a local ethics or professional regulatory body.	☑	☐

10. Final Declaration by Applicants:

(a) I declare that this application is submitted on the basis that the information it contains is confidential and will only be used by Unicaf University for the explicit purpose of ethical review and monitoring of the conduct of the research proposed project as described in the preceding pages.

(b) I understand that this information will not be used for any other purpose without my prior consent, excluding use intended to satisfy reporting requirements to relevant regulatory bodies.

(c) The information in this form, together with any accompanying information, is complete and correct to the best of my knowledge and belief and I take full responsibility for it.

(d) I undertake to abide by the highest possible international ethical standards governing the Code of Practice for Research Involving Human Participants, as published by the UN WHO Research Ethics Review Committee (ERC) on http://www.who.int/ethics/research/en/ and to which Unicaf University aspires to.

(e) In addition to respect any and all relevant professional bodies' codes of conduct and/or ethical guidelines, where applicable, while in pursuit of this research project.

☑ **I agree with all points listed under Question 10**

Student's Name: Josephine Donald Mremi

Supervisor's Name: Dr. Muraina Kamilu Olanrewaju

Date of Application: 14-May-2021

Important Note:
Save your completed form (we suggest you also print a copy for your records) and then submit it to your UU Dissertation/project supervisor (tutor). **In the case of student projects, the responsibility lies with the Faculty Dissertation/Project Supervisor.** If this is a student application, then it should be submitted via the relevant link in the VLE. Please submit only electronically filled in copies; **do not** hand fill and submit scanned paper copies of this application.

UNICAF UNIVERSITY

UREC Desision, Version 2.0

Unicaf University Research Ethics Committee Decision

Student's Name: Josephine Mremi

Student's ID #: R1704D2601935

Supervisor's Name: Dr Muraina Kamilu Olanrewa

Program of Study: UUM: PhD Doctorate of Philosophy - Education

Offer ID /Group ID: O22679G22937

Dissertation Stage: 3

Research Project Title: Factors Causing the Scarcity of Science and Mathematics Teachers and the Impacts on Secondary Schools in Tanzania

Comments:

REAF
5d - the gatekeeper letter is required from the management or the authorities in order to obtain permission to perform research in an organization - and not the informed consent. Each participant should provide written informed consent/ or guardian informed consent.

Informed consent, Guardian Informed consent:
Both informed consents are directed to each participant. Therefore, the phrase 'after obtained the informed consent from them or their guardians.' - should be removed. Explain in both consent forms why and how you have chosen this person to participate in this research.

Interview Guide Questions for the Students
Correct the title of the tool - Interview Guide for Focus group Discussion for the Students. Otherwise, untick 'Face to Face Focus Groups' from question 4b of REAF.

Decision*: B. Approved with comments for minor revision

Date: 29-Apr-2021

*Provisional approval provided at the Dissertation Stage 1, whereas the final approval is provided at the Dissertation stage 3. The student is allowed to proceed to data collection following the final approval.

Informed Consent Form

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UU_IC - Version 2.1

Informed Consent Form

Part 1: Debriefing of Participants

Student's Name:

Student's E-mail Address:

Student ID #:

Supervisor's Name:

University Campus: Choose from the list

Program of Study:

Research Project Title:

Date:

Provide a short description (purpose, aim and significance) of the research project, and explain why and how you have chosen this person to participate in this research (maximum 150 words).

The above named Student is committed in ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to the participants.

Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted.

All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

I, _____, ensure that all information stated above is true and that all conditions have been met.

Student's Signature: _____

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Informed Consent Form

Part 2: Certificate of Consent

This section is mandatory and should to be signed by the participant(s)

Student's Name:

Student's E-mail Address:

Student ID #:

Supervisor's Name:

University Campus: Choose from the list

Program of Study:

Research Project Title:

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation to this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. I consent voluntarily to be a participant in this study.

Participant's Print name:

Participant's Signature: _____

Date:

If the Participant is illiterate:

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had an opportunity to ask questions. I confirm that the aforementioned individual has given consent freely.

Witness's Print name:

Witness's Signature: _____

Date:

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Informed Consent Form

Part 1: Debriefing of Participants

Student's Name: Josephine Donald Mremi

Student's E-mail Address: josengalas@gmail.com

Student ID #: R170402601935

Supervisor's Name: Dr. Muraina Kamilu Olanrewaju

University Campus: Unicaf University Malawi (UUM)

Program of Study: UUM: PhD Doctorate of Philosophy in Education

Research Project Title: Factors Causing the Scarcity of Science and Mathematics Teachers and the Impacts on Secondary Schools in Tanzania

Date: 02-Jan-2021

Provide a short description (purpose, aim and significance) of the research project, and explain why and how you have chosen this person to participate in this research (maximum 150 words).

The main purpose of the research study is to examine the factors causing the scarcity of science and mathematics teachers and the impacts on secondary schools in Tanzania. The research will assess the impacts caused by the existing scarcity of science and mathematics teachers and evaluate the strategies which are being used by the school management to minimize the scarcity and the impacts on secondary schools in Tanzania. The findings will assist education authorities to find the best way of training, retaining, attracting science and mathematics teachers and to review the strategies that are used to minimize the scarcity of science and mathematics teachers; as well as to serve as reference to planners and decision makers to invest in training science and mathematics teachers. Study area was purposively selected based on the examination performance for three consecutive years; schools with advanced level are randomly selected the study area; the teachers and students who are involved in teaching and learning science and mathematics will be randomly selected after obtained the informed consent from them or their guardians.

The above named Student is committed in ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to the participants.

Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted.

All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

I, Josephine Donald Mremi, **ensure that all information stated above is true and that all conditions have been met.**

Student's Signature: J.D.Mremi

UU_IC - Version 2.1

Informed Consent Form

Part 2: Certificate of Consent

This section is mandatory and should to be signed by the participant(s)

Student's Name: Josephine Donald Mremi

Student's E-mail Address: josengalas@gmail.com

Student ID #: R170402601935

Supervisor's Name: Dr. Muraina Kamilu Olanrewaju

University Campus: Unicaf University Malawi (UUM)

Program of Study: UUM: PhD Doctorate of Philosophy in Education

Research Project Title: Factors Causing the Scarcity of Science and Mathematics Teachers and the Impacts on Secondary Schools in Tanzania

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation to this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. I consent voluntarily to be a participant in this study.

Participant's Print name:

Participant's Signature: _____

Date:

If the Participant is illiterate:

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had an opportunity to ask questions. I confirm that the aforementioned individual has given consent freely.

Witness's Print name:

Witness's Signature: _____

Date:

Guardian Informed Consent Form

UNICAF UNIVERSITY

UU_GIC - Version 2.1

Guardian Informed Consent Form

Part 1: Debriefing of Participants

Student's Name:

Student's E-mail Address:

Student ID #:

Supervisor's Name:

University Campus: Choose from the list

Program of Study:

Research Project Title:

Date:

Provide a short description (purpose, aim and significance) of the research project, and explain why and how you have chosen this person to participate in this research (maximum 150 words).

The above named Student is committed in ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to the participants.

Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted.

All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

I, _____, ensure that all information stated above is true and that all conditions have been met.

Student's Signature:

UNICAF UNIVERSITY

Guardian Informed Consent Form

Part 2: Certificate of Consent

This section is mandatory and should to be signed by the participant's legal guardian

Student's Name:

Student's E-mail Address:

Student ID #:

Supervisor's Name:

University Campus: Choose from the list

Program of Study:

Research Project Title:

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that the participant is free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of the participation to this study. I understand that all data will remain anonymous and confidential, unless stated otherwise.

I, _____, the legal guardian of _____ allow and provide consent that _____ can willingly participate in the study.

I, _____, the legal guardian of _____ have been ensured that verbal consent given by _____ will also be taken before the study.

UNICAF UNIVERSITY

UU_GiC - Version 2.1

Guardian Informed Consent Form

Part 1: Debriefing of Participants

Student's Name: Josephine Donald Mremi

Student's E-mail Address: josengalas@gmail.com

Student ID #: R170402601935

Supervisor's Name: Dr. Muraina Kamilu Olanrewaju

University Campus: Unicaf University Malawi (UUM)

Program of Study: UUM: PhD Doctorate of Philosophy in Education

Research Project Title: Factors Causing the Scarcity of Science and Mathematics Teachers and the Impacts on Secondary Schools in Tanzania

Date: 14-May-2021

Provide a short description (purpose, aim and significance) of the research project, and explain why and how you have chosen this person to participate in this research (maximum 150 words).

The aim of the research is to examine and unveil the factors causing the scarcity of science and mathematics teachers and the impacts on the secondary schools in Tanzania. The research will also work to assess the strategies that are used by the school management to minimize the scarcity of science and mathematics and the impacts to students, teachers and educational system in Tanzania.
The research findings will assist education authorities in finding the best ways of training, retaining, attracting and reviewing the strategies that are used to minimize the scarcity of science and mathematics teachers as well as to serve as reference to planners and decision makers to invest more on training science and mathematics teachers. The findings will also be useful to teachers, parents and students whose priority is to ensure that children join science careers in future.

The above named Student is committed in ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to the participants.

Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted.

All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

I, Josephine Donald Mremi, **ensure that all information stated above is true and that all conditions have been met.**

Student's Signature: J.D.Mremi

UNICAF UNIVERSITY

URI_GIC – Version 2.1

Guardian Informed Consent Form

Part 2: Certificate of Consent

This section is mandatory and should to be signed by the participant's legal guardian

Student's Name: Josephine Donald Mremi

Student's E-mail Address: josengalas@gmail.com

Student ID #: R1704D2601935

Supervisor's Name: Dr. Muraina Kamilu Ofanrewaju

University Campus: Unicaf University Malawi (UUM)

Program of Study: UUM: PhD Doctorate of Philosophy in Education

Research Project Title: Factors Causing the Scarcity of Science and Mathematics Teachers and the Impacts on Secondary Schools in Tanzania

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that the participant is free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of the participation to this study. I understand that all data will remain anonymous and confidential, unless stated otherwise.

I, _____, the legal guardian of _____ allow and provide consent that _____ can willingly participate in the study.

I, _____, the legal guardian of _____ have been ensured that verbal consent given by _____ will also be taken before the study.

Gatekeeper Letter

Josephine Mremi,
P. o. Box 78192,
Dar Es Salaam,
Tanzania,
19/04/2021.

Unicaf University
School of Doctoral Studies

RE: REQUEST FOR AN INTRODUCTION LETTER FROM THE UNICAF UNIVERSITY FOR JOSEPHINE DONALD MREMI - R704D2061935

Please, refer to the heading above. My name is Josephine Donald Mremi, a Ph. D Education Student at Unicaf University. I am working on Chapter 3 part of my thesis which involves conducting research data collection from the selected schools in the Kibaha and Bagamoyo Districts in the Pwani region. My research topic is "**Causes and Impacts of the Scarcity of Science and Mathematics Teachers on Education in Tanzanian Secondary Schools".** The main purpose of this research is to determine the factors causing the scarcity of science and mathematics teachers and the impacts caused on secondary schools in Tanzania.

During data collection, the researcher has to work with other education stakeholders including District Education officers, secondary school teachers, and students from selected districts (Kibaha and Bagamoyo) in Pwani Region. To conduct this research, the researcher requires informed consent from the Regional Administration Secretary.

I am therefore writing to request your office to grant me an introduction letter to the Regional Administration Secretary (RAS) in Pwani for a similar purpose, upon the approval of the forms by UREC. Please address this letter to the Regional Administration Secretary of Pwani Region, P.O. Box 30112, Kibaha Tanzania.

Thank you for your continuous cooperation.

With kind regards,

Josephine Mremi
Ph.D. Education Student

Research Permit

THE UNITED REPUBLIC OF TANZANIA
PRESIDENT'S OFFICE
REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

Telegram: "REGCOM COAST"
Tel. No. 023-2402287/2402086
Fax No. 023-2402358/2402151
E- Mail: ras@pwani.go.tz
ras.pwani@tamisemi.go.tz

Regional Commissioner's Office,
Coast Region,
P.O. Box 30080,
KIBAHA.

In reply please quote:
Ref.No. FA 221/265/01'E'121

21st May, 2021

District Executive Director,
Kibaha and **Bagamoyo**
COAST REGION.

Ref: **RESEARCH PERMIT**

Please kindly refer to the subject above.

2. I would like to introduce to you **Josephine Donald Mremi** who is a student pursuing a PhD Doctorate of Philosophy in Education at the UNICAF University and who is at the moment requires to conduct research.

3. Permission has been given for her to conduct a research titled **"The Factors Causing the Scarcity of Science and Mathematics Teachers and the Impacts on Schools in Tanzania"**.

4. The period to which this permission has been granted is from **21st May, 2021** to **15th June, 2021** and the research will cover **Kibaha Boys, Zogowale, Rafsanjani Boga, Kilangalanga, Gili, Wali Ul Asr Girls**, and **Baobab Secondary School**.

5. You are requested to provide necessary assistance which will enable her to complete the research study successfully.

6. With kind regards.

Hadija A. Mchelea
For: **REGIONAL ADMINISTRATIVE SECRETARY**

Copy to: Regional Administrative Secretary
COAST REGION

* Vice Chancellor,
UNICAFE University,
MALAWI.

" Director General,
Kibaha Education Centre,
P. O. Box 30054,
KIBAHA.

" **Josephine Dolnad Mrami.**